Landscape BMPs

For the purposes of this project, preventive measures have been categorized into two categories: landscape BMPs and source prevention BMPs. Landscape BMPs includes both vegetative practices (such as vegetative buffers) and structural controls that are engineered and incorporated into the course during golf course design and construction. Both vegetative practices and structural controls detain water and thereby reduce runoff quantity and nutrient and pesticide discharge.

The effectiveness of pollutant removal by landscape BMPs is a function of the following:

- physical, chemical, and biological processes
- the fraction of runoff treated by the BMP
- the nature of the pollutant being removed

Thus, an effective BMP train is one that treats 100% of runoff by physical, chemical, and biological processes. The table below shows relative removal efficiencies of infiltration basins, vegetated filter strips, grass swales, wet ponds, and storm water wetlands for five variables (total suspended solids, total phosphorus, total nitrogen, pesticides, and chemical oxygen demand). By including as many removal mechanisms as possible, the probability of success for removal of a particular pollutant is increased. These factors should be considered as follows:

1. BMPs that use settling and filtering processes are relatively effective at removing sediment and pollutants that are bound to sediment particles.

2. Turf buffers are very effective filters that allow drainage of water from the course and, at the same time, effective filtering to improve water quality.

3. Turf density, leaf texture, and canopy height are physical factors that restrain soil erosion and sediment loss by dissipating impact energy from rain and irrigation water droplets providing a resistance to surface movement of water over turf.

4. Ponds and infiltration BMPs can achieve 60 to 100% removal efficiencies for sediment.

5. Infiltration BMPs are capable of similar removal efficiencies for sediment, but are subject to clogging if sediment inputs are excessive.

Wet ponds and extended-detention ponds with shallow marshes have a moderate to high capability for removing both soluble and particulate pollutants because they use settling and biological uptake and degradation of pesticides.

Stormwater pollutant removal efficiencies, urban BMP designs (Sources: Schueler 1987 and NYSDEC, 1993)

BMP/Design	TSS*	TP	TN	Zn	Pb	BOD
Extended Detention Pond						
“First flush” runoff volume produced by 1.0 inch storm, detained for 24 hours	75%	50%	35%	55%	55%	40%
Runoff volume produced by 1.0 inch storm detained for 24 hours or more with shallow marsh added in bottom stages	80%	70%	55%	75%	75%	50%
Wet Pond						
Permanent pool equal to 0.5 inch of runoff per watershed acre	55%	35%	25%	25%	45%	25%
Permanent pool equal to 2.5 times the volume of runoff from the mean storm (0.5 inch)	75%	55%	40%	40%	70%	40%
Water Quality Basin						
Infiltration basin which exfiltrates “first flush” of 0.5 inch runoff/impervious acre	70%	50%	50%	50%	50%	70%
Filter Strip						
25 to 50 foot turf strip	40%	20%	20%	40%	40%	20%
100 foot wooded strip	90%	50%	50%	90%	90%	70%
25 to 50 foot wooded strip	80%	40%	40%	80%	80%	60%
Grassed Swale						
High slopes with check dams	20%	20%	20%	10%	10%	20%
Low gradient	30%	30%	30%	20%	20%	30%
*TSS= Total Suspended Solids; TP=Total Phosphorus; TN= Total Nitrogen; Zn=Zinc; Pb=Lead; BOD=Biological Oxygen Demand						

Structural Controls

Structural controls include water quality basins, infiltration basins, and catch basins to regulate or impound runoff. These structures detain and filter water through plant material prior to discharge and can reduce runoff quantity as well as nutrient and pesticide discharge.

Subsurface Drainage. Subsurface drainage directs drainage water and can reduce runoff and leaching. Subsurface drainage is also installed to control a water table or to interrupt subsurface seepage or flow. Where possible, directing this drainage into vegetative areas for biological filtration or infiltration basins helps to control the potential loss of nutrients and pesticides from the golf course, rather than directly draining it into surface water.

Water Quality Basins. These basins are designed to capture the "first flush" runoff and provide water quality treatment primarily through physical settling of sediment-based pollutants. These basins can be constructed by excavation or embankment (or both) to create a ponding area sufficient to handle the required water quality volumes. Planting wetland species in the bottoms of these basins achieves additional quality control through biological filtering and uptake. The discharge system for basins can include a gravel underdrain layer with a small diameter perforated drainage pipe to slow dissipation of runoff over an extended period. Gravel underdrains without an outlet can also provide a measure of infiltration and groundwater recharge where appropriate. Finally, higher intensity storms can be routed through water quality basins for proper flood control and flow attenuation.

Wet Ponds. These ponds are earthen embankments or a combination ridge and channel generally constructed across the slope and minor watercourses to form a sediment trap and water retention basin. Wet ponds are one of the most effective structural BMPs for protecting water quality. Wet ponds at the golf course use a permanent water surface to achieve a high removal rate for sediment, nutrients, and metals. Aquatic plants and biochemical processes within the ponds enhance the removal of nutrients, metals and other pollutants. Secondary benefits include recreation, aesthetics, and wildlife habitat.

Pollutant removal efficiencies of wet ponds vary based on the pollutant of concern and the size of the permanent pool. The highest removal efficiencies are achieved in larger ponds at the golf course, where the ratio of basin volume to the volume of runoff from the average storm is greatest. Wet ponds are also effective in reducing peak discharges, downstream flooding, and stream bank erosion at the golf course.

This feature traps and removes sediment and sediment-attached substances from runoff. Trap control efficiencies for sediment and total phosphorus transported by runoff may exceed 90% in silt loam soils. Dissolved substances, such as nitrates, may be removed from discharge to downstream areas because of the increased infiltration. Where geologic conditions permit, the practice leads to increased loadings of dissolved substances toward groundwater. Water temperatures of surface runoff, released through underground outlets, may increase slightly because of longer exposure to warming surfaces during its impoundment.

Infiltration Controls. Infiltration controls are a general category of structural BMPs that maintain or enhance the ability of water to percolate through the soil profile. Infiltration generally improves water quality by allowing natural physical, chemical, and biological processes to remove pollutants. Pollutant removal in an artificial media or natural soil profile occurs through filtration, absorption, and oxidation by soil microorganisms.

Catch Basins. Catch basins are used primarily as a pretreatment device for the removal of coarse grit, sand, and debris. This pretreatment extends the life and performance of the other BMPs. From the catch basins, runoff is conveyed to the other water quality BMPs.

Wetland and Riparian Zone Protection. Wetlands and riparian areas are often continuums along rivers, streams, and coastal waters and are particularly sensitive to landscape changes and fragmentation.

These areas play a critical role in attenuating nonpoint source pollution by intercepting runoff, subsurface flow, and certain groundwater flows and then removing, transforming, and storing pollutants (such as sediment, nitrogen, phosphorus, and certain heavy metals). In addition, they provide aquatic habitat, stream shading, flood attenuation, shoreline stabilization, and groundwater recharge. Wetlands and riparian areas are often highly regulated by the state and local regulatory authorities.

Constructed Wetlands. Constructed aquatic ecosystems features poorly drained soils and rooted emergent hydrophytes, which simulate the role of natural wetlands in water purification. These structures efficiently remove certain pollutants (nitrogen, phosphorus, metals, sediment, and other suspended solids) and can treat wastewater, such as discharges from equipment wash pads. Once these areas are constructed, however, they are considered wetlands and regulated as such.

Vegetative Practices

Turf uses the natural processes of infiltration, filtration, and biological uptake to reduce flows and pollutant loadings. A number of vegetative practices can be used to incorporate these processes in golf course design.

Vegetative Filtration. Common examples of vegetative filters that can be used throughout the golf course are conservation areas or buffers, land absorption areas (vegetated filter strips) and swales (diversions, berms). Vegetative filters act as natural biofilters to reduce storm water flow and pollutant load, and turf areas are effective filters.

Vegetated filter strips remove sediment and attached chemicals, organic material, trace metals, and nutrients (nitrogen and phosphorus). Sediment removal rates are generally greater than 70% and nutrient removal is typically greater than 50%.

Vegetative filters require management to achieve dense, hearty vegetation. Where changes in vegetative cover must be made, these changes are normally established in low maintenance ground covers. This practice may include the use of native or naturalized plants, including low maintenance turfgrasses. When turf is used as the filtration medium, cultural activities should focus on producing healthy turf with a minimum of maintenance activities.

Turf should be allowed to grow to the highest end of the optimum range for more effective filtration. Fertilizers and pesticides are usually not applied in these areas except sparingly (sometimes during establishment to reduce erosion and runoff problems much faster) or after a risk assessment has determined that application of certain materials will have no impact in adjacent areas. Establishing these buffers reduces erosion and sediment loss decreases. Buffers also protect surface waters by attenuating pollutants in surface runoff.

Soil surface runoff may also be moderated, reducing the impact on receiving water bodies and streams. The greatest benefit is the protection of adjacent ecologically sensitive areas—potential pollutants are simply not introduced, or are introduced on a limited basis compared to more highly maintained turf areas. Figure 4-1 shows several examples of vegetated buffers.

Conservation Areas or Buffers. These are areas where it is critical to establish and maintain perennial vegetative cover to protect resources. The most sensitive portions of watercourses are the areas immediately adjacent to the water. Disturbance within and adjacent to watercourses can degrade water quality by increasing the availability and transport of pollutants. Therefore, retaining vegetated buffers along watercourses is one of the most effective practices used to protect water quality and should be designed to handle the anticipated runoff. If the area is a state or locally designated wetland, a buffer may be required and the width of the buffer specified by the regulating authority.

Critical Area Planting. Planting vegetation on highly erodible or critically eroding areas also protects water quality. The greatest amount of soil erosion and sediment delivery to surface waters occurs when large areas are graded during the construction phase, which requires phased construction to minimize the amount of bare land. Quickly establishing vegetation reduces the movement of materials in runoff, as plants take nutrients in the soil and reduce the amount that can be washed into surface waters or leach into groundwater, as well as trap particulates.

Vegetative buffers. *Source*: Jennifer Grant.

Sodding is an important consideration in these areas since it provides instant ground cover and rooting can occur rapidly for permanent establishment. In certain instances, strip sodding rather than solid sodding can be used if the slopes are not too steep and the strips are wide enough to adequately handle the sediment carried in the runoff. However, sod production systems that use inputs can potentially contribute to water quality issues after installation; pesticides have been found in groundwater monitoring wells on very sandy sites following sodding.

Grassed Swales or Berms or Diversions. Channels constructed across a slope with a supporting ridge on the lower side are another effective control. These channels stabilize a runoff area and reduce sheet and rill erosion by reducing the length of slope. These measures also eliminate vertical channeling and large gullies, which reduces the amount of sediment and related pollutants delivered to the surface waters.

Berms direct water into specific areas to allow vertical filtration rather than allowing surface runoff. Vegetated swales are used to permit filtering and infiltration of storm water. The grasses for these swales should be water tolerant and erosion resistant (rapid germination and establishment to form dense sod). These types of swales are used on gentle slopes where slower velocities enhance the filtering and infiltration processes.

Swales are also effective in routing water to maximize contact time of water and vegetation. An example in which swales are helpful is the routing of water from the underdrains of greens. Filtration can be greatly increased by carefully choosing the route of water from the underdrain. If space is limited, drainage water could be directed to flow along a path that maximizes the distance of contact with vegetation, rather than choosing the shortest route to the lowest elevation. The effectiveness of swales in reducing flows and pollutants is similar to that of filter strips.

Vegetated Filter Strips. Filter strips are manmade or naturally occurring flat areas established at the perimeter of disturbed or impervious areas to intercept runoff as sheet flow and remove particulate matter and contaminants. Either grassed or wooded areas can function as filter strips.

Grassed Waterways. These natural or constructed channels are shaped, graded, and planted to ensure the stable flow of runoff. This practice reduces erosion in a concentrated flow area, such as in a gully or in ephemeral gullies, and reduces sediment and substances delivered to receiving waters. Vegetation may also filter some of the sediment delivered to the waterway; however, filtration is a secondary function of a grassed waterway.

Any chemicals applied to the waterway in treating the adjacent areas may wash directly into the surface waters when runoff occurs shortly after spraying. If standing water is present, applications of fertilizer or pesticides should also be avoided.

Turfgrass used as a Vegetative Filter. One of the most effective BMPs for protection of surface water is use of turf as a vegetative filter in swales and filter strips. Turfgrass areas are extremely effective in reducing soil losses compared to other cropping systems. In a comparison of soil loss from conventional agriculture with soil loss from turf, measured soil loss from tobacco production (4210 lbs/acre) was 842 times higher than from turf areas (5 lbs/acre), even with a slope of 16% on a silt loam soil.

Where polluted runoff from agricultural areas has occurred, establishment of turf buffer strips of only 15 feet have been shown to improve water quality. Studies at Oklahoma State University have shown that turfgrass buffers of 16 ft effectively reduce concentrations of chemicals in runoff (Cole et al 1997). Other studies noted that in cases where water quality has declined due to agricultural practices that lead to loss of nutrients and erosion, grass buffer strips placed between treated fields and surface waters significantly reduce the problem. This result is related to the architecture of the turf canopy, the fibrous turf root system, and the development of a vast macropore soil structural system that encourages infiltration rather than runoff.

Grass filter strips discharging into water filtration basins. *Source*: Robert Alonzi.

Turf density, leaf texture, rooting strength, and canopy height physically restrain soil erosion and sediment loss by dissipating impact energy from rain and irrigation water droplets. These turf features also provide resistance to surface movement of water over turf. Additionally, turfgrasses have an extensive fibrous root system, with 80% of the root mass found in the upper 4 inches of the soil profile. The combination of turf canopy and root mass has a strong soil stabilizing effect.