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Long-Term Monitoring of Nutrient Loss in Runoff from a Golf Course

A one-of-a-kind investigation at Colbert Hills Golf Course documents effects before, during, and after construction.

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OBJECTIVES

- Compare nutrient loading via surface water runoff from a new golf course versus the site's previous native prairie condition.
- Investigate the new golf course's impact on surface water quality during construction and during golf course operations.

Start Date: 1998
Project Duration: Nine years
Total Funding: $218,155

Kansas State University, in cooperation with Jim Colbert, PGA Tour, GCSAA, and various alumni, has built a 27-hole golf course, Colbert Hills Golf Course, near Manhattan, Kansas. The golf course was built on land with a prairie-woodland mix that is typical of the Flint Hills Region. The only previous land use was occasional grazing for beef cattle. The construction and operation of the golf course could possibly impact the surface water quality of nearby streams. Sediment washed away from the construction site would eventually flow into rivers and lakes and cause ecological damage. Excessive concentration of nutrients in rivers, lakes, and reservoirs can accelerate the growth of algae and other aquatic plants, causing problems such as clogged pipelines, fish kill, and restricted recreation.

Four monitoring stations were set up on Little Kitten Creek (the major stream) and its tributaries to collect water samples, measure runoff discharges, and collect precipitation data. Water samples were tested for total nitrogen, total phosphorus, and sediment concentrations. Surface water runoff amounts were studied so that mass transport of nutrients and sediment can be analyzed.

We continued our previous nutrient runoff research by collecting more samples and analyzing data. An average amount of precipitation enabled us to collect more than 120 total samples from inlet and outlet sites this year. We divided the data set into three subsets, namely pre-construction (native conditions), during construction, and during operation. At the main stream leaving the golf course, 28, 138, and 264 surface water samples were collected for the three periods.

Data analysis showed that golf course construction has the greatest impacts on surface water quality, with average concentrations of 3.94 mg/L, 0.93 mg/L, and 2,955 mg/L for total N (TN), total P (TP), and sediment (TSS), respectively, compared with 1.18 mg/L, 0.39 mg/L, and 477 mg/L for the pre-construction period.

During operation, sediment content was brought down significantly to an average of 550 mg/L, slightly higher than that of the native prairie condition. The average concentrations of TN and TP were 2.02 mg/L and 0.49 mg/L, respectively, much lower than those in the construction period, but still over 70 and 25 percent higher than those in the native prairie condition, respectively.

Sources of nutrients in streams under native prairie condition and during construction are thought to be from the input of rainfall and sediment eroded from fertile topsoils. During golf course operation, fertilizer application is another source of nutrients in streams, in addition to those mentioned above. Further analysis shows that there are direct connections between fertilizer application and concentration of TN and TP in streams. There are cases that clearly indicate the amount and timing of fertilizer application are to be blamed. This is the case when a good amount of fertilizer is applied over a large area and significant rainfall comes shortly after the application.

Less sediment in streams during operation is a contribution of golf courses to the environment. Higher concentration of TN and TP than that under native prairie condition is expectable. However, only a few samples have TN greater than 10 mg/L, a drinking water standard. We therefore believe that golf course operation, as a whole, does not pose an immediate threat to the aquatic system.

Aerial photo of the Little Kitten Creek Watershed and Colbert Hills Golf Course area after construction of the golf course near Manhattan, Kansas (terraserver.com).

Four water sample monitoring stations were established around the Colbert Hills Golf Course to collect water samples, measure runoff discharge, and collect precipitation data.

Using preliminary stream flow relationships, we were able to determine the surface water runoff amounts and the mass amounts of nutrient transported offsite. The determined rates of nutrient transport for native conditions were similar to those in the adjacent Konza Prairie Research Area. The rate of nutrient transport during construction was 3 to 4 times that under native conditions, which was consistent with the estimation of sediment yields.

SUMMARY POINTS

- Golf course construction has the greatest impacts on surface water quality, with average concentrations of 3.94 mg/L, 0.93 mg/L, and 2,955 mg/L for total N (TN), total P (TP), and sediment (TSS), respectively, compared with 1.18 mg/L, 0.39 mg/L, and 477 mg/L for the pre-construction period.
- During operation, sediment content was brought down significantly to an average of 550 mg/L, slightly higher than that of the native prairie condition.
- The average concentrations of TN and TP were 2.02 mg/L and 0.49 mg/L, much lower than those in the construction period, but still over 70 and 25 percent higher than those in the native prairie condition, respectively.
- There are cases that clearly indicate the amount and timing of fertilizer application are to be blamed.

CONNECTING THE DOTS

An interview with Dr. Steve Starrett *regarding the Colbert Hills project, monitoring nutrient runoff loss before, during, and after its construction.*

Q: *Was your water quality research at Colbert Hills mandated by the permitting process, or was this project initiated by your own interests?*

A: The research was not mandated by the permitting process. There was a citizens' environmental group that was happy we were performing this research. So that helped smooth out the relationship between the citizens' group and the Colbert Hills leadership.

Q: *Your project was unique in a couple of respects. First, it had a relatively undisturbed area upstream of the golf course development as a comparison for the water quality data. How much seasonal or yearly fluctuation occurs in this pasture or grassland system?*

A: The several hundred acres upstream of the golf course property includes a couple of residential homes, and the rest is lightly used pasture for cattle. This enables us to compare a low-input pasture area to the golf course property. Over the entire project duration, the maximum total nitrogen (N) concentration was 10.4 ppm from the upstream area, compared with 21.5 ppm for the downstream location, which included the golf course. The maximum total phosphorus (P) concentration was 0.45 ppm from the upstream area, compared with 2.98 ppm for the downstream location. Those downstream maximum values occurred during the construction phase. The maximum total N and P concentration during operation at the downstream location was 6.2 ppm and 1.42, respectively. So, the prairie gives up some N in runoff, but P is more tightly bound by the prairie. With respect to seasonal or yearly fluctuations, those differences do not show up because the variability of the data is so much larger in comparison.

Q: *Your data indicate that water quality was most affected during the construction phase of the project. Doesn't the Clean Water Act address the issue of maintaining water quality (i.e., erosion control) during construction? What measures are taken by golf course construction companies to mitigate the effect of golf course construction on the quality of surrounding water resources?*

A: Yes, the largest impact on surface water quality was during the construction phase. The Clean Water Act does cover construction periods. However, the language in the act is very vague, and there are no specific values in the Act that surface water runoff quality should meet because each environmental setting is different. This makes it difficult for contractors and regulators to easily determine that runoff quality is out of compliance. Some key features to use during construction are: permanent sedimentation basins that also serve as detention basins, temporary sedimentation basins, not allowing bare soil to remain uncovered for very long, erosion control blankets, soil binding sprays, mulch, and silt fences.

Q: *What do the results of your study enable you to say to superintendents who are genuinely concerned about environmental stewardship?*

A: Construction areas are critical areas to control runoff. Erosion control is not easy, but there are big benefits to maintaining a reasonable water quality for downstream users. As far as operation goes, continue to use the micro-release fertilizer products, do not spray over water surfaces, cover critical storm drains during application, and be careful about chemical storage. These are the same practices that golf course superintendents have been using for years.

Q: *Are there aspects about your research that you would change if you were to repeat it? Are there cautionary notes that you would share with other researchers who may be considering similar work?*

A: I can't think of any major changes I would make other than to be sure to place water samplers high enough on the bank so that a major storm doesn't wash them downstream. Watershed-scale work is challenging. There are lots of sources of variability: streamflow rates, channel cross sections, year-to-year weather, changes in fertilizer composition, and more. Measuring water quality from an operational golf course is important and valuable to the golf industry. The data can be compared with field-scale plot research projects, and they provide measured water quality information about what is occurring in the watershed.

Q: *What is the "bottom line" message from your work? In your opinion, how do golf courses rank in terms of land uses that may affect the environment?*

A: The bottom line is that the construction phase is critical. There is considerable potential for stream systems to be negatively impacted by high concentrations of soluble solids in the stream. Also, the public notices if the stream water clarity goes from good to bad, so the aesthetic value of the resources is reduced. Several stream biology, avian, plant, soil, and water environmental parameters have been studied at Colbert Hills by myself, Drs. Thein, Robel, Whiles, and others. It is my opinion that once Colbert Hills Golf Course was covered in turfgrass, environmental parameters could return back to prior conditions. Obviously, there is a 110-acre area of managed turfgrass that is going to stay in golf course condition and not be allowed to revert back. Overall, the stream water quality during operation is quite similar to the previous pasture condition.

Jeff Nus, Ph.D., *manager, USGA Green Section Research.*

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