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DRAINAGE MAPPING

Ground-Penetrating Radar Maps Drainage Systems

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Good golf green drainage is important for healthy turf and a well-maintained playing surface. With time, drainage systems can fail or become plugged because of improper construction and/or management. Unfortunately, many system maps are either unavailable or incorrectly marked, which makes the problems hard to fix.

Locating a drainage system in a green is time-consuming and often frustrating. Many superintendents invest hours in locating theses pipes when drainage problems arise. Correcting the drainage problems can destroy the green and are expensive when the location of the present system is unknown.

> **Ground-penetrating radar (GPR) is a non-invasive geophysical tool for locating subsurface features.**

Ground-penetrating radar (GPR) is a noninvasive geophysical tool for locating subsurface features. It was commercially developed in the mid 1970s, and is primarily used for imaging near-surface features such as buried artifacts (Conyers and Goodman, 1997), drains (Chow and Rees, 1989), irrigation pipes (Vellidis et al., 1990), utility cables (Annan, et al., 1984; Morey, 1974), land mines and human remains.

In addition, GPR has been used to monitor the movement of water through surface layers (Vellidis et al., 1990), detect perched water tables (Collins and Doolittle, 1987), and chart subsurface soil horizons and layers (Asmussen, et al., 1986; Collins and Doolittle, 1987; Mokema, et al., 1990; Raper, et al., 1990). Recently (Chong, et al., 2000), GPR has been successfully used to determine the thickness of the sandy rooting mixture in a golf green, locate the drainage pipes, locate areas of surface compaction and locate areas of concentrated subsurface wetness.

In this study, a SIR System 2000 GPR manufactured by Geophysical Surveys Systems was used to map the drainage systems in a USGA-style green and a California-style green. A previous study (Chong, et al., 2000) indicated that GPR could accurately locate the drainage tiles in a green with minimum time and minimum disturbance.

Study area and site conditions

The two study sites were located near Carbondale, Ill., located about 90 miles southeast of St. Louis. The first study site was located at the Hickory Ridge GC. The greens at Hickory Ridge are typically sand mixes following the California style of green construction on top of a loamy native soil. The green mix was designed to be 12 inches thick.

Located under the rooting mix are perforated plastic drainage lines, 4 inches in diam-

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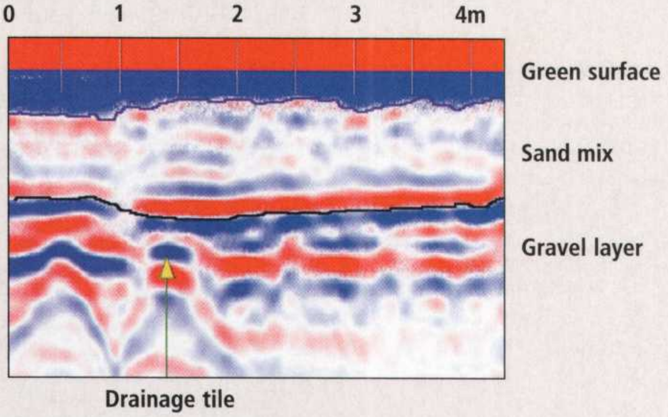
FIGURE 1

Cross-section, No. 3 Green at Stone Creek GC



GPR allows small objects, like the drainage tile, produce unique reflections, which help superintendents locate subsurface features more easily.

eter, lying in trenches cut into the native soil. The greens at Hickory Ridge are Penncross creeping bentgrass, and they were in their ninth season when the study was conducted. The second study site was located at the Stone Creek GC, just south of Carbondale.

The greens at Stone Creek are USGA style. They typically have 12 inches of sand above 4 inches of gravel overlying the native soil. The tile is 4 inches in diameter and lies under the gravel in trenches lying in the native soil. Gravel is placed around the tile.

Radar equipment and how it works

Our study used the Subsurface Interface Radar (SIR) System-2000, manufactured by Geophysical Survey Systems (GSS).

With GPR, the depth of observation decreases rapidly with increasing antenna frequency and soil conductivity. In one soil, radar may reveal features 10 feet deep, while in another soil material the radar may only reveal features 2 feet deep. In many radar studies, resolution is often sacrificed for increased observation depths as lower-frequency antennas (10 to 300 megahertz) are used.

When profiling and investigating golf greens, the depth of interest is generally 0 to 24 inches. For this study, a 400-megahertz antenna was used because it provides improved resolution of subsurface features at shallow observation depths.

The radar detects the interface between materials with different electromagnetic properties. Density, water content, texture or foreign bodies can influence electromagnetic properties. Each interface revealed on the radar profile is generally displayed as a group of dark bands.

Fig. 1 is a portion of a radar scan from the No. 3 USGA green at Stone Creek. The uppermost interface in Fig. 1 (the top red band) represents reflections from the soil or green surface. The major subsurface reflections in this radar profile are the sand mix, the gravel layer and the interface where the sand mix meets the gravel layer. With GPR even small objects such as rocks, roots or buried cultural features produce unique reflections.

These features are referred to as point reflectors, which can be seen between the 3.3 feet and 6.6 feet marks. This point reflector is the cross-sectional view of a 4-inch-diameter, perforated, plastic drainage pipe. To map the drainage system in golf greens, the radar scans are made perpendicular to the drainage system and the parallel scan lines are spaced 3.3 feet apart.

Drainage system maps

Prior to scanning, a 3.3-foot x 3.3-foot grid was overlaid on the entire green. To establish this grid pattern, the sprinkler heads were used as reference points. The grid was flagged every 3.3 feet, including the boundary of the green. The GPR system was then calibrated for each green to allow for the best viewing window.

A three-person team worked together to scan the greens. A green of 5,000 square feet took about one hour to flag and scan. In general, flagging takes longer time than scanning. The scanning takes about 15 to 20 minutes. The data was then analyzed. The results were transferred and mapped using a simple spreadsheet to plot the boundary and the drainage system of the green. Fig. 2 (page T4) shows the drainage system of Green No. 2 at Hickory Ridge, while Fig. 3 (page T4) shows the drainage system of Green No. 3 at Stone Creek.

FIGURE 2

Drainage System
Hickory Rirdge GC (Green No. 2)

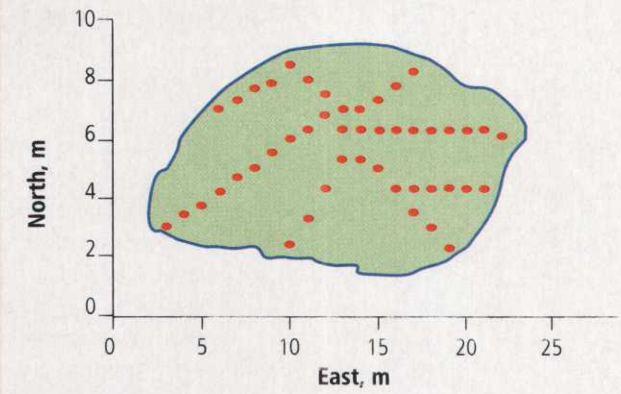
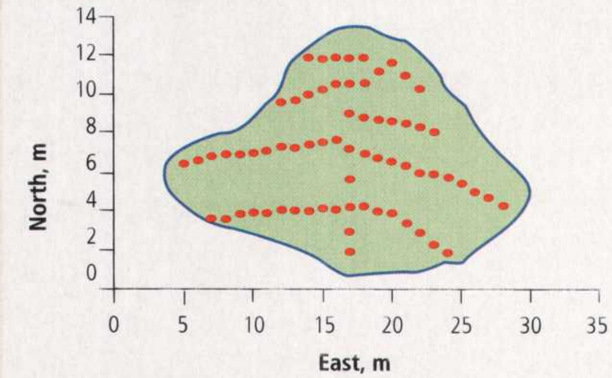


FIGURE 3

Drainage System
Stoney Creek GC (Green No. 3)



Superintendents can use GPR to map underground drainage systems without tearing up a green's surface.

Summary

Use of GPR for mapping drainage tile in golf greens can be effective. Superintendents can use this technology to accurately and precisely identify drainage tile and other subsurface features (e.g., areas of compaction or wetness) in a golf green.

The application of GPR technology to golf greens is still in the early stages, but it already shows great promise in the trouble shooting and management of golf green drainage systems.

Having the ability to study the subsurface features of a golf green without digging a hole will minimize the cost of finding and fixing subsurface drainage problems.

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