One way to avoid overwatering is to have two sets of sprinklers in order to irrigate the green separately from the surrounding rough.

Putting Green Drainage, Drainage, Drainage

Just as location is important in real estate, drainage is the foundation of any good putting green.

BY JAMES H. BAIRD

Drainage has long been considered the single most important element of good quality putting greens, and more often than not, failure of putting green turf can be traced back to one or more factors related to excess moisture and the inability to get rid of it. Poor drainage creates softer conditions on putting greens, exacerbating ball marks, footprints, spike marks, and wear damage, especially around golf holes, all of which adversely affect ball roll and the ability to make a putt. Wet soil is more prone to compaction, which leads to weak, shallow-rooted turf and encroachment of algae, moss, and *Poa annua*. In the end, turf in poorly drained areas usually succumbs to diseases such as anthracnose or *Pythium*, or stress caused by traffic, mower scalping, or weather extremes. In northern climates, loss of turf from winter injury frequently occurs in poorly drained areas of putting greens.

Troubleshooting a drainage challenge is likely to start by examining the underlying soil. However, soil is just one of several factors that can contribute to wet greens. The objectives of this article are to outline the various causes of poor drainage in putting greens and to offer the best and most current solutions.

STEP ONE: LOOK AROUND

Before reaching for your soil probe, take a step back and look around the green. Pay particular attention to irrigation, trees, traffic patterns, side-hill seepage or runoff, and poor surface drainage.

IRRIGATION

Overwatering due to improper irrigation practices, poor irrigation design, or both, is one of the leading pitfalls of golf turf maintenance and can contribute to poor drainage. Unfortunately, some

turf managers find it easier and safer to err on the side of applying too much water rather than barely enough, especially since most golfers view lush, green turf as good and anything less as problematic.

Besides reminding golfers that "green is not necessarily great," putting green irrigation systems of today should include properly spaced sprinklers that provide uniform water distribution and are controlled individually for site-specific water management. In addition, a second set of sprinklers should be installed to irrigate the green surrounds separately from the putting surface to account for differences in water use requirements relative to mowing height and turfgrass species. Irrigation scheduling should be based upon a combination of weather data and frequent monitoring of soil moisture to prevent excess irrigation. Finally, having a state-of-the-art irrigation system and employing proper irrigation scheduling methods will significantly reduce but not eliminate the need to hand water.

TREES

Trees contribute to poor drainage by blocking sunlight and air circulation, which reduces both evaporation and transpiration of moisture from the turf canopy. As a result, irrigation must be restricted accordingly to account for reduced water loss. Remove trees that block the direction of the prevailing wind and sunlight, especially during the morning hours when photosynthesis is optimal and in order to dry out the turf canopy to reduce disease incidence. If that is not possible, use fans. These will artificially elevate the evapotranspiration rate and help the turf pull more water from the soil, thereby aiding in drainage.

TRAFFIC

Wet turf is particularly susceptible to wear damage and soil compaction caused by concentrated traffic from equipment and golfers. Switching from triplex to walk-behind mowers, and from grooved to solid front rollers on the cutting units can help reduce turf wear, especially on poorly drained greens. Removal or repositioning of trees, bunkers, or other obstructions around the green can help to improve traffic distribution. Raising the height of cut is the easiest way to increase cupping area on sloped greens without having to level, add to, or rebuild putting greens. Finally, increasing cultivation practices such as aeration and sand topdressing will help reduce surface compaction and improve drainage.

SIDE-HILL SEEPAGE OR RUNOFF

Look for drainage challenges that may be caused by excess water from neighboring slopes. The best solution for side-hill seepage is to install an interceptor or curtain drain just above the wet area near the base of the slope. The bottom of the trench should be positioned just into the less-permeable subsoil and then back-filled with stone or highly permeable sand and drainage pipe. More than one interceptor drain may be necessary, depending upon the depth and volume of water entering the green.

Repeated applications of the deep drill or tine and sand fill procedure usually helps to improve wet greens short of drainage installation or total reconstruction.

SURFACE DRAINAGE

The presence of puddling in low areas of a green following irrigation or natural precipitation is a sign of poor surface drainage. This phenomenon can be caused by poor design and/or construction, or by settling over time. Poor surface drainage can be overcome by additional and selective topdressing of low areas. Broader low areas may require removal of the sod, regrading of and/or addition to the underlying soil, followed by replacement of the sod. Inadvertent topdressing applications to collars may create a "lip" that prevents positive surface drainage from the edge of the green. Extra aeration with core removal and rolling may solve this problem; however, for severe cases, regrading may be necessary.

In extreme cases, for example on a punch-bowl green, it may become necessary to install a surface inlet drain at the lowest point in the depression. Although this type of drain can obstruct playability, it will allow a large volume of water to leave the surface and enter the collector pipe. Be sure to use a large enough grate and pipe to handle the surface water and install a trap to capture sediment or debris before it enters the drainage system.

STEP TWO: LOOK DOWN

After looking around, next grab your soil probe or profiling tool to examine the soil profile. The initial evaluation can be subjective in nature, looking for clues such as color, hardness, root distribution and depth, presence of thatch, or any other visible layers. The most common causes of soil-related poor drainage are layering and impermeable soil.

LAYERING

Layering can be caused by excessive thatch accumulation, poor construction methods, inconsistent use of cultivation practices, including topdressing materials and the frequency of application, or continued use of the same cultivation

Installation of slit drainage is effective, but it is usually more disruptive than subsurface drainage.

practice whereby a "plow-pan" or compacted area develops underneath the penetration depth of the tine or implement. Most of the time, layering problems can be alleviated by aggressive conventional and/or deep-tine aeration combined with sand topdressing to maintain the integrity of the channels.

IMPERMEABLE SOIL

One of the most common causes of poor drainage is impermeable soil underneath the green. The desire to save a buck or two during construction can often lead to use of an improper or poorly drained rootzone mix. On the other hand, even an ideal rootzone mix can become poorly drained if cultivation practices such as aeration, verticutting, and topdressing are not performed as needed to minimize organic matter accumulation. Poor drainage is often associated with greens that were constructed using finer-textured native soils. Over time, drainage in these greens usually worsens due to organic matter accumulation, increased play and resultant compaction, and changes in equipment, irrigation, and other maintenance practices.

If the drainage problem is not too severe, then aggressive aeration and sand topdressing will likely improve the soil to a point where no further action is needed. In more severe cases, it would be best to have an accredited soil testing laboratory conduct a more objective analysis of the soil. The laboratory will provide instructions for submitting undisturbed soil profiles from the green(s) in question using PVC pipe. A complete physical analysis is usually conducted on two or more sections of the profile to determine particle size distribution, density, infiltration rate, porosity, and organic matter content. In most situations, recommendations for improving drainage in impermeable soil will involve either installation of drainage or complete reconstruction of the putting green. The two most common methods of drainage used today in the Northeast are slit drainage and subsurface drainage.

Subsurface drainage installation is tedious work that is often best left to the expertise of a drainage contractor.

Slit drainage can be installed using a customized vibratory plow, which injects coarse sand into veins that are approximately 1 inch wide, 12 inches deep, and on 1- or 2-foot spacing, depending upon subsoil composition, compaction, and surface pitch of the green. Veins are extended away from the green to a low point and then connected into a dry well or interceptor drain. Approximately two tons of material are injected per 1,000 linear feet of drainage installed, equaling about 12 tons for a 6,000-square-foot green. The top of the sand is made flush within a half inch of the putting surface, and then the green is blown, brushed, rolled, and smoothed with topdressing sand in preparation for play.

There are various procedures for installing subsurface drainage. The most critical components include: identification of outlet drain(s); arrangement of laterals, depending upon soil characteristics and perpendicular to the general slope of the green; excavation of narrow trenches by careful removal of sod and underlying soil where the drainage pipe will be placed; installation of 2- or 3-inch-diameter perforated drainage pipe surrounded by gravel or pea stone; backfilling of the trench with a rootzone mixture (something on the order of 60% sand, 20% soil, and 20% peat) using careful tamping along the way to prevent settling; and replacement of the original sod followed by more tamping and hand topdressing to smooth out the surface. Use of narrow trenches and pipe and a "dirty" rootzone mix is critical to prevent drought stress. Also, pipes should be extended out of the high end of the green cavity and marked with a metal tag so they can be located and flushed out if necessary.

The decision to install either type of drainage system is usually based upon several factors, including size and scope of the drainage problem, timing of the project, and availability of the contractor. While subsurface drainage can be installed in-house (see "Wet Greens: Let's Try This First"), the work is tedious and is best left to an experienced contractor who can complete the project on an average-sized green in one day with little or no disruption of the putting surface. Installation of slit drainage is equally or more rapid compared to subsurface; however, the putting surface will likely not be smooth afterwards, and repeated aeration and/or topdressing may be necessary to smooth it to an acceptable degree. Longevity is another consideration when choosing a drainage method, and it would be logical to assume that wider trenches that contain pipe will last longer than narrower veins of sand. The narrow slits may function well initially, but they will likely become silted in from the surrounding soil and eventually become non-functional. Nevertheless, the author has observed continued success of greens with slit drainage more than five years after installation.

FINAL STEP: RECONSTRUCTION

Unfortunately, many courses skip either or both of the two first steps in identifying and solving drainage problems and go straight to complete reconstruction of a green, only to be disappointed later when poor drainage is not solved and playability is far different from the remainder of the greens. In the event that all other measures have been exhausted and reconstruction is necessary, now is not the time to cut corners in the interest of saving money or time. Working together with your agronomist and a soil testing laboratory, it is possible to construct a green that closely matches the others in terms of playability without compromising drainage, drainage, drainage!

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