Watering in the 20s–

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apparent. The new seed had begun to show, and the old grass that was in there was green and healthy, and that little circle stood out from the rest of the fairway as though it had been painted with a brush.

Along the last of May and early in June the rains came, and then the rest of the fairway began to revive; and before long, when the benefit of the rains began to be felt, the surrounding fairway greened up, but it did not have as fine an appearance as the experimental area. During all this time, the area was cut with a power mower, passing over the area at the same time the surrounding fairway was cut, so that so far as the cutting was concerned it had exactly the same treatment as the rest of the fairway. Then in the middle of July the rains stopped and the drought came on, and we kept up the watering, and this piece of ground kept getting better and better; and day by day, as we watched it, and especially early in the morning when the dew was on the grass, we could see this new grass coming up everywhere – as the greenkeeper said, "as thick as the hair on a dog's back." The little fine grass grew up and mingled with the knot-grass; it grew up through the areas where the dandelions were, and apparently was driving the dandelions out. The fairy rings began to show life, and they filled up, and by the 1st day of September we had as fine a piece of fairway as you gentlemen, who are all accustomed to the very best of golf courses, would want to play over.

The lie of the ball was practically perfect. And this fall, just before the snow came, we went on to it as a temporary green. And I want to tell you gentlemen that it was a pretty fair western green at that, right in the fairway.

Now this is not hearsay; it is something I have seen and something I know. I know that if we give that land water and seed we can maintain that fairway. Now the question which you gentlemen have in your minds is, of course, how can you accomplish this result over a fairway of 18 holes? A little experimental area of that kind is certainly simple. I do not, by any means, propose to have you infer for a moment that what we did was a new invention. I have played golf in California, as a great many of you have, and I have seen their irrigation out there; I have seen the apparatus which has been in use for a great many years at the Midwick Golf Club; I have seen the apparatus at the Los Angeles Country Club; I have seen the system of irrigation which Mr. Frank Woodward has installed near Denver, which is an open system with strictly an irrigation flow. With us it was a question of how we could best develop some plan along the lines of the California clubs, and perhaps improve on them, and which would not be prohibitive in the way of expense.

Now I want to say that, first of all, if you are going to sprinkle your fairways, it goes without saying you must have an adequate water supply.

We are fortunate in having a beautiful lake right on the border of our course, with unlimited soft water, and we have a powerful duplex punip, and a very, large storage tank, with a 4-inch main running out through the center of our course, with laterals reducing first to 3 inches and then to 2 1/2 inches, and at every putting green a 2 1/2 inch outlet. The methods of irrigation which I have mentioned seemed to us too expensive to operate, and not convenient. The California system consists of a pipe long enough to reach across the fairway, supported on pulleys, such as you have on shafting in a machine shop, with the hub bored out so that the pipe turns loosely on the pulley, and with holes bored in the top of the pipe; and by pushing the pipe up the fairway it sprays water on each side. At one time we tried the rotary system, which has been in use at some clubs—movable rotary sprinklers in gangs of two or three. At one time we bought one of those large rotaries, such as they use on the Common in Boston, and we used that in front of the putting greens to keep the approaches in good order; but that stream of water was too heavy; the drops were too large; it threw too much water, and it washed out the roots in the grass, although it did help to keep the approaches green. Now the system which we have developed is very simple. First of all, we laid a pipe parallel with the fairway, and we went to the nearest supply pipe, whatever it might be: 2 1/2, 3, or 4 inch, and we ran a lateral along the side of the fairway of l 1/2-inch pipe, and in that pipe we placed a hose outlet every 250 feet. We buried that pipe about 8 or 10 inches below the ground. Of course, in our country our frost goes very deep, and our entire water system is practically on the surface, so that our pipes can be shut off and can be drained easily before they freeze. We had 1 1/2-inch hose outlets every 250 feet. Then we took two units of 11/2-inch pipe, each 54 feet long. We mounted those units on a carriage made of flat iron, and that carriage had on each end of the frame a caster-wheel, a wheel about as large as the wheel on an ordinary wheelbarrow, with a flange on the wheel rounded so that it would not mark the course in the fairway. These two sections of pipe, each 54 feet long, were connected in the center by a piece of high-grade 1 1/2-inch hose. Each one was carried on three carriages, and each carriage had two caster-wheels on the end. Now by a "caster-wheel" I mean a wheel which will revolve and go in any direction in which you want it to go, just as you move your dining-room table or your bureau. If you wish to push this pipe in a particular direction the wheels will automatically turn and run in that direction. If you wish to draw the machine endwise, to take it from one fairway to another, a couple of men can take a rope, or you can take a little tractor and hitch on to one end, and the wheels whirl right around and the machine moves lengthwise. The boys working on the course call this machine "the sea serpent." As I say, these two sections are connected by a piece of 1 1/2-inch hose, in a U-shape, with a 45 degree ell running into the end of each pipe. That makes it flexible. If there is a hill here and a hollow there, the machine accommodates itself to the contour of the ground. If you are moving up the fairway and the fairway is 60 yards wide at that point, and as you approach the putting green it narrows to 30 yards, you can do one of two things; you can have one section across the fairway, and the other at an angle, or you can move up in a V, whichever seems the most convenient, so that the machine does not reach out into the rough. Each machine is equipped with 150 feet of 1 1/2-inch hose. On each one of these sections are two risers of 5/8-inch pipe, with a rotary nozzle at the top of the riser, the riser being about four feet high, and these rotaries revolving on the top of that riser, so that on the two sections there are four rotaries, and when in action one stream of water from No. 1 laps over so that there is no gap between No. 1 and No. 2, or between No. 2 and No. 3; so that the entire area covered by the machine is thoroughly wet.

Now, when we are ready to operate, we go to an outlet and we put 150 feet of 1 1/2-inch hose on it and lead it down to the end of the pipe and screw it on and turn on the water. The rotaries begin to revolve, and you wet an area of 180 feet– about 60 yards. It will cover more if the wind is not blowing to disturb it; but absolutely under all conditions it will wet

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Watering in the 20s –

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60 yards in width by about 60 or 75 feet in length. After experimenting we found it would take about four machines of this kind to handle our course. On every golf course there are certain short holes where the fairway is of no consequence. We have four short holes where it is not practical or necessary to water the fairway. That leaves us 14 holes, and we found that four machines would satisfactorily take care of those 14 holes. We start a machine, and one man tends the four machines. The rig is very light and one man can push it; just roll it up the fairway, right up a hill. He turns on the water and lets his machine stand there and run for 40 or 45 minutes; or if it is a very dry spot he will let it run for an hour while he goes and tends the next machine; and when he has made his rounds he comes back and shuts off the water and moves his machine up to the next area that is dry.

We found that we would have to water the fairways in the daytime at present. We expect to water at night next year. A night crew waters the putting greens 8 hours every night. We found that we would have to increase our pumping capacity a little in order to carry all the fairway sprinklers and the putting green sprinklers at night; but that is a minor matter. We find the mechanics have figured out a method by which we can increase our pumping capacity this spring, so that we will do both the putting green watering and the fairway watering at night.We run 12 rotaries at night on the putting greens. We water 9 putting greens on Monday and 9 on Tuesday, so that every putting green is watered every other night for six nights in the week. We do not water on Sundays unless it is very dry. Those 9 putting green rotaries, together with 3 which we keep running on the tees on the dry places, are all regular night equipment. There are 4 rotaries on each one of those "sea serpents," so that the amount of water which is used by the 4 machines is a little more than you would use in watering 18 greens at night. Each rotary is just a riser with an arm and two outlets, a T-rotary. We figure these 4 machines will water the entire fairway once a week, which will be sufficient. That is what we have done.

One of the practical difficulties that we havc found in building this machine, as a great many of you men who are mechanics would know, was to make it light and at the same time rigid. On the first machine with which we experimented the pipe broke or bent and we had a great deal of trouble, so that we devised a scheme of trussing.

These machines can be built for not to exceed $200 apiece; and we bought the pipe and put in the side line, including the labor, for $1,800. You could equip a course which was already supplied with an adequate water system somewhere from $2,500 to $3,000, including the machines.

1949

USGA JOURNAL

LET'S SAVE WATER

Note on "Ion Exchange Process for Brackish Waters" (World Wide Chemistry), Chemical and Engineering News, Vol. 27, No. 45, Nov. 7, 1949.

"The world is becoming increasingly aware of shortages of a raw material once thought inexhaustible, i.e., freshwater. There are a number of regions, such as Los Angeles, Cal.; Perth, Australia; Johannesburg, South Africa, and Tel Aviv, Israel, where large population densities combined with small annual rainfall give rise to situations where the future economic development is limited by the fresh-water supply." The article describes several possible methods and costs of demineralization of brackish water and states, "although the maximum present-day water cost for very highly valued crops is 30 cents per 1,000 gallons, a more reasonable maximum figure for moderate-scale agricultural uses is 10 cents per 1,000 gallons."

Notes on we're Running Out of Water" by Pat Frank, *This Week Magazine*, p. 5, Nov. 6, 1949.

This article points up the alarming water shortage in a dramatic way. Scientists say that 1957 is the critical date when action will have to be taken if new sources of fresh water are not found.

The article stresses the possibilities of tapping the oceans for fresh water and says that the Department of the Interior has asked Congress for 50 million dollars to find a way to obtain fresh water from the sea. The author says, "Hundreds of thousands of acres of irrigated lands are being kept in production only through serious over - pumping of the existing water supply ..."The water levels of the reservoirs that feed Louisville and Indianapolis have dropped 40 and 50 feet, respectively.

"But the most critical areas are the great, expanding metropolitan districts of the nation where the population is jumping, constantly stepping up the use of water."

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Watering in the 40s–

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The article describes methods of purifying salt water, including the possible use of atomic energy, and ends with this thought: "There is no greater gift this country could give the earth than the perfection of techniques for transforming the sea into fresh water. And for our own good, we'd better do it soon!" The growing scarcity of fresh water is not an idle threat; it is real. Two recent references have been abstracted here to indicate the trend of thinking. To cite other references would serve no useful purpose.

During the educational turf conferences of the winters 1948-49 and 1949-50, USGA Green Section personnel stressed repeatedly the need for saving water on turf areas. Since 1945, Green Section research has been directed toward a program of growing the best turf possible with the minimum of artificial irrigation, using every known device such as: (1) Aeration of the soil to improve porosity and absorption and to reduce runoff; (2) More adequate fertilization to produce denser turf, which is the best-known method of saving water; (3) Emphasis on the turf grasses which have low-water requirements and high drought-tolerance. The Green Section expresses its considered opinion that funds for agricultural research may be used justifiably for turf research which is directed toward saving water. It is well known that, even in areas where water shortages are becoming critical, many turf areas regularly are overwatered. Agricultural and industrial interests should welcome the opportunity to support this phase of turf research because the savings in water largely will accrue to the benefit of agriculture and industry. We do not limit our thinking and our planning to golf course turf; we include all turf areas. We subscribe to the policy that the best turf for all purposes is that which is maintained with only sufficient water to keep it alive.

1953

USGA JOURNAL AND TURF MANAGEMENT: FEBRUARY, 1953

KNOW HOW TO WATER

By ROBERT M. HAGAN
DEPARTMENT OF IRRIGATION, UNIVERSITY OF CALIFORNIA

To do a good job of turf irrigation, we must consider the rooting habits of grasses. If given an opportunity, grasses will develop surprisingly extensive root systems. It is commonly thought that the roots under turf are confined largely to the top six inches or certainly to the top foot. What are the rooting capabilities of turf grasses? The rooting depths of 15-months old plantings on a deep clay soil at Davis, Cal., were studied by measuring the extraction of soil moisture. The plots were irrigated deeply and then allowed to go without irrigation until the grasses wilted. When wilting occurred, all of the available soil moisture in the following soil depths had been extracted:

Effective Rooting Depth Grass	(inches)
Chewings fescue	8
Wahee fescue	10
F-74 fescue	10
Highland bent	12
Kentucky bluegrass	30
Merion bluegrass	30-36
K-31 (tall) fescue	36
Bermuda (U-3 and Common)	36+

In all cases considerable moisture extraction took place below the depths indicated.

Some roots were found at the five foot depth under Merion bluegrass and at the six-foot depth under the bermudas. The ability of grasses to root so deeply has not been considered in the preparation of sites for planting or in the irrigation management of turf areas. Of course, rooting depths will be less in shallow soils or where management practices have restricted root development. These data simply indicate the rooting capability of grasses under these conditions at this location. What practical application does this information have in turf irrigation? Such data help to answer the two basic irrigation questions: (1) how much water to apply and (2) how often to irrigate.

How Much Water to Apply

How do we decide how much water to apply? After a rain or an irrigation, a given depth of a well-drained soil will hold a certain amount of water, depending on its texture or particle sizes. This amount is called the field capacity. Any water applied in excess of the soil's field capacity will drain out. The drier the soil is at time of irrigation, the more water is required to wet a given depth. If the soil has been dried until the grass wilts (approximate wilting point). For example, to wet a two-foot depth requires one and one-half inches of water for sands, three inches for loams and five inches for clays.

Some turf is overwatered that is, more water is applied and soaks in than the soil will retain within the root zone of the grass. The surplus water drains down through the soil, carrying away nutrients and often creates soggy subsoil and consequently shallow roots.

Turf is often underwatered. For example, traveling sprinklers, as they are commonly used, usually apply only one third to one-half inch of water. If the soil has been dried out, one-third inch of water will wet only about five inches of a sandy soil, two inches of loam, and one inch of clay.

The superintendent should determine how much water his sprinklers are putting on. This may be done by using coffee cans as rain gauges. Uniformity of application can be checked by placing the cans in a line running out from the sprinkler. Many will be surprised to find how little water they are applying, especially near the fringe of the area hit by the sprinklers.

Where there is no appreciable surface runoff, the correct running time for sprinklers can be estimated if the rate of water application is known.

In many cases it is easier to let the sprinklers run until coffee-can rain gauges contain the depth of water required to wet the soil to the desired depth. If the sprinkling time is recorded, it can be used as a guide for future irrigations.

Remember that shallow rooting may be caused by repeated shallow irrigations or, in some soils, by application of excessive amounts of water. In either case, the shallow-rooted turf thus produced will then demand frequent irrigation to prevent wilting.

How Offen to Irrigate

Our turf irrigation habits are often bad habits from the standpoint of soil characteristics and the needs of the grasses. Irrigation practices are usually set by habit, the calendar or what we are told are the special moisture requirements imposed by the use to which the turf is put. Let us forget, for the moment, these special demands and look at irrigation solely from the viewpoint of soil characteristics and needs of the grass. Consider the soil as a storage reservoir. The storage capacity within the root zone is determined by the rooting depth of the grass and by the difference between the amount of water retained by the soil after irrigation (approximates field capacity) and that remaining when the grass wilts

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Watering in the 50s–

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(wilting point). The water held by soil between field capacity and the wilting point is called readily available water. Grass will not suffer a water deficit as long as roots are in contact with available water. Sandy soils will hold one-half to three-fourths inch of available water per foot depth of soil, loam about one and one-half inches, and clays about two and one-half inches.

How long will the supply of available water in the soil reservoir last? This depends upon weather conditions, particularly light intensity, temperature, humidity and wind. Trees and shrubs may compete with the grass for water and increase the drain on the soil moisture supply. The rate of water use differs from day to day and place to place. Even on a single piece of turf, water consumption may vary considerably according to exposure. Thus one cannot give accurate figures for water use.

As stated previously, the approximate number of days between irrigation depends on (1) the depth of soil containing roots which has been wet by the last irrigation, (2) the soil texture which determines the available water capacity and (3) the rate of water use.

Where the water use rate is one-inch per week, as is assumed in Chart No.2, a grass which has effective roots to a depth of 12 inches should not need irrigation on a sandy soil for three or four days, on a loam for eight days, and on a clay for thirteen days. If the effective rooting depth is 36 inches, then the grass should not require irrigation on a sandy soil for 11 days, on a loam for 23 days and on a clay for 39 days. Are these right? Have grasses been shown to go without water for such long periods of time without drying or loss of color?

The possibilities of infrequent irrigation are being studied at Davis. This past summer was one of the hottest on record, with temperatures above 90° and close to 100° F most days, and low humidity. On a deep clay soil, the 15-month-old grass slots did not show distinct wilting until the following periods had elapsed:

Elapsed Days Before Distinct Wilting		
Grass		14
Creeping fescues and bent		24
Merion bluegrass		30
K-31 fescue	approx.	36

After these periods, the grasses were distinctly wilted but had not turned brown. The U-3 and common bermuda plots were irrigated by mistake after 36 days. Since beginning the experiment in June, the bermuda plots received only one irrigation up to the date of this meeting October 7). These data indicate that, where grasses are deep rooted, they can go for long periods between irrigations even in the hot, dry interior valleys.

Some of you will say, "1 can't do this with my turf."

I'll agree you can't if your roots are shallow because of shallow soil or management practices which have restricted root development. Shallow irrigation, very often the cause of shallow roots, results from application of too little water or from failure of the water applied to soak into oil. Slow water penetration is a major problem with many soils. On these soils which take water slowly, deep irrigations without excessive runoff are difficult with much of the sprinkler equipment now in use. With such soils, more frequent irrigation may be necessary until measures can be taken to improve water penetration and minimize runoff. The more often a soil is irrigated, the greater the opportunity for compaction of the surface soil which further retards water penetration. Thus a vicious cycle is established.

> ***"The curse of irrigated agriculture is often too much water. In turf, the curse is somtimes too much water, but more often it is too little water, applied too often."***

Consider, for example, a grass which has an effective rooting depth of 24 inches on a loam soil. Within this depth of soil the previous irrigation should have stored about three inches of available water. If the water-use rate is one inch per week and, to be conservative, one plans to use only two inches of this water, then this turf should go at least two weeks between irrigations. We could supply the water needed by one two-inch irrigation every two weeks. But if we apply only one-third inch of water or because of slow water penetration only one-third inch penetrates, then we would have to irrigate three times per week or a total of six irrigations instead of one. The more frequent irrigations add to labor costs, waste water, magnify disease and weed problems and increase the opportunity for soil compaction. No good pasture operator would allow stock on his pasture for at least three days after irrigation to avoid trampling damage. We can't keep human livestock off the grass, but we can decrease the opportunity for compaction in this example by adding two inches of water to the soil in one irrigation instead of in six light sprinklings.

This illustration should present us with a challenge to see what we can do to reduce irrigation frequency. To do this we must (1) use sprinkler equipment which will not apply water at an excessive rate, (2) cultivate turf areas where needed to improve rate of water penetration and (3) develop schedules and practices which permit sprinklers to remain in one place long enough to apply an adequate depth of water.

There has been a lot of talk ahout using too much water. You will note I have not said that we are necessarily using too much water, but in many cases we are watering far more often than would be required if full advantage were taken of the deep-rooting capabilities of the grasses. Generally, one cannot make a sudden change in irrigation frequency. If your grass is shallow rooted as a result of either dry or water-logged subsoils, gradually encourage deeper rooting by improving subsoil moisture conditions.

A good turf irrigator should know (1) the rooting depth of his grasses, what depth is being dried out between irrigations, and (2) how long sprinklers should be run to replace the soil moisture. Only if you have answers to these questions, can turf irrigation be put on a sound basis. Turf should be irrigated on the basis of soil characteristics and the need of the grass for water. Special turf uses may at times force us away from sound irrigation principles, but we should return to good irrigation practices whenever possible. Some type of soil sampling tool is a must for the good irrigator.

I haven't given you all the answers on how to water turf. We don't know all the answers. We hope our research program will help supply them. I believe we can now say with assurance that there are two simple rules to follow for good turf irrigation:

(1) Water deeply

(2) Water infrequently

The curse of irrigated agriculture is often too much water. In turf, the curse is sometimes too much water, but more often it is too little water, applied too often.

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Watering in the 50s –

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1968

Lessons Learned in Automatic Irrigation

By John H. Madison
Dept. of Environmental Horticulture
University of California at Davis

Irrigation costs in much of the nation are second only to labor. If we can increase our capitalization with the expectation of present and future savings of labor and water costs, the long-term savings may be worthwhile. Automatic irrigation systems are increasing in number, and the justification is long term economy. An automatic irrigation system has real value for the superintendent to the extent that it is a management tool. Without high management capability it may create its own costly problems. Automatic systems have not always resulted in the savings projected to justify them, and their management capability is the remaining good that can make the system worthwhile or - by its lack - a burden.

We can all recognize the good of economical operation. But automatic irrigation has come to us without our being prepared. We have not known what to ask of it in the way of management capability. We are still experimenting and improving, still discovering new things we want our system to do. We need to develop our criteria for high management capability as soon as possible. The longer we take, the more systems will be installed that are inadequate and soon become obsolete. Here I propose six criteria I should want to use in buying a system.

1) The irrigation design should be adequate. In the Northeast where a sprinkler system is used to supplement a generally adequate rainfall, second- and third-class design is used, and is tolerable. In the irrigated West where one depends fully upon irrigation, only first-class design should be used in an automatic system. The most sophisticated controller is only as good as the system it controls, and the controller cannot make up for deficiencies in the system. In the West, not only is the single fairway line wholly inadequate but also first-class agricultural sprinkle: design is inadequate on turf. With the compaction and traffic it receives, turf has lower infiltration rates than agricultural soils. Application rates are apt to be too high, and the higher they are the more inefficient the operation, the more water is wasted. Also, agricultural crops send out roots through a large volume of soil holding hundreds to thousands of gallons of water. The large root system compensates in part for inadequacies of application. More water is taken from the wet areas, less from the dry. The turfgrass plant, on the other hand, may explore only a few cubic inches of soil and have only a part of a cubic inch of water available after an irrigation. The only water available is that which enters the soil immediately beneath the plant. There is no adjustment possible between an area that receives too little and one a couple of feet away that receives too much. Inadequacies of sprinkler irrigation are illustrated by a bowling green irrigation system worked out by Tom Byrne, Farm Advisor in Alameda County, Calif. After much effort to develop the best system possible, 5 per cent of the green was underwatered and 45 per cent received more than twice the needed water. This illustrates the inadequacies and inefficiencies of even the best sprinkler design.

> *"Irrigation costs in much of the nation are second only to labor. If we can increase our capitalization with the expectation of present and future savings of labor and water costs, the long term savings may be worthwhile."*

2) The minimum programmed time should be about two weeks.

There are two reasons to want this: (a) In the spring, water applied more often than needed greatly increases weed germination and establishment.

(b) Deep rooted fairway grasses such as bermudagrass will conserve water - will use it more economically only if forced to byusing long intervals between irrigations. Water is held with increasing tension by the soil as it dries, and bermudagrass can respond with physiological adaptations which enable it to survive and grow with less water. For these reasons we want at least a 14-day program time.

3) Different stations within the controller must be able to have different automatic programs.

Shrubs have different requirements from turf. Bermudagrass requirements differ from those of bluegrass; those of shade turf from grass in the sun; those of fairways differ from those of the rough. Unless you can irrigate the grass in the shade, for example, every six days, while that in the sun is irrigated every three, you end up irrigating everything according to the needs of the most demanding area of shallow-rooted turf. You should not have to manipulate the controls by hand every few days to get this difference in program.

4) A single station within the controller should be capable of being programmed differently (and independently) on different days. Turf has more roots near the surface, fewer at deeper depths. When the surface layer has dried, soil of the lower root zones may still contain adequate water. However, there are not enough deep roots to take up water fast enough to meet peak needs. Consequently, afternoon wilt develops. A tensiometer-controlled irrigation program at UCLA has given results indicating how we may most economically apply water to use the whole root zone and still avoid mid-day wilt. Their records indicate that the most economical program is one that applies about two shallow irrigations before applying a deep leaching irrigation. The controller should be able to handle this program without need to reset it.

5) There should be a ratio control so that all stations within a control box can be changed with a single setting and so that each station puts on water in the same proportion to the others as it did before. The reason for this is the wish to meet the change in demand with change of the seasons.

A box should be reprogrammed about 10 times a year for optimum water economy. If each station were to be reprogrammed individually, some systems I have seen would require 10-20 days per year of skilled management time. This discounts much of the labor saving advantages.

Also, suppose you have one station set so that it controls sprinklers in the north shade and another controls heads on a sunny south slope. By trial and error you have adjusted them so that the first puts on about 35 per cent of the second, and both meet the demands of the areas they control. It is unlikely that you could reset these several times a year and still maintain this difference. As a result you would like to be able to set one control and change every station within the box by a proportionate amount.

6) The controller should be able to apply any single irrigation as a series of repeated short irrigations.

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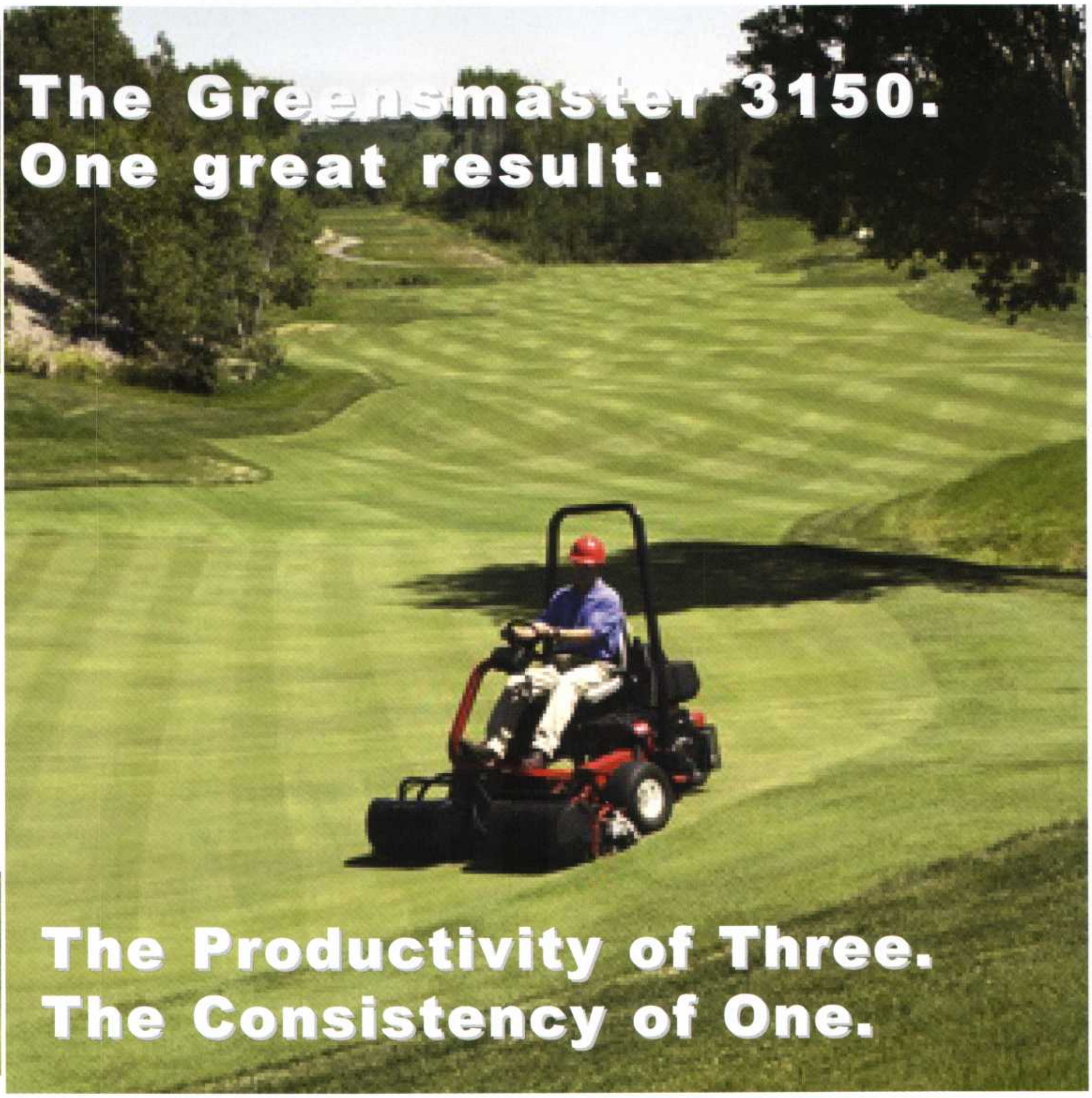

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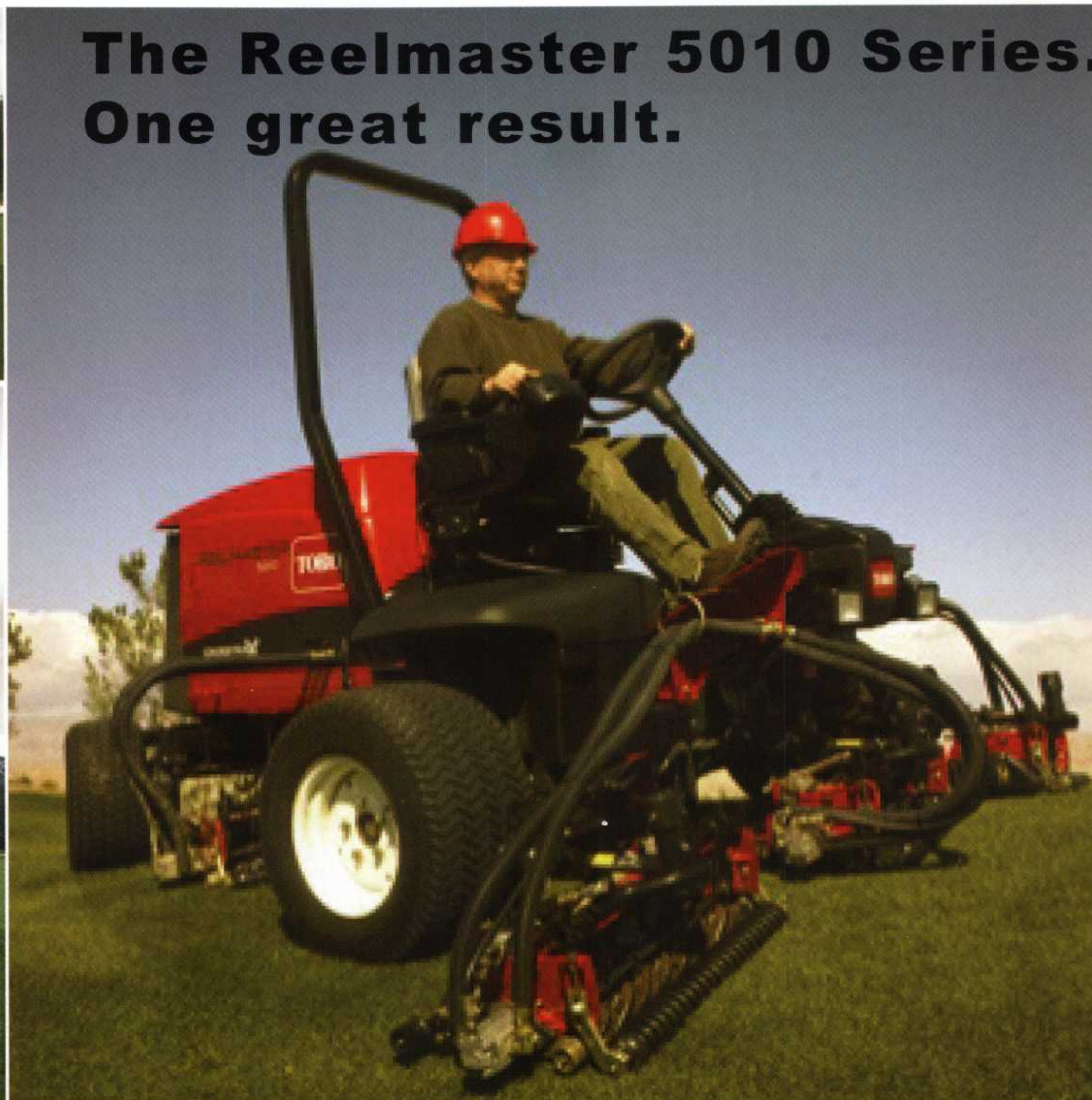

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TORO. Count on it.

Watering in the 60s–

(Continued from Page 15)

One difficulty of sprinkler irrigation is that efficiency of application is obtained only at high application rates - rates that are too high. At these rates efficiency of infiltration, of use, is low. Too much water runs off and high spots are left dry. One of the great potentials of automatic irrigation is the possibility of solving this dilemma. By using a high degree of overlap we can increase our efficiency of application but at application rates that are too high. However, the turf mat is able to hold a fraction of an inch of water.

By applying water at a high rate for a short time the water is held in the sponge of the mat until it infiltrates the soil. The application is repeated again and again at spaced intervals until the full application is given. The system operates at a high capacity throughout the interval it is on, but at a single spot, the mean application rate averages out to a suitably low value.

At present all controllers have some of the features I have asked for - none has all. The manufacturer will design a controller with what he considers to be sales features unless you can tell him what you need - what you demand. Automatic irrigation is still young, and controllers will continue to undergo a slow evolution. You can hasten that evolution with a clear statement of your needs and wants.

An example of good use of existing equipment to provide flexible management is provided by the new system at the San Francisco Golf Club, engineered by Don Hogan. Each station of the controller controls heads of similar elevation and exposure.

Each station is set for a short irrigation period (a few minutes) and the times are adjusted (by trial and error) to compensate for differences due to sun, shade, slope, elevation, etc., so each receives a proportion of water appropriate to the area. The entire controller is itself controlled by one station of another controller in the superintendent's office. This two echelon system permits the superintendent easily and quickly to change his program to exercise management flexibility.

A long irrigation is given by allowing a large number of cycles to repeat, a short one by repeating only a few cycles. With the water applied in short cycles, the effective rate of application is reduced, which helps to increase wetting of dry areas and to reduce runoff.

Having a suitable automatic system is not enough. Poor use of it can lead to problems. With poor operation one often sees a tremendous increase in crabgrass and other weeds during the second season of operation.

A new system is not automatic in its programming; the program must be set up by trial and error. The best tool for programming is a soil tube. You must know where the water is going, and nothing beats the soil probe for examining a large number of locations in a short time. Wet and dry soil are easily distinguished, so that you can determine how deep your water is going and whether you are wetting the entire root zone or only part of it.

Once the system is programmed it still requires management to achieve goals of water economy.

The advertised "set it and forget it" exemplifies the abdication of management. The following offers some guidelines for management use of an automatic system after you have it.

7) Patrol the system regularly. Operating at night the system is out of sight and often out of mind. Damaged heads, malfunctions, or vandalism may go unnoticed until they show up as dry turf. In a schoolyard a missing head went unreplaced for over a year. A geyser every night caused a permanent wet spot, and the loss of pressure created doughnuts around other heads. But the system was run by a custodian who was uninterested and who responded to the brown turf by increasing the irrigation time. Diddling the controller will not replace a missing head. Patrol for missing or damaged heads, heads not turning, heads cocked at an angle, heads set too low so that they operate under water, or heads blocked by overgrown grass.

Check nozzles periodically. An inexpensive set of drills provides a good set of plug gauges for checking nozzle sizes. At longer intervals check pressures at the nozzle with a Pitot gauge. Low pressures may indicate hidden leaks, worn nozzles, corrosion, or dirt blockages. 2. Start slowly in the spring. Irrigate as infrequently as you can, but when you irrigate, apply enough to wet through the root zone. This will assist greatly in keeping down crabgrass and other weeds. The cracks that develop as the soil becomes dry will help get the water in with reduced runoff. 3. For economical water use, change the program according to the season. Use will depend on the solar energy input. This is affected primarily by the angle of the sun's rays, length of days, and degree of cloudiness.Weekly difference in turf water use tends to be small near the solstices, large near the equinoxes. Economical water use in the irrigated West will require about 10 changes of program a year, each involving at least a 10 percent change in water use. In any location, East or West, close control of water applica tion can be achieved by adjusting water application to parallel loss from a Bureau of Plant Industry evaporation pan. This is a pan 6 feet in diameter, 2 feet in depth, set flush with the ground and having the water surface about 4inches below soil level.

4. Avoid daily wetting. Daily sprinklingleads to heavy invasion of crabgrass, Poa annua, dallisgrass, and other weeds. Daily sprinkling keeps the soil at moisture levels where it is most subject to compaction from traffic. Compaction is our biggest turf problem. Daily sprinkling keeps the soil at its lowest infiltration rate so that waste from runoff is maximum. Daily sprinkling stops the cycle of wetting and drying, shrinking and swelling which restores soil texture and aids soil aeration. Daily sprinkling favors disease, buildup of lawn moths and promotes a soft growth readily injured by stress.

5. Know when to make an exception to Number 4. Sometimes in the middle of summer two or three days of over-irrigation will stimulate the grass, help wet up dry spots, leach salts and improve appearance. Again in late August a few days of heavy irrigation may help relieve summer stressed areas so that they begin to recover. Also, when summer disease has injured roots, a daily sprinkle may keep grass alive until new roots form.

6. Decrease irrigation by increasing intervals. When cutting down on water use after the summer peak, decreasing irrigation frequency is preferable to giving shorter irrigations. More frequent irrigation favors weeds and abuses the soil as discussed above. In addition, remember: a little water does not wet the soil a little bit - a little water wets a little soil and leaves the rest dry.

Several years ago I presented some irrigation design formulas based on plant soil relationships. These are very useful for checking out a system and finding weak points in it. Their usefulness is limited by the fact that often we do not have figures for evapotranspiration and infiltration rates to insert into the formula.

However, if we are concerned with the worst month in the worst year in a series of dry years, we can use an ET figure of 2 inches per week and an infiltration rate guessed at 0.1 inch per hour. For a low ET and a high infiltration rate we can use 1 inch per week and 0.5 inch per hour as

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exploratory values. Even though inaccurate, these values used in the formulas will often point out system weaknesses and indicate the kind of compromises that will need to be made.

1981

Effective Use of Our Natural Resources

by MELVIN B. LUCAS, JR., CGCS
President, GCSAA
Piping Rock Club, Long Island

WHEN YOU ARE about to waste anything, stop for a moment and consider the energy needed to produce it. It has been said that half the world could exist on what the other half wastes. No commodity illustrates this statement more than the most taken for granted commodity on earth - water. It is the most wasted, overused, and the most precious natural resource in many areas of the world.

While I was attending Penn State University, in 1961, Dr. Fred Grau cited the importance of water as described in the 1955 Yearbook of Agriculture, and he emphasized its usefulness in fine turf culture. His address had a great impact on many of us at that turf conference.

Since then many others have described the role that water plays in proper management of turf for golf. For example, in some of the proceedings of golf turf conferences held over the past few years, Dr. James Watson has addressed the critical water problems we must face. Within the last few years many have come to agree with the water use ethic of Sandy Tatum, past president of the USGA, and with the arguments presented in numerous articles by Joe Dey that have appeared in Golf Digest on the overuse and waste of our most precious commodity.

During the recent drought in the Northeast, articles concerning the water shortage have appeared daily within the first three pages of the *New York Times.* Restaurants have stopped providing water at tables unless requested, and motels have requested that people conserve water during showers, etc. How we respond to these conservation measures will determine whether or not we experience the crisis of a water shortage.

It is interesting to note the remarks of the people who visit clubs of the stature of the National Golf Links of America, Shinnecock Hills, Maidstone, Winged Foot, Baltusrol, Pine Valley, Saucon Valley, and other courses that play so well. They comment on the firm, fast greens and the tight fairways that allow the clubface to come in direct contact with the ball. The golf course superintendents at these clubs all describe the same type of management philosophy: "Try to keep it as dry and close cut as possible."

Several years ago the Monterey Peninsula and Marin County, in California, were brought to their knees for lack of water, and in the Midwest many golf courses experienced water use restrictions. This year some of the courses in New Jersey were prohibited from using water on any turf areas.

How can we cope with this dilemma?

Grants from various turf organizations, such as the GCSAA, USGA, state and regional turf foundations and chapters of the GCSAA, provide money to develop permanent grasses for drought tolerance. Through continued research, many improved turfgrass cultivars will be developed. Through research and practical experience, several valuable lessons have been learned. Avoid overstimulating turfgrasses with nitrogen early in the spring, for they will grow when they are ready. Second, irrigation should be used only to keep the grass alive and to sustain adequate growth.

Following is the description of an experience I had involving irrigation and turf management. When I arrived at Garden City Golf Club 15 years ago, I was confronted with maintenance problems created by the overuse of water. Bunker facings near several greens eroded after every irrigation and were eventually refaced with grass. The utmost in discomfort to any golf course superint.endent comes with the realization that the course is predominantly Poa annua. Annual bluegrass requires more water than permanent grasses, and the more you water it, the more it requires. This results in a never-ending management problem. I felt that 85 percent of the Garden City Golf Club turf was annual bluegrass, but as a result of a pumphouse failure on July 4, 1966, my estimate proved to be on the low side. On Long Island we are compelled to submit a meter reading each month to the Water Resources Commission. When I arrived at Garden City I called the Water commission for pas reports. The water use total for 1965 had been slightly over 55 million gallons. Reports from prior years showed that water use had increased each year after 1958, when a new irrigation system had been installed. By 1978, the number of gallons used for irrigation had been cut to 12 million, and even then I felt I was overwatering.

The ability of the superintendent to coordinate golfers' demands with agronomic needs will determine the success or failure of the golf course management program. In my experience as golf course superintendent, I have observed that golfer requests and complaints significantly influence the management of golf courses and the priorities of their superintendents. Some of the members' advice and comments have included: "The greens don't hold, so give them a good soaking." "Annual bluegrass is indigenous to this part of the country and no one will ever get rid of it. let's not waste our money on Poa controls." "We have our own well and the water is free and unlimited, so why not use it? Doesn't more water mean greener grass?"

"We want everything green and lush to impress our guests." "We were out this morning and we saw an area burned out on No.7 fairway (you know, that high knoll in the drive zone), so why isn't the course being watered more? It's dying!" "We saw the golf tournament on TV ... what happened to our course? It just doesn't compare." "Why do they (grounds crew) have to renovate during prime playing time in late August or early September? If they had better control of operations during the year, this wouldn't be nece ssary."

However, to put all this in proper perspective, we must presume that if we overwater, the soil will often be filled to capacity and turfgrass root growth will be reduced. This will ultimately lead to soil breakdown, compaction and annual bluegrass and weed invasion. Experiences around this country and Europe have shown me that annual bluegrass is indigenous to the fine turfgrass world, growing profusely on all continents. So why don't we just seed new courses to Poa annua rather than bentgrass? To do nothing about it means only disaster during hot spells of summer, not to mention the winter problems and inclement springs when Poa annua is the most severely injured species. Yes, for many clubs water is free, but in 1977 I calculated our electricity cost to be \$.0003 per gallon. That may seem reasonable until we consider that over 12,000,000 gallons were used. This cost

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more than $3,600. Since 1977, the cost of electricity has tripled. With overwatering, we will of course need extra fertilizer, more chemicals to control disease and, naturally, more frequent mowing. Does the result of this vanity outweigh the added expense? Because ofthe attention given to the high dry spots on fairways, the fate of the entire course is in jeopardy. The amateur agronomist sees golf courses on television at their peak a few Sundays each year through the wonderful world of color. If equal attention is paid to the player and the quality of turf for that tournament, there is no question that our course doesn't stand up to that comparison. However, it sometimes is too bad that television doesn't come back weeks later to show the same course as it is prepared for regular membership play.During the season we have all seen approaches to greens that are wet, soft and soggy with little grass and many weeds. The greens are so wet that algae have turned them black, and disease, carried by surface water, has eradicated grass faster than a nonselective herbicide. When excess water has finally drowned all the turf, then out comes all machinery (the aerifiers, thatchers, slicers, spikers and, yes, even rototillers) to try to bring the golf course back. Requiring all this extra work of an already small crew, much of the normal everyday work is let go, making the course look even worse.

"A rule of thumb used by many is to try to put back the same amount of water that was taken out the day before."

The expense of all this unnecessary renovation, at an inconvenient time, certainly points out the folly of overwatering the course. There is an old adage which states that it is easy to put water on but it is almost impossible to take it away.

A rule of thumb used by many is to try to put back the same amount of water that was taken out the day before. Many superintendents play "Russian roulette" with nature during the summer. Water is not applied until the last hope of rain has faded for that night. Then the ultimate of management weapons, the automatic irrigation system, allows the superintendent to take every day as it comes. A cloudy, overcast day results in little or no water loss. A hot, humid day results in little water loss. Rain forestalls watering that day and possibly the next. Hot, dry days and those with cool or hot breezes tend to trigger the use of the water system at times of the day that raise the ire of the golfers. This is called syringing. What this does is to slow the evaporation-transpiration rate and thereby stop the plant from wilting. Some superintendents have found that a dew syringe cycle used every morning for five minutes on each fairway head tends to keep the fairway turf in good shape for the day. This also applies to greens and tees, but the time must be increased slightly. The critical concern is that turf managers should not go into August with an overly wet soil.

Augusts in the New York metropolitan area are generally hot and humid and just bloody uncomfortable for man and, yes, grass. So, to give the turf half a chance, all our season's watering efforts should be geared for the dreaded months of July and August. With the improper management and wasteful consumption of water by so many people, it is no surprise that there is a severe water shortage in many areas of our nation. We all must share the burden of conservation; if we do not, we will have

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