Understanding the Hydrology of Modern Putting Green Construction Methods

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Goals:

- *Examine the effects of rootzone composition and putting green construction method on water drainage and redistribution within the profile.*
- *Examine the effects of rootzone composition, soil depth and degree of water perching on turf water use and irrigation management.*
- *Examine long-term changes in physical, biochemical and microbiological properties of the rootzone; and relate these changes to the long-term hydrologic behavior of modern putting green designs.*

Cooperators:

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This research investigates the influence of modern putting green construction method on hydrologic processes in the root zone, including water infiltration, redistribution, and drainage. The greens construction methods under investigation are the United States Golf Association (USGA) and California (CA) specifications. Additionally, each soil profile design contained either a high or low water permeability root zone, resulting in four, soil profile/root zone composition treatments, each replicated three times. The experimental greens contained a creeping bentgrass turf maintained at a mowing height of 3/16th inches.

Of particular interest is the effect of green slope on hydrologic processes. The greens were built above ground in 4 by 24 foot boxes with slopes of 0, 2 and 4 percent adjusted by jacking and blocking the legs. The units also contained drain lines at 2 and 17 feet from the down slope end effectively yielding a 15 foot drain spacing. The root zone of each experimental green was instrumented with TDR soil moisture probes at three depths (3, 6 and 9 inches) and five locations (2, 7, 12, 17 and 22 ft from the down slope end). A tipping bucket rain gauge was connected to the outflow of the furthest down slope drain line to monitor drainage outflow rate.

Each green received simulated rainfall from a device delivering either 4.44 ±0.09 inches per hour for the high rate or 1.89 ± 0.04 inches per hour for the low rate treatment. Continuous measurements of drainage outflow and soil water contents were started at the beginning of the rainfall period. Rainfall was then applied for 3 hours to ensure a constant drainage rate. At the end of the rainfall period, the rain simulation device was turned off but drainage outflow and soil moisture measurements continued for an additional 48 hours.

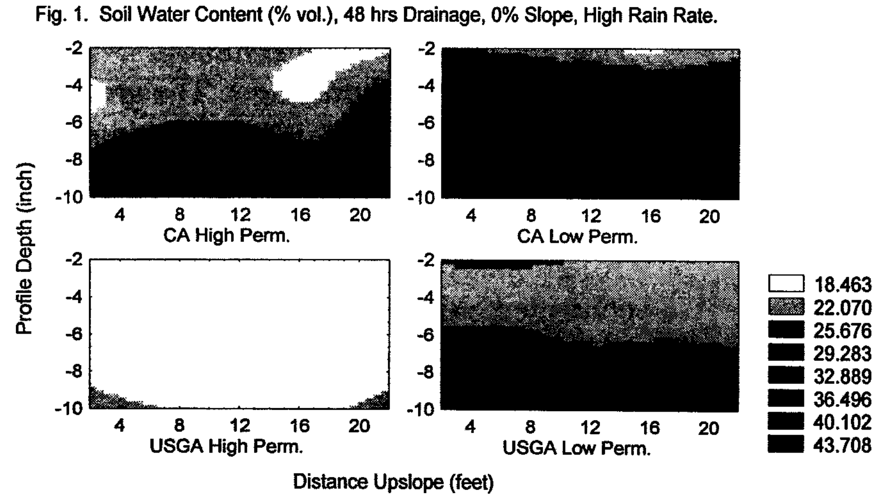

Figure 20. Root zone soil water content (% volume) after 48 hours drainage (0 % slope and high precipitation rate).

While drainage rate is but one aspect of putting green hydrology, there is some confusion regarding which construction method should be the more rapidly drained and proponents of either system have claimed that theirs promotes faster drainage. The important understanding we demonstrated in this study is that both profile design and root zone mix permeability contributes to drainage rate. Given equal root zone mix permeability, the USGA profile yields drainage that is more rapid. Indeed, even rainfall rates of about 4.5 inches per hour failed to overwhelm drainage of the USGA profiles as evidenced by equivalent drainage rates for both the low and high permeability root zones.

Further, this same rainfall rate exceeded the drainage capacity of a CA profile containing a root zone mix initially tested to have a permeability of 20 inches per hour. For equivalent drainage performance, therefore, it seems that a CA style green would need a root zone mix permeability 10 to 20 inches per hour greater than a USGA green.

Drainage rate represents an intensity factor. The capacity factor of the drainage process, in the context of the present study, is the completeness of excess water removal from the respective root zones. Here, it is commonly thought that a USGA putting green profile would become less completely drained than a CA green. This belief results from the water perching effect in a USGA green. Our results showed that for equivalent root zone mix permeabilities the USGA green is drier after 48 hour (interpreted as more completely drained) than a CA system green (Fig. 1). This appears to be principally due to the need for water to move laterally through the root zone in a CA green before reaching a drain line. Again, for more complete drainage, a CA green would appear to need a higher root zone permeability as evidenced by the nearly equal soil water contents after 48 hours drainage in the CA high permeability profile and the USGA low permeability profile.

All greens are contoured or sloped to some degree. This contouring may be slight in hole location areas, but is more extreme between terraces or throughout links style greens. This sloping clearly has an effect on water redistribution following rainfall. Prior to this study we believed that the perched water table in a USGA green would lead to strong lateral movement of water to more down slope locations. This would suggest the possibility of 'hot spots' forming at higher elevations in a USGA green. We did not believe this would occur to a great extent in a CA green because this green construction method was thought to be more completely drained, having no perched water to migrate. The results from this study suggested that our prior beliefs were somewhat incorrect. While lateral water movement was observed in the USGA greens, it was also observed in the CA greens. Thus, for equal root zone permeabilities, there was a much greater lateral difference in water contents after 48-hour drainage in the CA greens than the USGA greens (Fig. 2).

One caveat in the results of this study is that these constructions were just one year old and had not experienced foot traffic. Our plan for the experimental greens is to simulate foot traffic and repeat this study under more natural conditions. We also have collected undisturbed soil cores in November 1996 and 1997. These cores are currently being measured for soil physical properties and changes relative to the fresh mixes. These periodic sampling and measurements will continue throughout the study.

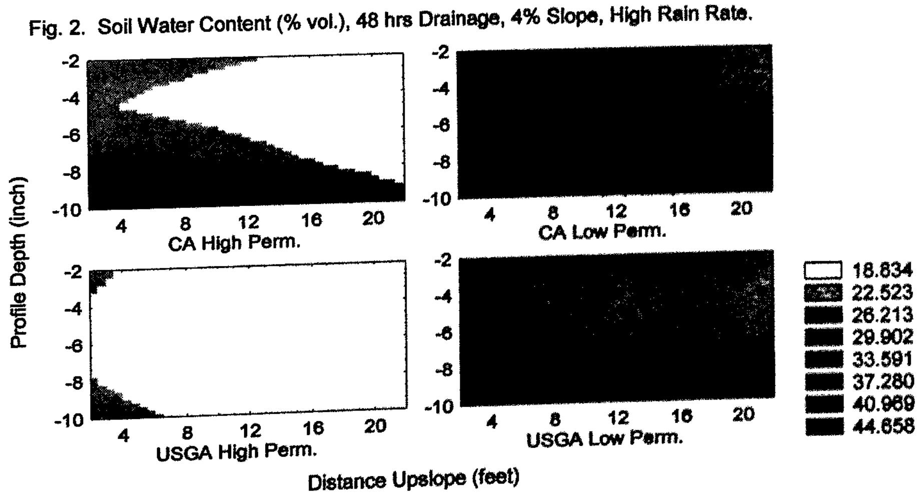

Figure 21. Root zone soil water content (% volume) after 48 hours drainage (4 % slope and high precipitation rate).