A Step-By-Step Guide For Using Recycled Water

An outline of the costs and maintenance practices necessary to manage this valuable resource.

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Water is fast becoming the new gasoline. Turf has to have it, and at the same time the supply continues to decline and the costs keep going up. As the water crunch becomes more severe in various regions of the United States, there is heightened awareness that conservation and the use of recycled water are necessary and viable alternatives for the irrigation of golf courses and large turf areas.

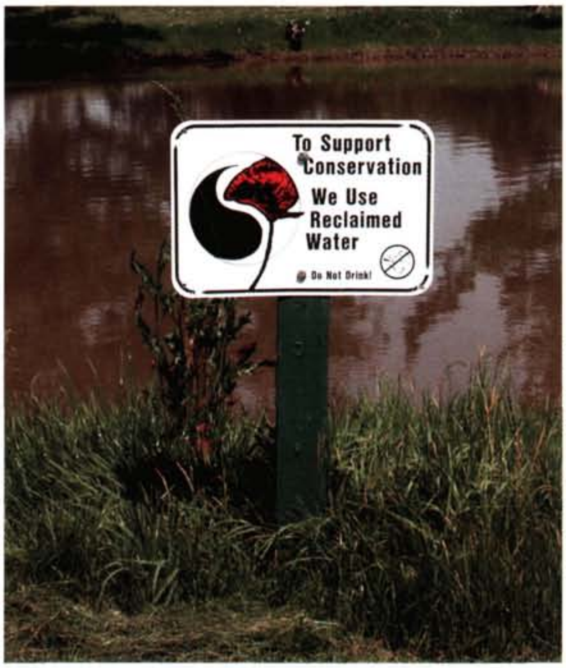
Changing from potable water to recycled water is not an even proposition. Despite the advances in treatment technology, high levels of soluble salts and sodium contained in the water continue to be a major concern when used to irrigate sensitive turfgrass species and landscape plants. Extra maintenance practices must be employed to counteract the negative impacts of salts and sodium, and these practices add time, labor, and expense to the maintenance operation.

Books and articles have been published about how to manage turf irrigated with recycled water, many of which focus on the complex chemical interactions in the soil and water matrix. Once the chemical formulas and mathematical equations start flying, many practitioners throw up their hands. Managers and owners simply want to know the specific practices needed to manage recycled water and how much it will cost. Although the quality of recycled water and necessary management practices vary greatly from region to region, some basic guidelines should be used when irrigating with recycled water. This article offers a step-by-step approach for using recycled water and an estimate of the associated costs based on the experiences of 13 golf courses in the southwestern United States.

SOIL AND WATER TESTING

Routine soil and water testing is a cornerstone of successfully managing the use of recycled water.

Where recycled water is used, vegetative buffer areas around lakes help reduce infestations of algae and aquatic weeds along shorelines.



As the water crunch becomes more severe, there is heightened awareness that conservation and the use of recycled water are necessary and viable alternatives for golf course irrigation.

(Top) Problems with algae and aquatic weed growth can be reduced or eliminated by storing recycled water in a covered reservoir.

(Above) Aquatic weed growth can be prolific in storage reservoirs due to the increased nutrient content of recycled water.

Although laboratory reports may be confusing to some, the information provided by these reports provides a history of soil and water quality and is a valuable tool for implementing preventive maintenance practices and preserving turf quality. The main concerns with recycled water are the increased levels of soluble salts, sodium, bicarbonates, and heavy metals that can have a negative impact on soil structure and directly affect sensitive turfgrass species and landscape plants. The method and frequency of testing is very important. Most recycled water producers will freely share monthly water quality reports with their customers; however, these reports are focused on health quality standards and typically do not provide enough information regarding agricultural suitability. Successful users of recycled water work with an independent soil and water testing laboratory that is familiar with saline and sodic soil conditions as well as golf course requirements. It is important to be aware that various laboratories may use different procedures for analyzing soil and water samples. It is generally recommended that the laboratory follow procedures developed by the United States Salinity Laboratory, including the use of a saturated paste extract for determining EC (electroconductivity) and SAR (sodium adsorption ratio), which is the standard reference used for determining thresholds and management recommendations in the scientific literature (Carrow, Duncan, 1998).

Superintendents who manage recycled water have implemented a variety of strategies for monitoring soil and water quality. Water sampling should be performed at least four times per year, and soil sampling a minimum of two times per year, including representative samples from tees, greens, and fairways. A more accurate approach recommended by Stowell and Gelernter is to arrange for an annual aerial photograph to be taken of the golf course to identify weak areas and evaluate the impact on trees. Once the aerial photograph has been analyzed, at least ten soil samples from fairways should be taken in both good and bad areas to provide a comparison of soil chemical properties (PACE, 1999). Over time, the information provided by these reports can help to identify trends and aid in the development of preventive maintenance programs.

Another useful monitoring technique is to purchase a portable EC meter and moisture sensing equipment that can be used in the field to provide instant feedback on soil salinity and moisture content. Although these instruments are not as accurate as laboratory testing equipment, they provide an acceptable amount of information on which to base management decisions (Vermeulen, 1997).

The superintendents surveyed offered the following information regarding the frequency and annual cost for soil and water testing along with the purchase of monitoring equipment:

- Total cost for monthly water sampling and soil testing two to four times per year — $2,000.
- Portable EC meter — $350.
- Soil moisture probe — $900.
- Three to four hours of labor per week for monitoring from May through November.
- Aerial photograph — $1,200 per year.

WATER TREATMENT

Not all recycled water requires treatment. The need for treatment and the specific method depend on an analysis of the soil and water by an independent laboratory familiar with saline and sodic conditions. A variety of treatment options have been used successfully to improve recycled water, including gypsum injection, sulfuric acid injection, the use of a sulfurous generator, and blending. The cost of treatment, if necessary, varies widely based on the soil and water conditions at each site.

During the early phases of planning for the conversion to recycled water, some courses have successfully negotiated agreements to have the recycled water provider pre-treat the water prior to delivery or arrange the periodic delivery of fresh water for leaching fairways. In some parts of the southwestern United States, water agencies appear to be more willing to treat the water prior to delivery to help meet health and safety standards as well as improve agricultural suitability for their customers. The following is a general estimate of the cost for various on-site water treatment programs:

- Gypsum injection — Equipment costs $7,000 to $15,000; gypsum costs $10,000 to $20,000 per year.
- Sulfuric generator — Equipment costs $12,000 to $16,000; sulfur costs $3,000 to $5,000 or more per year.
- Sulfuric acid injection — Equipment costs $15,000 to $18,000; acid costs $8,000 to $25,000 per year.
- Water blending — Equipment cost is variable; operation costs $10,000 to $50,000 or more per year.
- Wetting agents — $8,000 to $10,000 per year (Gross, 2003).

Proper design, along with the use of fountains, bubblers, and other circulation devices, can minimize algae and aquatic weed growth in lakes where recycled water is stored.

LEACHING TO CONTROL SOLUBLE SALTS

Due to the higher levels of total dissolved salts, sodium, and other constituents, the application of extra water over and above normal irrigation requirements (leaching) typically is required to preserve healthy turf growth. The overall goal is to maintain a net downward movement of water and salts to prevent harmful concentrations in the rootzone (Harivandi, 2007). Although many water agencies sell recycled water for 15% to 20% less than potable water, many superintendents report having to use 10% to 20% more water for leaching programs to control soluble salts — a break-even proposition.

Prerequisites for an effective leaching program include an irrigation system with good distribution uniformity and a regular on-site monitoring program so that leaching can be performed before any visible turfgrass damage occurs (Huck, 2000).

Leaching strategies vary based on site conditions, the demands of the golfing schedule, and the preference/experience of the superintendent. The overall goal is to keep the accumulation of soluble salts below the damage threshold for the specific turf species/variety being grown. This can be done in several ways:

- Periodic leaching with good quality water.
- Including a leaching fraction (extra water) as part of normal irrigation applications.
- Periodic deep watering with the existing recycled water source, using multiple cycles of 15 to 30 minutes with 1 to 2 hours between cycles (Carrow and Duncan, 1998).
- The use of low-precipitation-rate sprinklers for 8 to 12 hours.

Soil salinity must be monitored in the field before and after leaching to determine if salts have been moved effectively beyond the rootzone. The use of a handheld portable EC meter is invaluable in this regard. Some practitioners incorrectly assume that simply doubling the amount of time on the irrigation controllers for a single night will provide effective leaching. Through frequent sampling and monitoring, many superintendents have found that this is not nearly enough water to control soluble salt accumulation and that leaching may need to be performed over two to three consecutive nights.

The costs associated with a successful leaching program will depend on water quality, prevailing site conditions, and the cost of water. The following is a general estimate of the extra water necessary for leaching programs. The added cost will depend on the price of water at each site:

- Greens — In the Southwest, heavy leaching is typically performed monthly from May through November. The amount of water and the associated costs varied among the courses surveyed, but generally it was in the range of 10% to 20% additional water over and above normal irrigation requirements.
- Fairways and tees — Typically, 10% to 20% additional water over and above normal irrigation requirements.

AERATION, DRAINAGE, AND TOPDRESSING

Programs for aeration, drainage improvement, and sand topdressing are of particular importance in the successful management of recycled water. The overall goal is to improve soil properties to enhance water penetration and percolation, allowing for the removal of soluble salts from the rootzone. Aeration frequency needs to be increased, especially in spring and early summer, so that the turf is healthy and able to withstand heat stress and the increasing salt accumulation that typically occurs in late summer and early fall (Huck, 2000). Deep aeration on fairways has become a standard program at sites using recycled water. Although more disruptive and time consuming, this form of aeration does a better job of relieving soil compaction and providing deep channels for the incorporation of gypsum or other soil amendments to preserve soil structure. Various forms of cultivation are typically employed at more frequent intervals on greens, tees, and fairways. Coring and deep-tine aeration in the spring and fall remain the cornerstone of most successful programs. This is typically supplemented at monthly intervals with spiking, slicing, quadratine, or venting techniques to keep surfaces open for gas exchange and to accept larger volumes of water.

Drainage is another essential program for dealing with salt and sodium accumulation. Damage is most prominent in low-lying sections of the course where water accumulates, resulting in a higher concentration of soluble salts and sodium once the water evaporates. The installation of drainage inlets and subsurface drainpipe can help to remove this excess water and prevent the toxic buildup of salts and sodium.

Sand topdressing of fairways is another program that has become popular throughout the Southwest in an effort to improve playing quality, traffic tolerance, turf health, and allow for the rapid removal of excess water. Many courses have implemented a fairway topdressing program, regardless of whether they are using recycled water, in an effort to improve year-round playing quality. A topdressing program is not essential in the management of recycled water; however, it does make it easier to leach salts and sodium while providing firmer turf conditions immediately after deep watering cycles.

The survey indicated the following extra practices and costs associated with aeration, drainage, and topdressing where recycled water is used:

- Greens — An average of three extra aeration treatments per year.
- Fairways — An average of two extra aeration treatments per year.
- Deep aeration of fairways — One to two times per year at an average cost of $10,000 to $11,000 per treatment.
- Drainage improvement — $5,000 to $10,000 per year.
- Fairway topdressing — $25,000 to $65,000 per year.

FERTILITY AND SOIL AMENDMENTS

Particular attention must be paid to fertility and the application of soil amendments when using recycled water. The type and quantity of fertilizer and amendments should be based on routine soil and water quality tests. When significant amounts of sodium are present in the soil, it is typically recommended to apply a calcium-based soil amendment, such as gypsum, at routine intervals. The incorporation of gypsum in conjunction with aeration and leaching helps to preserve soil structure. Many courses surface-apply gypsum to greens in conjunction with monthly spiking or venting, followed by a heavy leaching cycle.

Another strategy typically employed by superintendents who use recycled water is the routine application of a soil wetting agent. Such products help to maintain good water infiltration and percolation, helping flush salts and sodium away from the turfgrass rootzone.

Recycled water may contain a significant amount of nutrients, including nitrogen, phosphorus, and potassium. It is important to track the seasonal variations of nutrients that may be contained in the water and adjust fertility programs accordingly (Huck, 2000). Frequent leaching also can deplete mobile elements, such as potassium, and it is often necessary to make supplemental potassium applications following leaching cycles.

Superintendents surveyed reported the following costs and/or savings with regard to fertility and the application of soil amendments:

- Fertilizer savings — Only two of the courses reported an annual savings of $7,000 to $9,000 per year due to the nutrient content of recycled water. The other courses noted negligible impacts.
- Additional costs for fertilizer — One of the courses surveyed reported an increased cost of $3,000 to $5,000 per year for the application of potassium and micronutrients.
- Gypsum applications — $5,000 to $30,000 per year (the higher cost is typically associated with multiple applications to fairways by a contract applicator).

IMPACTS ON TURF QUALITY AND PLAYING CONDITIONS

The use of recycled water affects turf quality and playing conditions in several ways:

By necessity, sites using recycled water must apply extra water to control soil salts and sodium levels. Soil conditions need careful monitoring by using portable testing devices such as the moisture probe (opposite page), used to monitor soil moisture levels, and an EC meter (above), used in monitoring soluble salt levels to help maintain the critical balance between healthy turf growth and good playing quality.

When significant amounts of sodium are present in the soil, typically it is necessary to apply a calcium-based soil amendment, such as gypsum, at routine intervals. Custom application on a frequency of two times per year can cost approximately $30,000.

Fairway sand topdressing can improve soil properties, making it easier to leach salts and sodium while providing firmer turf conditions immediately after deep watering cycles. The cost of an effective topdressing program is approximately $25,000 to $60,000 per year.

Deep aeration on greens, using 5/16" needle tines, has become a popular program to enhance water percolation and allow for the removal of soluble salts from the rootzone.

- Some turf species are more susceptible to salinity damage.
- Generally wetter turf conditions as a result of leaching programs.
- Additional costs are associated with supplemental seeding or sodding to repair areas damaged by salinity stress.
- Courses that conduct winter overseeding report using higher seeding rates to compensate for seedling mortality as a result of the higher salt content of the water.

Another issue faced by many older golf courses is the management of native soil greens that lack a subsurface drainage system. Such greens are more susceptible to damage due to salt and sodium accumulation and the difficulty of leaching these components from the soil profile (Moore, 1994). In such circumstances, many courses have chosen to install a separate piping system to provide potable water exclusively for the greens. If this is not feasible, frequent deep-tine aeration or possible putting green reconstruction could be the only remedy.

Of the courses surveyed, few have attempted to convert fairways to a more salt-tolerant species, preferring to manage their existing mixture of grasses. Although converting to a more salt-tolerant turf variety such as bermudagrass or seashore paspalum is an effective strategy, the cost and disruption of such a project is viewed as prohibitive by many courses. A few of the courses surveyed have incorporated conversion to a more salt-tolerant turf variety as part of future golf course remodeling plans.

Survey responses regarding the cost associated with turf repair and renovation are as follows:

- Sod for damaged areas — $10,000 per year.
- Increased costs for winter overseeding — $3,000 to $20,000 per year.
- Conversion to a more salt-tolerant turfgrass variety (including the cost of sod, soil improvement, and drainage) — $20,000 to $30,000 per acre.

IRRIGATION SYSTEM RETROFITTING, MAINTENANCE, AND REPAIR

Due to the sensitive nature of *Poa annua* and creeping bentgrass putting greens, many courses have reconfigured the irrigation system to include a separate supply line to deliver potable water to the greens. Since greens typically comprise 2% to 4% of the total golf course acreage, it is a relatively cost-efficient solution to preserving turf quality on this important area of the course.

A slightly higher cost can be expected for managing the irrigation system where recycled water is used. The costs can differ based on the age and design of the irrigation system and whether the water is delivered under pressure or needs to be pumped. Due to the higher salt content, recycled water can be corrosive to metal components typically used in irrigation pumps and valves. There also are additional costs associated with regulatory compliance for annual cross connection checks to ensure that the piping systems for potable and recycled water are not interconnected.

Survey responses regarding maintenance and repair of the irrigation system varied based on the age and design of the system, with many courses reporting no additional costs for maintenance and repair. Regulatory compliance and costs for other items are as follows:

- Regulatory compliance and cross connection check — \$150 to \$400 per year.
- Accelerated wear on pumps and valves (approximately 50%) — \$6,000 per year.
- Repair of plugged irrigation heads — \$5,000 per year.
- Installation of a separate piping system to provide fresh water to the greens — \$250,000 to \$300,000.

MANAGING LAKES

Lakes and reservoirs for the storage of recycled water present a major challenge for superintendents. The increased nutrient content of the water provides a perfect environment for the rapid growth of algae and aquatic weeds, which detract from the general appearance of the water

The lack of water penetration may be a sign that water treatment is necessary. A variety of treatment options are available, from gypsum injection to sulfuric acid injection, at a cost of **\$3,000** to **\$25,000** per year, depending on the type of treatment required.

(Above left) Salt and sodium accumulation can cause the decline of sensitive turf species, especially in low areas. Some courses spend approximately $10,000 per year for sod to repair these damaged areas.

(Above right) Routine chemical water testing is essential where recycled water is used. The total cost for monthly water sampling and soil testing two to four times per year is approximately $2,000.

features. Proper design of the lakes and reservoirs can help reduce many of these problems. Depths should be at least 10 to 12 feet or more to reduce sunlight penetration and maintain cooler water temperatures throughout the year (Gill and Rainville, 1994). If given the opportunity to design the lakes prior to the delivery of recycled water, it is recommended to provide at least five days of water storage capacity and provide shading along the banks with trees, shrubs, and vegetative buffer strips (Terry, 1994).

Problems associated with algae and aquatic weeds can be reduced or eliminated by having the water delivered under pressure directly into the mainline piping system. As an alternative, some courses store recycled water in tanks or covered reservoirs.

Survey responses with regard to managing lakes revealed the following information:

- Treatment for algae and aquatic weeds — $20,000 to $40,000 per year.

CONCLUSION

The key word to keep in mind with regard to the management of recycled water is *adjustment*. There need to be adjustments in budgets, management practices, and golfer expectations if recycled water is to be used effectively. Rarely does one find the ideal scenario of sandy soil conditions, perfect drainage, and salt-tolerant turf species. Usually it is a mixed bag of conditions that the superintendent must manage to achieve the best possible playing conditions given the circumstances. The biggest issue remains the management of soluble salts and sodium that are inherent in most recycled waters. Special attention must be given to regular soil and water quality monitoring, aeration, leaching, and developing a sound strategy for the application of soil amendments.

Is it possible to have championship golfing conditions with the use of recycled water? The answer is definitely *yes*! Three future U.S. Open venues currently use recycled water, including Torrey Pines (2008), Pebble Beach (2010), and The Olympic Club (2012). As these courses have done, a step-by-step approach to managing recycled water can address agronomic concerns while still providing good playing quality.

REFERENCES

Carrow, R. N., R. R. Duncan. 1998. *Salt Affected Turfgrass Sites: Assessment and Management*. Ann Arbor Press. Chelsea, Mich.

Gross, Patrick J. 2003. *USGA Green Section Record*. May/June. 41(3):17-20.

Harivandi, Ali. 2007. *Golf Course Management*. June. 75(6):98-108.

Huck, Michael, R. N. Carrrow, R. R. Duncan. 2000. *USGA Green Section Record*. March/April. 38(2):15-29.

Huck, Michael. 1994. In: *Wastewater Reuse for Golf Course Irrigation*. Lewis Publishers, Ann Arbor, Mich. pp. 242-247.

Gill, Garrett, D. Rainville. 1994. In: *Wastewater Reuse for Golf Course Irrigation*. Lewis Publishers, Ann Arbor, Mich. pp. 44-52.

Stowell, Larry J., W. Gelernter. 1999. PACE Insights. 5(3):1-4.

Terrey, Andrew. 1994. In: *Wastewater Reuse for Golf Course Irrigation*. Lewis Publishers, Ann Arbor, Mich. pp. 130-142.

Vermeulen, P. 1997. *USGA Green Section Record*. September/October. 35(5):16.

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