The turbulence created as water passes the end of the wall that is used to control shoreline erosion will begin to back-flush soil from behind the structure. This process is exacerbated when flood waters flow over the top of the wall. In the end, these walls usually collapse, or the soil behind them must be continually replaced.

TAMING WILD WATERS

Using soft engineering principles to control erosion and create a wildlife habitat.

by LON MIKKELSEN

WHO AMONG US has not had a perfect round of golf spoiled by an errant shot landing in a water hazard? The truth is, most golfers consider streams and lakes to be nothing more than obstacles. In fact, if it weren't for the occasional complaint about the grass not being mowed to the water's edge, golfers probably would not give water hazards any serious thought.

In reality, streams often play multiple roles in the golf course landscape. The most obvious is that they are used by golf course architects to add challenge to the course layout. As significant as this role is to the game, an even more important role is the ability of a stream to contain and release surface and subsurface runoff water from the course.

For a stream to function properly in the golf course landscape, certain criteria should be taken into account during its design and routing. These criteria can be broadly divided into two categories — structural and environmental.

From a structural perspective, the design of a stream should take into consideration shoreline erosion, sediment accumulation, cost of maintenance, public safety, ground stability around bridge foundations, and downstream flooding. From an environmental perspective, wildlife habitat, noxious weed proliferation, and the transport of pesticides and fertilizers are crucial concerns.

Until recently, the relationship between structural and environmental design criteria was either discounted or, worse yet, completely ignored. This failure gave birth to single-objective designs that, in many cases, have had recurring financial consequences.

Single-objective designs are those that take into consideration a single criterion and generally ignore the multitude of forces that cause a stream's personality to change over time. Using structural criteria, an example of a single-objective stream design would be one that focuses on shoreline erosion above all other criteria. This design is very common and can be found on most golf courses. The conspicuous feature of this design is a fixed, vertical wall constructed with available materials, such as gabion cages, concrete or railroad ties.

The Achilles' heel of a fixed, vertical wall is that it sometimes limits the cross-sectional area of a stream channel during peak flow. This limitation causes the velocity of the water to increase through the restricted area. By increasing the velocity of the water, it has a greater capacity to pick up sediment, thereby down-cutting the streambed. After several flood cycles, the floor of the streambed is lowered and the water then begins under-cutting the foundation of the wall. If the foundation of the wall is not undermined because, for example, the streambed is solid rock, then the turbulence created as the rapidly moving water passes the end of the wall will begin to back-flush soil from behind the wall. This process is exacerbated when flood water also spills over the top of the wall. In the end, walls used to control shoreline erosion eventually collapse, or the soil behind them must be replaced continually.

Problems also can develop by using single-objective design criteria. A case in point would be the artificial creation of spawning areas for various fish species. If the hydrology of the stream is not fully understood, the spawning areas could quickly disappear. In the process of creating these spawning areas and other wildlife habitat, the stream channel is usually modified. During normal storm events, the stream acts like a conveyor belt, dropping sediment into the spawning areas.

The starting point for designing a successful stream or restoring a degraded one is to examine the drainage basin (watershed) on which the golf course resides. Keep in mind that the size and shape of a stream channel are largely influenced by the characteristics of the watershed.

Prior to urbanization, a watershed has the capacity to store, and then slowly release, large quantities of surface runoff — much like a sponge. As urban development occurs, the characteristics of a watershed (i.e., the water's routing, volume, and velocity) usually change. In developing or urbanized landscapes, watersheds tend to lose their retentive ability as an increasing percentage of rainfall lands on impervious surfaces, such as rooftops and pavement. Once in contact with these surfaces, the water usually is intercepted by a pipe or ditch that routes it directly to a nearby stream. The cumulative effect of decreased water retention throughout a watershed can greatly increase the peak flow of the receiving stream channel. Thus, the impact of urbanization on waterways has ranged from minor stream bank and shoreline erosion to catastrophic flood damage and stream channel degradation.

Except for direct modifications by man, streams change in response to drainage events, which are caused by storms and intensified by urbanization. While the interval between storms is somewhat erratic, the pace of urbanization proceeds at a relatively steady rate. Thus, changes in a stream's hydrological personality are somewhat predictable, but may lag behind urbanization's effect on storm water drainage. In addition, it often takes many drainage events before urbanization changes are fully manifested in stream channels.

Many of our watersheds are now undergoing a rapid rate of change. The unsteady nature of an urbanized stream causes more than channel alterations. It forces a change in the way golf courses are managed. Green committees, superintendents, and golf course architects have to reevaluate course play, infrastructure, and course layout.

These reevaluations are necessary when the current hydrology (stream flow) is no longer supported by the stream channel. The old stream channel must adjust to increase its capacity to convey flows resulting from altered hydrology. Channel widening and down-cutting, bank erosion, sediment deposition, loss of vegetation, and undermining of bridge and wall foundations are just a few of the responses one can expect from a stream's changing hydrological personality.

Added to the typical structural problems is an increasing awareness of environmental issues and a need to incorporate them into any restoration project. Creating and maintaining buffer zones along streams and lakes to lessen the impacts of pesticides and fertilizers, erosion and sediment control, and creating or enhancing habitat for fish and wildlife are just a few considerations imposed on course managers when designing or undertaking stream and lakeside restoration projects.

Realizing the potential effects of urbanization on a watershed, it may be helpful to work with city, county, and state agencies and planning boards. By working in a cooperative manner, the peak flow down a water channel can be controlled by periodically storing storm water in available flood plains. Such flood plains can be incorporated into a watershed by including them in the design of parks and golf courses, or by adding retention reservoirs downstream from large impervious surfaces, such as shopping mall parking lots.

Traditional methods of preventing bank erosion are becoming outdated in many cases, since they do not address a full list of structural and environmental concerns. The challenges posed to design and restoration professionals have developed into a need to provide multi-objective designs that resist erosion and address environmental concerns. The development of soft engineering principles is a natural outcome of these events.

Soft engineering is based on the philosophy of working with nature by examining a stream's natural communicators and understanding its hydrological personality, both present and future. To prevent catastrophic shoreline erosion and create a stable wildlife habitat, construction materials must be selected for each section of a stream channel based on the water velocity and flow characteristics. After the stream channel has been constructed, a broad range of native riparian vegetation must be established to provide a highly resistant erosion barrier.

In some cases, the fundamental elements of soft engineering must be adjusted to avoid conflict with golf course management considerations. These considerations include the pruning of vegetation to prevent obstruction of play, shading of greens and tees, and/or maintaining viewing corridors. The merits of soft engineering designs include relatively low-cost erosion protection, habitat enhancement, water quality improvement, and a natural appearance.

Designing stream channels that are a true asset to the architectural theme of a course, that resist shoreline erosion, and provide valuable wildlife habitat is an ominous challenge. To be successful, the design must consider multiple structural and environmental objectives. If these objectives are not carefully balanced using soft engineering principles, the eventual result will be a catastrophe — either structural or environmental.

LON MIKKELSEN *is a principal with Inter-Fluve, Inc., located in Hood River, Oregon. Over the past 12 years, Inter-Fluve, Inc., has restored or created more than 350 miles of stream channels and hundreds of acres of lakes and wetlands in urban and rural environments.*