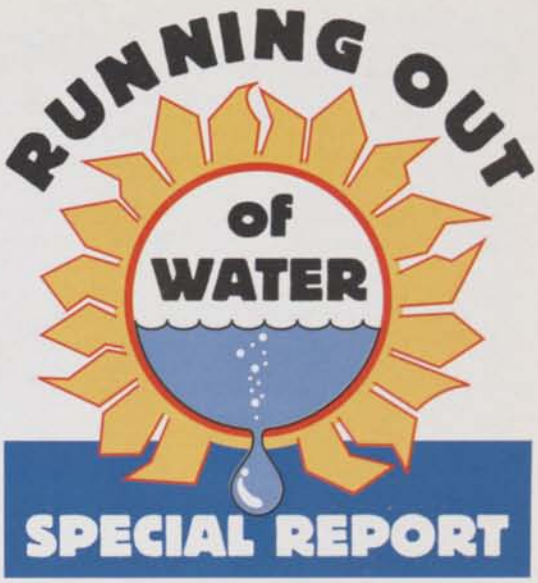
AS WE ENTER THE THIRD DROUGHT SUMMER it is beginning to dawn on us that water is no longer the inexhaustable resource it once was and the phrase "spending money like water" is no longer relevant.

To examine the implications of the prolonged, perhaps indefinite, water shortage *Greenkeeper International* asked four experts from the irrigation field to take a look at the situation and explore possible solutions.

Giles Wardle, who has written for the magazine before and who is an independent irrigation consultant; Roger Davey of Ocmis Irrigation (UK) Ltd; Graeme Francis, of Toro Irrigation Ltd, and Richard Pocock, of Watermation Sprinklers and Controls Ltd have each produced an excellent examination of the situation.



The **efficient use** of water

Why and how we should conserve a finite and valuable resource. By Giles Wardle BSc. MSc, MIAgrE.

We have, apparently, just experienced the driest 20 month period since records began. As the demand for water increases and its supply seemingly diminishes, competition for this essential resource will become more heated.

The consumption of water for irrigation by agriculture, horticulture, amenity and sports turf combined, comprises less than 2% of total water consumption. The use of water for irrigation pales into insignificance when compared to domestic and industrial use. So why does irrigation get disproportionate attention and criticism in the media?

The reason is that while the annual proportion of water used for irrigation is small, the consumption of that water is concentrated in the summer months, when supply is at its lowest.

Long term weather forecasting is fraught with difficulties. There is, however, a generally accepted view by meteorologists that the climatic trend in the British isles is that of increased temperatures, hotter and drier summers, more frequent droughts but not necessarily less average annual rainfall. The trend, we are told, is towards wetter winters and longer and drier summers.

Irrigation therefore is set to feature still more prominently in the water debate. Irrigators do not have a very good public image. This, whether it is deserved or not, needs to be improved if irrigators are to be listened to in the debate. This can be done by showing that irrigators are using this valuable resource in a responsible and efficient manner?

1. Winter Storage of Surface Water

On the face of it a simple solution. The Environment Agency is encouraging the construction of reservoirs for storage of winter water and look upon this favourably when awarding licences. The messages is when water is plentiful "grab it while you can". Once you have stored this water it is yours to use, as and when you please. Farmers see the advantages in this, as it avoids having their licenses revoked in the middle of irrigating their potatoes. There has thus been a boom in the reservoir construction industry... in agriculture.

But this has not necessarily been the case for the golf sector. Farmers generally have a large area of land to find a suitable site. Where golf clubs are concerned land is at a premium. So why not incorporate a lake around the golf course? It would not only provide a reliable source of water but would add to the strategic and aesthetic value of the course.

The reason is that non-impounding reservoirs ie. lakes and ponds are less cost effective than impounding reservoirs as there is less volume of water stored per cubic metre of earth excavated and the removed earth has to be disposed of. Further more during the summer months the water level drops exposing the dry banks.

If water storage reservoirs are to be used on a golf courses and combined as a water feature, it is preferable that they are steep sided so that small variations in height of the water do not expose large areas of the banks. This can be achieved for example by using railway sleepers as the siding of the embankment, or using stone to face the banks. Careful thought must also be given to the siting and design of the reservoir with consideration given to cost, engineering implications, safety, aesthetic and strategic value to the course and disposal of the excavated material.

If there is a suitable site then the construction of an impounding reservoir is more cost effective as the cut and fill can be balanced to avoid having to import or dispose of earth.

Reservoirs/irrigation lakes can also add to the environmental value of the golf course and serve as a valuable wildlife habitat, if the design and construction is undertaken with sensitivity to conservation issues. Irrigation lakes should also, where feasible, be incorporated into the drainage system of the golf course.

2. Irrigation Scheduling

The best irrigation scheduler is the greenkeeper/irrigation technician. There are many tools at his disposal in order to perform the task accurately.

■ Weather stations: Visit a golf course in Florida or California and you will invariably find the golf course has its own weather station with software to calculate the evapotranspiration rate and a link to the irrigation controller.

Yes they are expensive but in climates where the irrigation season is nearly all year round and all the fairways are watered, a 5% saving in water consumption results in huge savings in water and energy costs. More than enough to justify purchasing the weather station on financial grounds let alone environmental ones. This is not really the case in Britain, where irrigation is often confined to merely greens, tees and approaches. However on courses with full fairway irrigation the installation of a weather station is certainly justifiable. (see Learning Experience article elsewhere in this issue)

There are alternative, cost effective ways of irrigation scheduling.

■ Balance Sheet Method: This can be done manually, using a computer spreadsheet or purpose written software. This method when properly carried out can give very accurate results. Crop (grass), meteoriogical, rainfall and irrigation data are used to calculate rates of evapotranspiration and soil moisture defects.

This method, however is only as accurate as the data fed in (soil type, rainfall, irrigation etc). The method is really no different to using the weather station above, but the meteorological data is input from the local met station ➡

'Water everywhere but not a drop to spare'

This may be the case in the not too distant future, as the pressure increases on the water companies, those golf courses with "mains" water feed irrigation system may need to ensure that every drop is accountable. Those, however, with existing abstraction licences and storage reservoirs will do no harm by ensuring that each application of water to each green, tee, approach and fairway is exacting and precise.

The Environment Agency is, and will as time progresses ensure as far as is practically possible, that water abstraction from natural ground water reservoirs is used to its utmost effectiveness by limiting amounts/periods of abstraction and implementing time limits/review periods on abstraction licences.

Savings in water (be the water from a borehole, winter storage reservoir or mains supply) will increase the long term cost efficiency of the golf course, by reducing leaks or over irrigation it is possible to reduce pumping costs and water charges. With mains water costing approximately 70-80p per cubic metre and an average golf course using approximately 100 cubic metre per night at peak irrigation period every cubic metre of water saved is a financial saving.

To this end, today's modern irrigation equipment is armed to the teeth regarding conservation and efficiency, pinpointing exact areas of irrigation.

All existing irrigation systems waste water to some extent, whether through old and leaking pipes, inefficient and ineffective sprinkler heads, too high application rates or unmanageable control systems. All these areas can be improved by today's modern equipment and design capabilities, for example:

Old UPVC – (glue jointed) underground mains can be replaced with 100 metre coils of Medium or High Density Polyethylene jointed at intervals by compression fittings or electrofusion welding.

Sprinkler heads such as the Rainbird Eagle 700/900 series have built in solenoid valves (valve in head) so enabling each sprinkler to be switched on for a separate run time and separate application rates, particularly useful on large areas such as fairways where soil types and ground contours change and blanket coverage would produce one area of "run off" while the other receives the correct amount of precipitation. These sprinklers are also fitted with automatic pressure regulating valves, therefore every head delivers even flow and uniform coverage no matter how far away or close they are to the pumping set.

Today's control systems feature hydraulic and electrical optimisation, on course hole graphic pictures and have the ability to cycle and soak – (apply 8 x 1 minute applications in a 3/4 hour period instead of 1 x 8 minute applications which produces run off and water wastage). These systems such as the Rainbird Nimbus are now PC based and can control up to 1000 individual stations.

The irrigation designer has also a very large part to play and we, Ocmis, do not underplay our role. Every aspect of water conservation is looked into, specifying a fairway or greens irrigation system is no longer a case of blanket flows and blanket coverage. State of the art design systems can simulate water flows and areas of coverage, these can be linked to the irrigation control programmes ensuring a design with conservation of both water and finances. Each project is individually specified, to save water may require an initial investment but this will reap rewards in the future years. Remember more maybe less.

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rather than recorded on site. There are companies (eg ADAS, Levington) that offer an irrigation scheduling service using this method.

Incidentally, if you don't have one; get a rain gauge!

■ Plant stress indicators: There are methods (infra-red thermometry, displacement transducers, chlorophyll fluorescence, porometers) that identify the first signs of drought stress in the plant. These methods, while in use for research purposes, are not widely used in the irrigation industry as they do not indicate the amounts of water required.

■ Other Methods: Electrical resistance measurers, neutron probes, tensiometers, time domain reflectometry etc. are of limited use in golf because they are not suitable for taking measurements on sports turf. The probes must be permanently placed in the soil profile, thus being destroyed during maintenance operations such as verti-draining, otherwise they have to be placed too deep in the profile to be of interest. With the neutron probe, method holes are dug and lined as observation pits, furthermore a licence is required to store the radio-active source.

3. Irrigation Programming

Determining how much water is required is only one half of the story. Programming the irrigation to apply the requisite amount of water is just as important.

Irrigation programming is the easiest part of irrigation scheduling, yet rarely is it done properly. When an irrigation operator is asked how much water he is applying the answer is often in minutes per day this could mean anything between five to 25 millimetres of water per week, depending on the design and type of the irrigation system.

Irrigation should be programed on the basis of depth of water applied. However, most irrigation controllers are programmed in minutes rather than inches or millimetres. One must therefore calculate the run time in minutes for a given depth of water.

To calculate this, one needs to know the desired depth of water to apply and the precipitation rate of the sprinklers (a factor of sprinkler flow, spacing and degree of arc in the case of part circle sprinklers).

Upgrading your controller to a PC based unit, will remove the repetitive task of calculating sprinkler run-times and will allow you to program watering on the basis of depth. There are many PC control systems on the market now, of varying costs and specifications. Most PC control systems can be retrofitted to your existing control system.

Alternatively draw up a table with the run times for given water applications(say 1,2,3,5,7 and 10mm) for each station on the controller.

How often do you reprogramme your irrigation to take into account changing conditions? Do you program the irrigation according to the conditions of each individual station or do you program according to station type ie. tee station, green station etc? Do you have a flow meter? If so do you check that the actual water consumption matches that calculated by the irrigation controller?

4. Irrigation System Design

The design of your irrigation system is probably the most important factor in enabling you to operate your system effectively and efficiently. Good design is fundamental to the long term success of an irrigation system.

The two keys design factors affecting water use efficiency are:

a) Uniformity of water distribution by the sprinklers. This is a factor of sprinkler model and nozzle, sprinkler spacing, sprinkler configuration (triangular, square, single-row etc), operating pressure and wind speed.

The most commonly used measurement of distribution uniformity is known as Christiansen's Coefficient of 'Uniformity (CU). A CU of 80% is acceptable but ideally a figure in excess of 90% should be attained.

b) The level of control of the sprinklers. The ability to differentiate the sprinkler run times for certain areas to match their individual conditions is paramount. Avoid systems with too many sprinklers grouped to one control station and systems with two solenoid valves attached to one controller station.

5. Irrigation Operation, Service & Maintenance

Not all golf courses have well designed irrigation systems, whether through lack of funds, poor design or that the system has been extended and modified over a number of years. If you do not have the funds available to replace or upgrade your existing irrigation system, what can you do to improve its water use efficiency?

Poor uniformity is manifested by dry or wet spots. The dry/wet spot maybe due to a variation in soil type or topography. However a dry spot in the middle of a green or tee is almost certainly a problem of poor sprinkler uniformity. Firstly you should check that the sprinklers are running at their design operating pressure. Do you have the correct sprinkler nozzle and operating pressure for the spacing? Is the sprinkler appropriate for this application? Are the sprinklers poorly positioned? Is the area particularly susceptible to wind?

If you do have dry spots, they should be watered manually using a hose rather than the sprinklers. Alternatively get an irrigation engineer to check your system to see if the problem an be remedied.

'Methods such as reverse osmosis and desalination have been successfully used to provide irrigation quality water from the sea'

Sometimes the conditions may be such that you do not want "uniform" watering eg a green that has a low lying and wet corner. If you have a valve-in-head system, or a block-system with say only two sprinklers per station then you con accommodate differences in conditions (soil, topography, shade, etc) in the irrigation programming.

However, if you have a block system with many sprinklers per station you cannot differentiate the run times. A simple solution to this problem is to change the sprinkler nozzle to match the conditions surrounding it.

There are valve-in-head systems with up to three heads grouped together on one control station. This is poor design and I would urge anyone that is offered such a system to reject if. For those of you that already have such a system, the best way to occommodate differences in watering requirements, within a control station, is to run the individual sprinklers manually with the valve key. This obviously time consuming and if is done during the day disrupts play.

Do you have a rain sensor to stop the controller in the event of rain? These items are very inexpensive and very effective, with the exception of one I once saw that had been used by birds as a base on which to construct a nest.

Pipe bursts and leaks are a more obvious waste of water. Once the pipes are in the ground there is little one can do to remedy the situation. The working life of a pipe network is affected by hydraulic design, material choice and installation. Make sure your irrigation system is designed by a qualified engineer with experience in golf.

Good design is worth more than a guarantee as your irrigation system should last much longer than the period of time for which the installer is likely to offer a guarantee.

6. Alternative Sources Of Water

Methods such as reverse osmosis and desalination have been successfully used to provide irrigation quality water from the sea. The situation in the British Isles however does not call for such drastic and expensive measures ...yet.

The use of Treated Sewage Effluent (TOE) is becoming more widespread across the continent as a source of irrigation water, one such example is Mallorca which has a long history of stretched water resources. The feasibility of such measures will depend on various factors. One such factor in Mallorca is that there is simply no water and you will not get planning permission for a new golf course unless you provoke alternative sources of water. Other factors are proximity to source of TOE or treatment plant, amount of TOE available, health and safety, implications for turf management and irrigation system, storage of TOE, reduction of odour and aeration of TOE.

Importance of encouraging water conservation

To quote Benjamin Franklin, "We know the worth of water when the well is dry". Contrary to the perception of the British nation being a country with constant rain; the average lower precipitation rates over recent years, combined with the changes in urban and industrial water requirement, have left us no option but to ask ourselves the following questions; "what is water conservation?","why do we need it?", and "what do we intend to do about it?"

"Conservation" is defined as the preservation of the natural environment, and in this case water, secondly, we leave this earth to our children, so let's leave it in a better state than when we arrived, and thirdly to do something about it we need to adopt some common sense strategies:

- We need more public education and awareness programs aimed at educating the end user in efficient water use;
- We should investigate price structures on water usage that buy "water usage" saving by providing a financial incentive for using water more efficiently, or by encouraging the use of alternative water sources such as reclaimed water;
- We need to improve efficiency within the water system itself, such as ongoing maintenance of irrigation systems, and optimisation of existing systems by conducting irrigation system audits;
- we need to improve system design by getting "back-to-basics" and designing more efficient systems, without going to great expense, and to getting the optimal operating costs in line with irrigation system efficiency.

In line with the above facts, as a responsible public we must get our irrigation moral codes right if we have any obligation toward our future. The irrigation designer or contractor is not the consumer who pays the water bills. Life-cycle costing is not factored into the decision making process. Instead the irrigation system with the lowest initial cost is often favoured. This quite often leads to disaster, as apples were not compared with apples. The first time I went to the USA I become aware of why the Apple Computer Company called its upmarket PC "Macintosh". This had always been a mystery because to me a Macintosh was a raincoat but in discussions about apples , when I issued the wisdom that Australians probably ate more green apples than red, I learned that for Americans green apples where not for eating, only cooking. Red apples were for eating and why there was really only one red apple – the Mackintosh.

That observation taught me a very important lesson and that is that when you start making decisions about anything you really need to know everything there is to know about what you are deciding about.

Your natural expectation is that irrigation designers keep their information up to date as possible. Certainly some do, but sadly some don't and equally certainly some "designers" are not truly designers at all, but are merely product salesmen masquerading as designers. The true designer will have a very broad spread of knowledge in a given area, and as will, will have a depth of technical knowledge which takes him past the problems which he immediately has to deal with. He will also know what he does not know but know to whom to talk if he does not know.

Over the years greenkeepers have accumulated a lot of wisdom about what they use and will have options about certain equipment which either they swear by or swear at.

If you swear at it why did you buy it in the first place? Did you compare apples with apples or did you compare a lemon with an apple.

We must ask, "What do we want from our irrigation system?"

Basically we are trying to emulate useful rainfall, trying to make a turfgrass are playable and visually enticing.

There is no "secret formula". It is obvious that lower pressures and precipitation rates to match soil infiltration rates will mean energy saving and water conservation. The initial cost savings will be augmented by such long term benefits as extended system life, and lower ongoing maintenance costs.

You might ask yourself if there is, or, if there should be any commonality between golf courses and agriculture. I happen to believe there is, let's face it, they are both in business to make a profit, and it makes good business sense to invest in good equipment, good people, and any tool that can make the operation more efficient.

Therefore the anatomy of future golf course irrigation systems should contain the principles of low pressure, controlled volume, precipitation rates that match soil requirements and uniform sprinkler distribution.

The future of control has to lie in the direct measurement of soil moisture in the root zone and climatic condition at the irrigation site linked together with lower pressures and precipitation rates to match soil infiltration rates.

The end result of this is that I have endeavoured to bring some very important irrigation considerations forward for the late '90s'.

Apples may be red or green, but they still need to be apples – not lemons.

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