GUIDE TO IRRIGATION DESIGN UNDER DROUGHT CONDITIONS

BY WILLIAM REINECKE

Replacing overhead systems with drip systems can cut water usage in half in areas of ground cover or ornamental plantings. Weed growth caused by airborne seed is also not germinated by overhead watering.

In the past decade many regions throughout the United States have suddenly been required to curtail water usage for non-essential needs. These non-essential needs, in general, have been limited to the washing of automobiles, washing down of sidewalks, children playing in garden hose sprinklers, wetting down of roofs and walls of homes (during summer's heat), and other sundry acts of minimal water usage not considered as necessary to the health or welfare of the public in those communities most heavily stricken by these droughts.

Unfortunately, in many of these communities, the sprinkling of lawns and ornamental plantings around private homes was also unlawful. In one town north of Los Angeles several years ago, the construction of new homes ground to a halt because the local water purveyor was unable to provide this essential commodity to any potential users with the limited source to which this agency was confined. At that time the limitation per subscriber was less than fifty gallons per day. Normal use for customers of the Metropolitan Water District, which serves the Los Angeles area, is close to two hundred gallons per day per person, under conditions of normal supply.

We are now being told drought is expected to become the norm. The great increase in the country's population must, by physical need, require more water than was needed just twenty-five years ago. And even though natural cycling of the waters from lakes, ponds, streams, and oceans does recirculate that which is available by nature, America's agricultural requirements for man-applied irrigation consumes approximately eighty-five percent of all available water. Industry, if my memory is correct, will take another nine to ten percent, leaving five or six percent remaining for domestic use. These figures will vary with different communities, but demonstrates a picture of stark reality for water consumers in times of severe drought. It must be finally realized that America can no longer be considered (in abundance) as the land of sky blue waters.

And, of course, the pollution of lakes, streams, rivers, and other waterways by industrial contamination should be no longer tolerated. According to the GNP, American industry is presently obsoleted by other nations with newer manufacturing facilities using modern disposal techniques. Now, then is the time for America to rebound and rebuild with an eye to more automated production and with preferential consideration to resubstantiating our natural resources, of which water is a prime concern.

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> The practice of competing for the lowest installed cost can cause severe wastage of water due to overspray and inefficient distribution patterns.

It can be expected, during a continued drought, that not only will residential plantings be restricted by law from irrigation, but also to be included will be limitations on parks, cemeteries, athletic fields, and, of course, golf courses, for human consumption will preclude all sorts of "non-essential" demands for this most precious resource, water.

The following pages are prepared to offer suggestions that, hopefully, will be beneficial to any of those agencies who have not yet experienced the trauma of being "caught in a drought."

Irrigation designers' responsibilities

It has been said that the irrigation designers who employ their services in the southwestern parts of this country have more lucidity than those designers in the balance of the nation. This statement may be fact or fiction. However, the independent, professional designers of this portion of the nation have, by need, become extremely knowledgeable in working to conditions of extreme heat, plant stress, limited water supply, excessive winds and the "Dries," that state of aridity that provokes the designer to overlook all spacing recommendations of heads as stipulated in the various equipment catalogues and to squeeze these outlets to proximities so close as to cause embarrassment to any respectable manufacturer. And yet, experience in the West has become the supreme dictator. And necessity has demanded that spacings of fifty percent of the diameter be established as the maximum norm.

Approximately six years ago my office had the opportunity of reviewing a set of irrigation drawings that had been prepared by a professional designer from the Midwest. When questioning why there were no part circle rotary heads used to protect the buildings, public walks and streets, the response was given that these surfaces are repeatedly wetted by summer rains so why protect them from artificial rain and it saves considerable amounts of money to eliminate the perimeter rows of heads.

This may be true but the prorated savings of both money and water, over the years, realized by only sprinkling in the planted areas will more than justify the initial cost of the additional heads and controls.

Further, in the Midwest and East and southern parts of the country, it is common practice that manufacturer's representatives, or distributors, act as irrigation designers supplying their drawings to the professional offices of architects, landscape architects, or engineers. With this concept in mind, each distributor/designer will attempt to make his "installed-cost" less than his competitor who may be also preparing drawings for the same site and to be delivered to the same professional office. As such, heads are spaced, or stretched, to their maximum or even beyond, part cir-

Continues on page 26

cle heads eliminated and systems too heavily loaded to conserve on the control system. These practices cause severe wastage of water due to overspray and unwanted runoff on paved or structural surfaces and, secondly, through inefficient uniformity of distribution patterns. The latter causes severe over watering of some portions of the wetted pattern in order to successfully apply the proper amount of daily required precipitation to the thinner areas of coverage. This action repeated throughout a season of irrigation can cause considerable wastage of water and money.

Further, the responsibility of the head manufacturers should be addressed here. Several brand names of heads manufactured today provide a balanced precipitation between full circle heads and all arcs of the part circle heads of the same model number. However, many manufacturers still do not engineer their products to perform in this manner. They should, for many designers prefer to connect fulls and parts on the same valve and if the heads are not balanced the part circle heads, in many cases, can be delivering twice the amount of water, over their area of throw, as do the full heads. Here, again, this overwatering must be performed just to apply the proper amounts of precipitation in the areas of thinner coverage to be attained by the full circle heads.

Design challenges

Flooding and overwatering should not be tolerated by any designer, contractor, or owner. And this condition exists in the design of stationary shrub heads, stationary pop-up heads, and intermediate throw heads as well as rotary heads. It will be better for all, when the manufacturers upgrade their standards of product design with an eye to potential drought conditions for the less water used is that same amount saved.

Runoff of excessively applied water on slopes is another fine example of poor design and/or lack of control on the part of the water manager of the site. This will be discussed later on in this article.

There are many authorities that advocate the shrinking of irrigated areas of existing sites, as golf courses and parks, in an effort to reduce water consumption. This includes additions, to these same sites, of hard surface areas by increasing sizes of parking lots and constructing tennis courts, handball courts, etc. Of course, the planted areas removed when using this water conservation method are so small that only a minimal savings could be effected in percentage to the whole. Others suggest cutting down great numbers of large trees to reduce their water consumption without realizing that mature trees take very little from surface water with the majority of their needs coming from deeper rootings into available ground water sources.

Great savings can be effected in many cases where shrubbery or ground covers blanket large areas of ornamental plantings. This can be realized by replacing existing overhead systems with drip (emitter) systems. It has been observed by some authorities that water usage by drip can be as low as forty percent of that delivered by conventional overhead systems. It must be noted, though, that emitter systems, unless totally buried, are extremely susceptible to destruction in public areas that are known to be vandal-prone. Drip systems also save on labor costs, as weed growth caused by airborne seed is not germinated by overhead watering.

> Many manufacturers do not design their heads to provide a balanced precipitation between full circle and part circle heads of the same model number.

The recommendation of some developers is that existing golf courses can save considerable water by reconstruction of the irrigation system to allow watering only on the "landing spots," greens, and tees. All fairways between the tee and the first landing spot or "target" would be left unwatered, but left in mowed native grasses or ground covers. Then again from that green target all would be unwatered until the next target area, etc.

This, possibly, is a solution for a Pro-Course or any course on which the players are reasonably proficient at their game. In such cases the irrigation water required would be minimal and a great conservation readily realized.

However, such a course could never be anticipated as a Public Course where players of varying degrees of expertise will be using the site. For play would be extremely slow due to hookers, slicers, and random searching for short balls. And so municipal courses must, by the very essence of their purpose, remain as wall-to-wall turfed areas so designed to allow play from novices to proficient non-professionals.

This criteria must, by necessity, result in development of an irrigation system of overall coverage, thus from its very beginning must be considered as one of the enemy in the battle of water conservation.

Design resolutions

Resolutions must then be considered that will, during the design stages, weaken the appetite of this thirsty giant.

Thought must be given to applying a planting that will, under the local environmental atmosphere of the site, generate a hardy, durable, drought tolerant cover that will be resistant to the known seemingly intolerable plagues of nature that usually destroy a fine turf. Many of the states' Universities now have fine experimental test stations that have, for a number of years, been exploring hybrid types of various stands of cold and warm season turf grasses. These agencies are a readily available source of invaluable information and are extremely cooperative and happy to relate the results of their explorations and in a totally non-biased manner. More professionals should take advantage of this service.

Public (municipal) parks must also fall under the criteria of design as the municipal golf courses de-

Continues on page 30

scribed above.

Other measures that result in a substantial water conservation, of *any* site, are discussed further on under water management.

Tensionmeters are another means of restraining excess precipitation. But, like a computer, they are only as accurate and meaningful as the water manager allows them to be. Many consider that the additive costs of maintenance required for servicing negates the use of these instruments. But, overall, it will be found that dollar volume savings for water use more than compensates for the time given for maintenance—if maintenance procedures are properly ordered.

If one considers using tensionmeters to measure soil water balances, the devices need not be installed at every control system but randomly spotted throughout the site and precisely in the known dryest locations. This will cause a slight overwatering of some areas, but will prevent burn, or dry out, of those known dry locations. Tensionmeter spot locations should be pinpointed only after exploration and experimentation on the site before a final "tuning" of the available soil is achieved. Once this has been accepted, from that time on, it becomes merely a matter of periodic readings and occasional servicing of the instrument.

Another method of reading soil moisture content is by use of the soils probe, or auger. Daily readings are taken and the observer then must communicate his recommendations to the irrigator, if it be a manually operated system, or to the control system operator, if it be an automatically controlled irrigation system. Each will then program into his specific schedule the amount of water to be applied that night. This daily reading habit is finely attuned for the utmost in water savings.

The final method of calculating daily water needs that will be discussed is the pan evaporation method. The pan to be described is not to be confused with the U.S. Weather Bureau—Class A evaporation pan, though, if in the vicinity of the site, the Class A pan can be referred to as a general source of information. However, if the latter is to be used, adjustments must be made through experimentations of evapotransporation requirements at the actual field level. The Weather Bureau pan is installed with the bottom of the pan above grade. This differs from the evaporation pan used for irrigation evapotransporation rates. This pan is called the "Bureau of Plant Industry (BPI) Evaporation Pan." The BPI pan is six feet in diameter, twenty-four inches deep and is placed in the ground twenty-one inches deep. This pan offers a more accurate indication of evaporation at ground (turf) levels than the Class A pan. The BPI pan has an offset stilling well with integral device to accurately measure the periodical amount of evaporation. This pan (BPI) was developed by the Texas Board of Engineers in cooperation with the U.S. Department of Agriculture, Division of Irrigation, and the Texas Agricultural Experiment Station. It is advisable to install a chain link fence approximately ten feet square around the pan to prevent "unaccountable" water losses caused by bathing birds, thirsty rodents, cougars and/or coyotes. The enclosure should be eight feet high and screened across the top. This pan is used to determine irrigation needs by many agencies today throughout the U.S.A.

In California it can be taken that the number of inches of evaporation can be multiplied by a factor of seventy-five (percent), and the resultant figure is the precipitation that must be applied by artificial means to replace the soil water lost between the past reading and the most recent reading. This, then dictates the timing of irrigation cycles if the irrigation system precipitation rate, in inches per hour, be known. And it must be known if one is to properly manage the amounts of water delivered as related to the actual amounts required.

Other multipliers are given for other types of grasses being supplied with water. There have been a number of excellent, and authoritative papers prepared on the fine tuning of daily irrigation needs by the research teams at the experimental test stations previously mentioned. Copies of these papers are usually provided free of charge to anyone asking. The Department of Plant Science, University of California, has on file a variety of these papers available to the public. Some especially prepared to assist turf owners in preparing for drought.

It was said, forty-five to fifty years ago,

"One inch per week
all over the ground
will grow healthy grass
the world around."

This was a totally unscientific assumption, but perhaps our fathers were more correct in their assumptive powers than many of us are today by using our "eyeball" method of determining the water needs. And fifty-two inches a year is an annual total and does not assist a manager in programming the daily water requirements. But the old adage is remarkably close, though perhaps a little on the high side.

Most managers, through attentive monitoring, can cut fifteen percent from their peak demand watering periods without altering any of the equipment in their present systems. Tests have proven this in Southern California on a park site located near a rather large lake. The annual evaporation near this lake is approximately fifty-two inches. The park managers have recorded application of irrigation, over a five year period, at approximately a thirty-eight inch per year average. Lake evaporation cannot be equated to the BPI pan evap but can be, generally, a good starting point if the pan installation is not available.

Other measures that can be taken are such things as:

1. Only water where and when needed.
2. Improvement of existing irrigation efficiencies.
3. Control of thatch.
4. Prevention of runoff during irrigation cycles.
5. Aeration.
6. Mowing heights.
7. Vertimowing.
8. Lessening of fertilizer applications.
9. Removal of weeds.
10. Application of soil

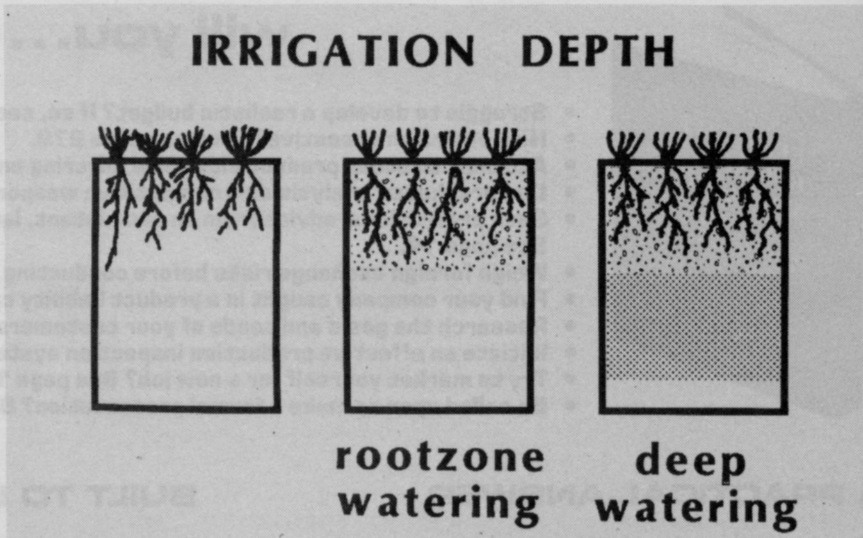
Continues on page 32

amendments or wetting agents.
11. Eliminate wash down of hard (paved) surfaces.
12. Mulching to provide greater water holding capacity of soils.
13. Installation of check valves to prevent low head drainage of pipes.
14. Any others of sound logic and peculiar to the individual site.

Reclaimed sewage water is probably the ultimate goal for all large site irrigation installations but has its own inherent problems yet to be overcome. This source, on all sites of which I am acquainted, is tertiary treated thus eliminating most of the problems. However, one in considering its use must study carefully the chemical analysis available through the supplying agency. Application of too heavy a solution of nitrogen should be avoided as nitrogen causes plant growth and particularly algae growth. Further, inspect for heavy metals, boron, phosphates, and bacterial and virus concentrations.

Reclaimed sewage water should be studied carefully by a water/soil scientist prior to any consideration for use. This is a complex specialty of which this author is not infinitely knowledgeable. Consult with a specialist for your requirements. There is a quantity of technical papers that have been written on this subject that are available to those interested. The Irrigation Association 1981 Technical Conference Proceedings is one such publication.

Lastly, water conservation must begin with proper water management and maintenance. And the only way to reduce maintenance costs of an efficiently designed and operated system is to reduce the size of the irrigated area of the site. A well maintained system must be inspected periodically (once every week or two) under flow conditions and any malfunctions immediately corrected to maintain the high efficiency the system had when first installed. Faulty equipment must be replaced with like kind only to keep the system in balance. Low head drainage should be prevented by installation of check valves of the spring-loaded poppet type under each of the low heads. Monitoring stations of tensionmeters must be checked periodically, as recommended by the manufacturer, and serviced when needed. Auger samplings should be taken prior to every irrigation on manually controlled systems. Tensionmeters can be installed at every valved section on automatically controlled systems. It is advisable to set the automatic controllers to operate at the timing required for the precipitation required during the summer's peak demand loads. Rather than applying one cycle per night, the sequence should be divided into several watering periods per night and repeated the correct number of times each night to accumulate the whole. For instance, a system requiring thirty minutes of watering per night would be timed to a ten minute watering period and repeated three times at equal intervals throughout the allowed hours available for watering to provide the required total of thirty minutes. This prevents runoff and, in most cases, puddling. However, under most conditions, no less than two-tenths of an inch should be applied for any one night. As the droplets cling to the blades of grass, a quantity of the water applied never reaches the soil and is lost by evaporation the next day.



Fine results are now being attained by filling the soil to its optimum moisture capacity and to the depth of the root structure of the grasses, and then replacing the daily losses nightly.

This author does not agree with the older watering concept of waiting until the turf shows stress and then deep watering. Fine results are now being attained by filling the soil to its optimum moisture capacity and to the depth of the root structure of the grasses being used, and then maintaining that fine balance of soil, air, and water by replacing the daily losses every night, or every other night, however the observed dictates may demand. To reiterate, this is evaluated by the evaporation pan, the tensionmeter, or the soil auger. And this is only the responsibility of the site water manager.

An independent Irrigation Consultant, and member of the American Society of Irrigation Consultants, has made available, for modest cost, a "Sprinkler System Operation Guide" which should be found useful by most water managers of turfed fields. The address for Lee E. Bean is given under "Cited References" at the end of this article.

Due to limited space, no mention has been made of a recent development in irrigation form. This novel approach supplies irrigation water from below the turfed surface and is drawn directly into the root zone of the turf. The plots are sealed approximately two feet deep with a waterproof membrane. It is reported that this method has been successful in over seven hundred installations on athletic fields and golf course greens. The inventor is Dr. Willaim Dainel of Purdue University. He has available literature

Continues on page 34

Irrigation *from page 32*

for any interested parties. This system uses only water for plant transpiration, eliminating most of the moisture losses usually realized through soil surface evaporation.

There is much yet to be learned about proper and efficient irrigation practices. Much has been written on many facets of this nebulous art. One day it will become a controlled, predictable science. Until that day arrives, those who practice this art must experiment and test and reveal to others their results so that comparisons and contrasts may be examined.

The state universities must continue to advance their explorations of hybrid grasses to develop drought resistant, weather and disease resistant stands. Their experiments on moisture requirements for turf grasses has already advanced this industry many fold.

The American Society of Irrigation Consultants is presently conferring with the California University System to establish a formal curriculum in Irrigation Design for Ornamental Turfs and Plants. Hopefully this will be followed by other university systems in the U.S.A. There has never been, to my knowledge, a degree offered for this discipline.

The practice of irrigation design is approximately sixty years old. It has developed tremendously in the past quarter century only through the dedicated indulgence of those engaged.

It is a most needed science. As formal education becomes available, it will become more respected for what it is.

CITED LITERATURE

1. Department of Plant Sciences
University of California
Riverside, California 92502

2. The Irrigation Association
13975 Connecticut Avenue
Silver Springs, Maryland 20906

3. Lee E. Bean, Irrigation Specialist
110 West 31st Street
Boise, Idaho 83704

4. Dr. William H. Daniel, Turfgrass Specialist
643 Sharon Chapel Road
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