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Protecting Water Quality On and Off the Golf Course

Design features for filtering fertilizer nutrients.

BY ERIC MILTNER


Wet cells that seasonally hold water are one way of potentially reducing fertilizer from leaving the property.

In recent years, issues such as storm water retention, wetland preservation and mitigation, and preservation of wildlife habitat on golf courses have received increasing attention throughout the design, permitting, construction, and management processes. This is in addition to the now ever-present scrutiny on maintaining water quality. In the Pacific Northwest, sand topdressing and/or building courses with extensive sand caps is becoming the norm. This is done primarily to allow play to continue during the mild, wet winters. The sandy soil profile provides for rapid infiltration of rainfall. This reduces the potential for surface runoff, provides a large volume of temporary water storage in the pore spaces of the soil (storm water retention), and improves stability for both golfers and maintenance equipment. However, the sandy soil also creates an environment of potentially increased mobility of fertilizer nutrients used on the golf course. Measures to mitigate this potential mobility are critical and can be accomplished through design and construction or management practices, or both.

This article describes research conducted at Trophy Lake Golf and Casting Club on Washington State's Key Peninsula. A natural 18-acre lake surrounded by wetlands is the central drainage basin for 15 of the golf course's 18 holes. The entire course was constructed with a 6- to 10-inch-deep sand cap to allow for rapid infiltration and storm water storage, preventing large influxes into the lake during storm events. Such influxes can disrupt wildlife habitat in the lake and in the stream that exits the lake. In addition to the sand cap, bioswales (mounded berms), wet cells (low-lying areas that seasonally hold water), constructed wetlands, and tall grass buffers were included at edges of fairways and in roughs. These features were designed to intercept runoff water and shallow subsurface flow, allowing for filtering of nutrients through the actions of plants, soil, and microorganisms.

Six sites throughout the course were selected for monitoring the effectiveness of these design and construction techniques. These areas had obvious flow gradients created by surface contours and directed water across slopes and into and through the filtering features previously mentioned. The monitoring sites can be thought of as mini-watersheds. Instruments that enabled collection of soil solution were installed upslope, within, and down-slope from bioswales, wet cells, and constructed wetlands. (Soil solution is the water within the soil profile, including any dissolved solutes that might be present.) The samplers were located at the interface of the sand cap and the less-permeable subsoil below. Soil solution moving through the profile collects in the sand, above the less-permeable subsoil, allowing for its extraction.

Thirty-six samplers were initially installed, and 15 more were added in critical areas as the study progressed. Samples were collected periodically and analyzed for nitrate-nitrogen and orthophosphate (soluble phosphorus), two potentially important pollutants of surface and ground water. Nitrogen (N) and phosphorus (P) were both regularly applied to golf courses as components of the overall maintenance program.

On 15 dates between May 2002 and June 2004, 396 individual samples were collected from either the soil solution samplers or from free (standing) water present in the wet cells, wetlands, and lakes. Most of these samples (329, or 83%) contained less than 1 part per million (ppm) nitrate-N. In 86 (22%) of these samples, nitrate-N was non-detectable (less than 0.01 ppm).

Fourteen of the soil solution samples (3.5%) had nitrate-N levels above the EPA drinking water threshold of 10 ppm. Some of the soil solution samples collected from down-slope areas where water accumulates had relatively high nitrate-N concentrations (3 to 60 ppm) on selected dates. Typical locations were bioswales and unmowed tall grass buffers located between fairways and constructed wetlands. Following these findings, additional samplers were installed at a depth of 2 feet into the subsoil at these locations. Subsequent sample collection did not show high nitrate-N concentrations in these deeper samplers, indicating no appreciable downward movement of nitrate-N. In addition, nitrate-N concentrations were always lower in locations further down-slope from these near-surface accumulations (within wetlands or in soil on banks of the lake). The highest concentration of nitrate-N found in the surface water of wetlands or lakes was 1.4 ppm (only 2 samples were above 0.25 ppm, and these were both in constructed wetlands).

In addition to nitrogen, 342 of the samples were analyzed for orthophosphate (there was not sufficient volume in some of the samples to analyze for both). Eight-one percent (278 samples) were below the surface water quality threshold of 0.05 ppm (a concentration often cited as one above which algal blooms may occur). Orthophosphate was not detected (less than 0.01 ppm) in 101 (30%) of the samples.


Streams and water features require very careful applications to the surrounding areas. Buffer strips help minimize nutrient and chemical introductions to the water.

The results of this study indicate that even in fertilized fairways, soil solution concentrations of N and P were usually below recognized water quality thresholds. Grasses are extremely efficient in scavenging nutrients from the soil due to their dense, fibrous root systems. As soil solution moved down-slope through the monitored areas, concentrations remained low. In the few cases where nutrient concentrations increased in buffers and wet cells, there was no evidence that these higher concentration waters continued to move down-slope or percolated deeper into the soil profile. This indicates that as the soil solution moved through these areas, where the rate of flow was lower due to gentler slopes, nutrients were likely filtered from the water through uptake by plants or soil microorganisms or immobilization by other soil processes. Nutrient concentrations in the native wetland and lake were not impacted by golf course maintenance practices.

When the potential movement of water and dissolved nutrients from the golf course to surrounding areas is a concern, grass buffers, bioswales, wet cells, and constructed wetlands can be useful tools in maintaining water quality. Increasing the residence time of the soil solution on the golf course is critical and can allow the grass root system, as well as other soil organisms, to effectively filter nutrients from the water before it leaves the golf course site.

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