Golfing Green Virginia

Golf Course Environmental Stewardship

Golf courses represent an increasing land use in Virginia. Golf offers recreational opportunities and is open space in urbanizing landscapes. Like any development activities, golf course development can result in environmental impacts greater than if the land were in a natural, wooded condition. Using best management practices (BMPs) that specifically address controlling nutrient and pesticide pollution of ground and surface waters can minimize adverse effects and create benefits. These practices also promote conservation of irrigation water, recycling of materials generated on golf course properties, restoration of plants native to Virginia and beneficial management of wetlands.

Golf course superintendents are well trained in maintaining quality turf for the game of golf. This publication highlights golf course BMPs that can positively impact environmental stewardship efforts. Each BMP is described individually, identifying its benefits and detailing basic principles for adopting the practice in a golf course setting.

The BMPs were selected for use in Virginia by a committee comprising state natural resources agency representatives, consulting firm representatives, and university extension personnel. They were presented at the Environment Virginia 2002 "Golfing Green Virginia Workshop" hosted by the Virginia Military Institute on April 11, 2002.

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BMP #1 Develop a Nutrient Management Plan

A nutrient management plan promotes healthy turf while minimizing the loss of nutrients to the environment. Golf course superintendents can use this type of plan to apply lime and fertilizer efficiently and economically. It may also save on costs while improving turf health by reducing mowing and the over-application of nitrogen. Nutrient management plans are proven to produce vigorous, hardy grass plants.

A plan's site-specific nutrient recommendations for fairways, tees, greens and roughs are based on inputs analyzed to produce agronomically sound and environmentally friendly recommendations. These plans are written to established standards that assure minimum nutrient loss to the environment.

Some inputs used to develop nutrient management plans include:

- Detailed map of locations and sizes of areas to be treated.
- Identification of soil characteristics.
- Type of turf determines proper timing of fertilizer.
- Soil tests to determine plant nutrient needs, based on existing nutrient levels.
- Environmentally sensitive areas identified and appropriate management practices, including buffers and application timing, recommended to minimize nutrient loss from the root zone.
- Irrigation water analysis to determine what nutrients at what rates are supplied through irrigation water.
- Current fertility program used to established residual nitrogen contributions to adjust current season's nitrogen rates.
- Recommendations are made including the type, amount and timing of lime and fertilizer applications.

As the input data changes or is updated (example: when new soil test reports are received), the plan is revised. Usually, this involves adjusting nutrient recommendations as needed to maintain positive environmental effects from following the plan.

The goals of nutrient management planning for golf courses are simple, but important. Apply fertilizer while plants are actively growing so the plant will "take up" the nutrients. Apply nutrients at rates that closely match the nutrient need of the plant during the time period for which the application is made. Nutrients taken up by the plant are not subject to being lost by leaching down through the soil profile or by water running off the landscape into streams and lakes.

BMP **#2**

Recycle Nutrients in Grass Clippings

Golf courses commonly maximize the benefits of recycling grass clippings on most areas, a nutrient management practice that uses already available nitrogen. Dried grass clippings contain between 2 and 5% nitrogen, thus can account for more than 80 pounds of nitrogen per acre, or two pounds of nitrogen per 1,000 square feet *per year*. As they decompose, clippings release nitrogen to the soil that can become available for plant growth. **Returning clippings to the turf can reduce fertilizer requirements by 30% or more**.

The most efficient strategy to recycle nutrients in clippings is to leave them where they are cut. Frequent mowing during the active growing season should keep the volume of clippings to a low level that won't interfere with golf play in fairways. Areas should be mowed when grass blades are dry to minimize clumping, allow the fine clippings to filter into the sod and minimize potential disease transmission by the mowing equipment.

Since removing clippings is often necessary on tees and greens, a strategy for reusing them is a critical nutrient management practice to reduce pollution potential. Collected grass clippings *from tees and greens* should be uniformly spread on grassed areas of the rough, being careful not to apply so thickly that grass is smothered. Alternatively, grass clippings may be composted by thoroughly mixing with leaves or other high carbon materials and composted for use in repairing or expanding turf areas on the course. As they are nitrogen rich, a mix of one-part clippings to three parts leaves, wood chips or sawdust is recommended. Either way, the nutrients in clippings can be recycled to reduce fertilizer expenses as well as environmental impacts.

If disposed of improperly, such as dumping in the woods, clippings can leach nutrients through soils and contaminate groundwater. If put in low-lying areas, the clippings and/or the nutrients contained therein can be washed into nearby streams, ponds, lakes, or rivers where they contribute to algae blooms and other water quality problems.

BMP #3 Recycle Nutrients from Irrigation Water

Many golf courses depend on ponds for irrigation water. While ponds supply needed water to supplement natural rainfall, water in them may contain nutrient levels sufficient to consider in the overall nutrient management plan. Because ponds within the course property often are collection points for stormwater runoff and attract waterfowl, they may contain nutrients and other pollutants. Recycling pond water for irrigation use can reduce the amount of nitrogen leaving the spillway that could contaminate surface waters downstream.

Planned fertilizer applications should be reduced by the amount of nutrients supplied in the irrigation water. Golf course operators should test pond water for nutrient levels, particularly nitrogen, at least twice a year. This can be done when water is analyzed for soluble salts. One part-per-million (ppm) or one mg/l of nitrogen in water is equivalent to 2.7 pounds of nitrogen per acre-foot of irrigation water applied. For example, if water has 8-ppm nitrogen, and a total of 12 inches of irrigation is applied during a season, about 22 pounds per acre or 0.5 pounds per 1,000 square feet of nitrogen will be supplied to the grass.

If well water is used as a back-up supply of irrigation water, it should be tested for nitrate-nitrogen. Any significant content of nitrate-nitrogen in well water used for irrigation should be used when determining nitrogen fertilizer rates. Areas within the Shenandoah Valley and Eastern Shore regions of Virginia have documented groundwater contamination from high nitrates.

Re-using disinfected wastewater for irrigation may be a viable option in Virginia in the near future. This practice is a primary source for irrigation water in some western states. If managed properly, its use could be very beneficial in conserving groundwater and surface water. Wastewater usually contains significant quantities of plant nutrients, so a nutrient management plan for the golf course using it may indicate a reduction in applied fertilizers.

Recently, there has been interest in using gray water and treated effluent from sewage treatment plants, or reclaimed water, to irrigate golf courses. This may have the added benefit of potentially supplying nitrogen and phosphorus, enabling the course to reduce applied fertilizer. However, if a course uses reclaimed water for irrigation, then testing and tracking the nutrient content of the water is critical.

BMP #4 Sound Fertilizer Use

Maximize nutrient uptake by grasses and reduce its runoff by applying the proper ***rate*** of fertilizer and controlling the ***timing*** of applications. Apply **no more than** one pound of water soluble nitrogen contained in fertilizer per 1,000 square feet within any 30-day window on fairways and **no more than** 0.75 pounds per 1,000 square feet on sand-amended greens and tees. Alternatively, use slowly available nitrogen fertilizers to control the timing of nitrogen release to the grass.

The following ranges of annual nitrogen rates are appropriate for golf courses in Virginia:

Annual nitrogen fertilizer (lbs/1,000 sq. ft.)

	Fairways	Tees	Greens	Roughs
Cool Season	**2 – 3**	**2 – 5**	**3 – 6**	**1 – 3**
Warm Season	**3 – 4**			

For cool season grasses like fescue and ryegrass, fertilize when the grass shoots or roots are actively growing, generally in the spring and fall, with lighter applications during the summer if needed. Warm season grasses begin growth later in the spring and cease growth earlier in the fall so fertilizer schedules should favor spring and summer applications. Nitrogen-containing fertilizers should not be applied in the fall on warm season grasses, or in the winter on either warm or cool season grasses. There is little or no fertilizer uptake by grass makes this the period of greatest leaching potential for nitrogen.

Phosphorus is less mobile in soils than is nitrogen; therefore timing of applications during the year is not as critical. Excessive phosphorus applications to turf grass can accumulate near the soil surface, and could cause polluted runoff to surface waters during rainstorms or with excessive irrigation water. Established golf courses may need little or no phosphorus; phosphorus applications to golf courses should always be based on soil tests. Avoid the general use of high phosphorus ratio fertilizers, such as 10-10-10 or 5-10-10, unless soil tests indicate phosphorus availability below the medium level. Potassium is intermediate in terms of mobility in the soil. Base these applications also on soil tests.

BMP #5 Compost Wastes for Re-use

Materials generated through normal golf course maintenance can be mixed and composted to use on the property. Compost is an excellent soil amendment for repairing turf areas of a course or developing additional areas. Compost is the end-product from controlled aerobic decomposition of plant and/or animal waste material, such as leaves, grass, twigs and paper. It is entirely different from the raw materials used to create it. This finished product is a mixture of complex compounds that is free of unpleasant odors, can be stored for long periods of time and is easy to handle. It has high humus content, which makes it less dense than soil, yet it holds more nutrients and water than soils.

Compost has numerous environmental benefits:

- Added organic soil content, increasing nutrient levels and allowing for better water retention in sandy and clay soils.
- Increased fertility for soils on slopes and in exposed areas, allowing for faster and more adequate turf grass growth, which can reduce soil erosion.
- Improved water holding capacity of soils, allowing plants to thrive with less water/reducing drought effects.
- Improved soil structure and aggregation, promoting better plant rooting and soil's capacity to better withstand compaction forces from golf carts and mowing equipment.
- Increased soil aeration, allowing better plant root development and biological activity.
- Improved soil nutrient holding capacity, minimizing leaching of plant nutrients, making them available to plants over broader climate and soil physical conditions while reducing the risk of water contamination.

Approximate mixtures of golf course waste materials for composting consist of one part grass clippings to three parts leaves. A reasonable amount of ground twigs can be added to the blend. Twig grindings should not be considered a carbon contribution to the mix, but are beneficial bulking agents providing air space. Proper active composting requires temperatures between 110 and 150°F, moisture content between 50 and 60%, and adequate oxygen for the microbes. Odors at compost sites can be an issue if piles are not aerated properly; materials should be turned and re-mixed every few days. Turning and bulking agents are especially critical if grass clippings are a major component of the compost. Composting is complete when pile temperatures remain below 105°F. A subsequent curing period of 2 to 6 months is recommended for compost to mature, after which it will not overheat or produce unpleasant odors during use or storage.

BMP #6 Wetlands Benefits

Benefits of wetlands are numerous: they retain sediment and remove nutrients, control flooding, encourage wildlife and aquatic diversity and discharge or recharge groundwater.

Sediment and nutrient removal in wetlands is important to protect downstream food sources for fish. Sediment that gathers downstream can smother insect populations and prevent light from reaching water plants, limiting plant growth. Nutrients from fertilizer carried in stormwater runoff and already in ponds also create problems for downstream water bodies. Like the Chesapeake Bay, small water bodies become nutrient-enriched, resulting in large algal blooms. When the algae die, their cells consume oxygen in the water, contributing to fish kills as well as taste and odor problems in public water supplies. Wetland plants consume nitrogen and phosphorus and reduce these potential impacts.

Golf courses using groundwater for irrigation may find wetlands very useful for slowing surface water runoff. As the runoff is slowed, groundwater is recharged and the potential for flooding downstream properties is lessened.

Wetlands themselves produce a large amount of food called detritus, created from leaves and stems breaking down in water. Detritus is food for insects, shellfish and forage fish, and it provides nutrients for wetland plants. Recreational fish, such as striped bass in lakes downstream of wetlands, as well as mammals, reptiles and amphibians, eat aquatic invertebrates and forage fish.

Constructed wetlands

The base layer of constructed wetlands should be impervious to prevent infiltration into groundwater. Also, to avoid wetlands filling with sediment, construct settling basins to hold stormwater flows. Slowing these flows can reduce erosion. Constructed wetlands are just one way to accomplish this. Other methods include adding rock check dams or level spreaders. Construction disturbing more than one acre of land may be required to have a permit from the Virginia Department of Environmental Quality.

Constructed wetlands that meet all U.S. Army Corps of Engineers criteria may be sold to a wetland mitigation bank, as an offset to a locality or company that must replace wetlands destroyed for construction projects. To be eligible the wetland is required to become permanent.

BMP #7 Maintain Water Quality Buffers

Buffers are vegetated strips of land typically composed of meadow or woody plants, usually located between surface water bodies and playing areas. Specifically, water quality buffers protect wetlands, sinkholes, erosion prone areas and water bodies such as ponds, lakes and streams by reducing contaminants in surface runoff or subsurface water flow that originates in fairways, tees, greens and other maintained areas. According to one study (Herson-Jones et al., 1995), buffers that are wide enough to provide "nine minutes of residence time for stormwater runoff can be expected to remove up to 80 percent of total suspended solids."

Buffers featuring woody vegetation or matted layers of tall grasses and other meadow plants are typically more effective for stormwater treatment and water quality protection than are buffers primarily consisting of turf grasses. Denser, deep-rooted areas are effective at removing sediments, fertilizers, pesticides and grass clippings in surface water runoff and have several advantages:

- Trunks, stems and leafy ground cover slow down runoff in areas prone to concentrated amounts from storms.
- Decomposing woody roots help nitrate convert to less mobile forms of nitrogen.
- Nutrients accumulate in woody biomass.
- Forest litter forms a mat to filter runoff water.
- Forest litter provides a carbon source to fuel the process that removes pollutants.

Unfertilized rough, mowed no lower than three inches high, should be maintained in areas around surface waters where it is not feasible to maintain buffers of woody vegetation or thick stands of meadow plants.

BMP #8 Native Plants for the Landscape

Generally, native plants require less water, fertilizer, and less pest control than imported ornamental species. Golf course managers can promote these species and educate course users about their environmental benefits by posting signs and labeling native plants in the landscape design.

In flowerbeds and landscaped areas around the clubhouse and parking lot, consider using plant species native to the region. Native plants often benefit resident birds and butterflies, are well adapted to climate and conditions of their region and reflect a region's natural character. Many native species have been developed for horticultural use, including herbaceous species with showy flowers, such as butterfly weed (*Asclepias tuberosa*), New York aster (*Aster novi-belgii*), and mistflower (*Eupatorium coelestinum*). Ferns, such as cinnamon fern (*Osmunda cinnamomea*), and grasses like switchgrass or eastern gama grass add interesting texture to landscape design. Red chokecherry (*Aronia arbutifolia*), downy serviceberry (*Amelanchier arborea*) and other native shrubs and trees bloom attractively and provide food and cover for birds.

Another use for native plant species is to create or maintain corridors of continuous cover, connecting habitats in and around the golf course. These corridors allow wildlife to move across the landscape between habitats. Many animal species cannot cross large open areas, such as golf course fairways, or do so only at risk of succumbing to predators. Corridors vary in width; animals choose those that suit their need for cover. A corridor that works for migratory songbirds, which could be no more than a hedgerow of shrubs, is not large enough for deer. Generally, wider corridors are favored by more species than narrow ones.

Many areas within a golf course are often left in a natural state. Natural or naturalized woodland or forested areas may be a habitat patch or a corridor, or both. Some corridors may serve multiple ecological functions. Riparian buffers, for example, help protect water quality and are excellent wildlife corridors.

BMP **#9**

Protect Natural Resources When Constructing a Golf Course

Golf club members can help influence sound decisions in the construction and operation of golf courses. The following principles outlined in *Principles for Golf Courses in the United States* (USGA, 1996) are excellent suggestions for golfers:

- Recognize that golf courses are managed land areas that should complement the natural environment.
- Respect environmentally sensitive areas within the course.
- Accept natural limitations and variations of turf grass plants growing under conditions that protect environmental resources.
- Support golf course management decisions that protect or enhance the environment, and encourage development of environmental conservation plans.
- Support maintenance practices that protect wildlife and natural habitat.
- Encourage maintenance practices that promote long-range turf health and support environmental objectives. Such practices include aeration, reduced fertilization, limited play on sensitive turf areas and water conservation.
- Commit to long-term conservation efforts (efficient water use and Integrated Plant Management) on the golf course.
- Educate others about the benefits of environmentally responsible golf course management.

Support research and education programs that expand our understanding of the relationships between golf and the environment.

BMP **#10**

Reduce Reliance on Pesticides With Sound Turf Management

Implementing classic agronomic turf grass management principles can reduce the need for pesticides.

Fertilization - Fall fertilization of cool season turf grass has been shown to produce increased root growth, turf density, drought tolerance, fewer summer annual weed problems and decreased summer disease activity. In addition, fall fertilized cool season turf remains greener throughout the winter and greens up earlier in the spring. Annual soil testing and sound nutrient management principles will help produce healthy turf. There may be less need for pesticides as the turf out-competes weeds, withstands insect infestations and is less susceptible to certain turf diseases.

Mowing - Whenever more than 40% of the existing green tissue is consistently removed in grass, there is a significant detriment to the root system. By returning clippings to the grass, one can expect higher turf grass quality with a lower fertilizer requirement. Higher mower heights (for rough areas on the golf course) have been shown to reduce soil temperatures and enables the turf to better compete against certain weed species.

Aeration - Periodic aeration alleviates compaction, re-inoculates thatch layers with soil, increases water infiltration, rooting and stored food reserves. With less compaction, it is reasonable to expect a decrease in the incidence of related problems such as high temperature injury, scald, wilt, drought damage, cellular freezing and winter desiccation.

Pesticide selection - Earthworms play a major role in the thatch decomposition process as well as in soil quality. Certain fungicides and insecticides have been known to reduce earthworm populations by 60 to 99 percent, with significant effects lasting as long as 20 weeks. Selecting less toxic pesticides can lead to improved turf quality. Make selections with target species, pesticide characteristics and the application site in mind. Soil texture, pH, organic matter, depth to groundwater and geology are site-specific parameters that must be considered. Evaluating and reducing the number of pesticide applications is one of the most effective practices for reducing potential adverse effects from pesticides. Pesticide use should be based on pest pressure and pest thresholds. IPM principles should be an integral part of the turf pest management program.

BMP #11 Follow the Pesticide Label

A pesticide label is a *legal agreement* between the U. S. Environmental Protection Agency, the product manufacturer and the user. The label provides instructions for all stages/phases of product use. Applicators must read, understand and follow label directions carefully. If they don't, they are breaking the law. Pesticides may not be applied to any site not listed on the product label. Materials may not be applied at rates higher than the label directs. Also, applicators are required to follow label directions for transport, mixing, loading, application, storage and disposal of pesticide products and containers. Federal law prohibits the use of any pesticide inconsistent with its label, and sets penalties for deliberate violations.

A pesticide label will have on it the **product name**, which includes the manufacturer's name, and its function. It also has the **active ingredient** and a **toxicity signal word** (danger, warning, caution) that indicates how toxic the product is. The label also has **precautionary statements** defining hazards regarding product use. These hazards may be environmental, physical or chemical. **Directions for use** also appear on the label, as well as **storage and disposal** instructions.

Some of the more common **environmental hazards** associated with pesticide use:

Sprays and concentrates - drift, runoff, groundwater contamination, air pollution, soil contamination and sewage system contamination
Dusts - drift and runoff
Granules - runoff, soil contamination, non-target plant damage and bird kills
Oils - non-target damage due to improper application, spills or improper timing
Aerosols and bombs - non-target damage
Drenches - non-target damage to soil organisms

Following the label instructions means the pesticide applicator is complying with the law. Additionally, he/she is implementing a practice that improves the chances for accurate, safe application of a pesticide product with minimum risk to the applicator and to the environment.

BMP #12 Maintain and Calibrate Spray Equipment

Proper calibration of all pesticide spray equipment is critical. Using too much pesticide may injure turf, is costly and may contribute to an environmental hazard. Using too little may result in little or no pest control and can be costly. All pesticides should be applied at their recommended rates.

Pressure, nozzle size, spacing of nozzles and application speed all affect application *rate*. Sprayers should be operated within the manufacturer's recommended pressure range for the appropriate nozzle and product. Operating at higher than recommended pressures can cause small drops that are more likely to drift or volatilize. Worn nozzles should be replaced. Consider spot spraying whenever possible. All equipment should be in good working order and the sprayer should be configured properly.

Keeping the boom or nozzles as close to the target as possible minimizes spray drift. Use minimal spray pressure and check pressure gauges for accuracy. Avoid spraying on extremely hot or dry days, or when wind speeds are greater than 12 mph. Leave an unsprayed buffer area between water supplies, streams, ponds, wetland areas, downwind neighbors or sensitive plants.

Spray distribution refers to the uniformity of spray coverage across the boom swath. The goal in broadcast spraying is an even (uniform) distribution. Factors affecting spray distribution are nozzle type, spray pattern angle, nozzle spacing and boom height. Nozzle spray angle and the height of the boom will determine overlap between adjacent tips, which is critical to uniform distribution.

<u>Large-area method of calibration</u>

1. Measure and stake off one acre (43,560 sq. ft.)
2. Fill a sprayer tank with clean water (no chemicals added).
3. Spray the acre, maintaining constant pressure and speed. Mark pressure, throttle and gear settings.
4. Measure the amount of water used: The amount of water necessary to refill the tank is equal to gallons per acre applied.
5. Based on the water applied per acre, make up the spray solution with the correct amount of chemical.
6. Make the application at pressure, throttle, and gear settings used in calibrating.

BMP #13 Use Less Toxic, Less Mobile and Less Persistent Chemicals

Signal words on pesticide labels indicate their toxicity levels. ***Danger*** means the product is highly toxic; ***Warning*** means it is moderately toxic and ***Caution*** means either slightly toxic or almost non-toxic. When you can, choose the least toxic product, where control effectiveness is the same. It's safer for the applicator, for golfers on the course and for the living organisms in and around the golf course.

A "less mobile" pesticide is less likely to move off-site and into nearby water resources. Pesticide mobility may vary depending on the product's water solubility or its propensity to travel via air movement. If a product is very soluble in water, then a rain event soon after pesticide application may send residue off-site and into streams. Do not spray when rain is expected. A product that tends to bind to soil particles may not be readily moved; it could take a major rainfall event with much erosion to move it. Pesticides that are more water-soluble are riskier for groundwater contamination. "Drift" occurs with a pesticide when it volatilizes in the atmosphere and moves off site via air movement. Never apply pesticides on a windy day. Adjust nozzles for larger drop sizes and use products not susceptible to drift.

Persistent chemicals are those more active for a longer time in the environment. Products vary in the periods of time their active ingredient persists in the environment. Obviously, less environmental risk is expected with chemicals that don't persist for long periods of time or have low solubility after being applied. Less persistent chemicals is the environmentally friendly choice when pesticides have to be used.

Pesticide application methods should be chosen to minimize off-site loss. Soil applied pesticides should be incorporated or watered in with the proper amount of irrigation water. When choosing products, evaluate proximity to water resources, slope of the land, amount of ground cover, depth to the water table and soil type. When options are available, always choose the least toxic, least mobile and least persistent pesticides.

BMP #14 Integrated Pest Management (IPM)

IPM is a multidisciplinary, ecologically based pest management system that uses all available methods to keep pests at acceptable levels while minimizing effects on people, environment and turf. A sound IPM program is based on a tolerance of pests that does not significantly reduce the quality of the turf.

Pesticides are only one of several options available for use in pest management; IPM can reduce the reliance on pesticides. A knowledgeable superintendent knows the grasses grown, pest threshold levels and the environmental conditions that drive pest outbreaks. The course should have a written pest management plan that includes IPM as its cornerstone. Appropriate agronomic practices, scouting for pests to determine thresholds, weather monitoring and accurate record keeping are important aspects of IPM.

Diseases - Minimize fungicide treatments by maximizing turf grass health through agronomic practices. Generally, lower mower height stresses the plant greatly. Drought- stressed turf can be susceptible to brown patch disease and blight. Timely irrigation is important, as is selecting disease-resistant grass varieties whenever possible. Over-fertilization can also increase the risk for turf disease.

Weeds - Be aware of weed seed sources including: contaminated grass seed, maintenance equipment, straw, mulch, wind, water and golfers. Scout for weeds regularly to help with long-term weed control decision-making. For example, if crabgrass is a problem, then a pre-emergent herbicide in the early spring may be the most effective control. Do not disturb the soil after applying a pre-emergent herbicide because it could reduce its effectiveness. Weed scouting and record keeping the year before helps with decisions the following year. Winter annual weeds often germinate in late summer, which could be the best time for control. Know your weed species, weed populations and their life cycles in order to make the best possible weed control decision.

Insects - Insects that damage turf grass are considered to be root-feeding, shoot-feeding or burrowing. White grubs and billbug larvae feed on roots. Sod webworms, armyworms, cutworms, leafhoppers, chinch bugs, spittlebugs and billbugs feed on aerial shoots. Most insect pests develop very rapidly when air and soil temperatures are optimum. Scout for insect pests during the appropriate time of year. Remember that pesticides can kill beneficial insects. Bio-control agents that can be used for insect pest control include: parasites, predators, pathogens and endophytes. Insecticides are effective tools but they should not be used indiscriminately. Since many products now have a very short period of residual activity, it is more important than ever to scout, determine insect thresholds and to control at the window of opportunity. In order to do this, one needs to be able to recognize the pest, the damage it makes, its life cycle and the control alternatives.

BMP **#15**

Mix and Handle Chemicals Away fromWater Resources

Pesticides, fertilizers and waste from equipment maintenance are all potential sources of surface and groundwater pollution. Small releases of concentrated pesticides over time can result in substantial contamination of water resources, especially ground water. Pesticides and fertilizers are frequently purchased in relatively small containers and mixed prior to their application. Transfer and mixing activities provide opportunities for spills that may threaten water resources. Equipment maintenance includes activities where petroleum products such as motor oil, hydraulic fluid, gasoline and diesel fuel may be spilled.

Especially in the construction of new golf courses and/or maintenance facilities, locations for mixing and handling the chemicals should be sited in areas where a potential spill will be less likely to contaminate a water resource. Consider these features, in terms of their proximity, when determining a suitable site for these activities:

- Creeks, rivers and streams
- Sinkholes
- Rock outcroppings
- Wells
- Storm sewer drains
- Wetlands

Setbacks as large as practical from these features should be maintained. In addition, the quantities of chemicals stored on site should be minimized. In some cases, regulations may require that certain setbacks be maintained.

BMP **#16**

Secondary Containment for Chemical Storage, Handling Areas

Secondary containment for chemical storage and handling areas is very important to reduce potential liability and risk of site contamination. Secondary containment provides a valuable passive measure of spill protection and facilitates product recycling. Secondary containment structures are typically concrete coated with a chemical resistant material. Uncoated concrete is permeable to most pesticides and fertilizers.

A secondary containment device should hold approximately 125% of the largest single container volume within the containment structure. A minimum 2% slope on the containment floor increases the life of the concrete (Broden et al., 1992). Another material commonly used for secondary containment is polyethylene; however, materials such as polyurethane, polyvinyl chloride, polyethylene and other plastics may not be suitable with pesticides that are mixed with solvents. Other secondary containment related recommended practices are as follows:

- Pesticides and fertilizers should be in separate secondary containment structures
- Free liquids should be removed
- No gravity drains should be located in the structure
- No underground or buried pits should be used
- Sumps should be emptied and cleaned daily
- Pesticide mixing, loading and equipment washing should be done within secondary containment under roof to avoid contaminating stormwater
- Containment structures should be routinely inspected for cracks, signs of leakage and free liquids
- Loading areas within secondary containment should be kept clean to prevent tracking by equipment

BMP #17 Conserve Water Resources

Whether it comes from a reservoir, a river or groundwater well, much of the water available at a golf course is shared with the surrounding community. Golf course ponds not only look great and eat golf balls, but are also used for irrigation. Having full capacity is important to courses that rely on ponds for their water. A pond's capacity can be cut in half by poor upstream erosion and sediment control; pond sedimentation can results from construction adjacent to or miles away from the course. Contact local building officials as soon as this problem is noticed to keep course ponds at full capacity.

Streams are often used to irrigate courses. Pipelines leaking sewage and industrial wastewater have been known to lower a stream's quality and may be harmful to turf grasses. Superintendents at courses where stream water is used must be knowledgeable about the stream's quality as well as downstream water users.

On-site wells are another source of irrigation water. However, in the interest of conserving groundwater, it is preferable to use wells only as a last resort to supplement other water sources. The DEQ requires reports for any water user that withdraws ground and surface waters exceeding 300,000 gallons during any single month. In Ground Water Management Areas, water users exceeding the 300,000-gallon per month threshold must obtain a withdrawal permit from DEQ. Current Ground Water Management Areas in Virginia include those east of I-95 and south of the Mattaponi River, including the Eastern Shore.

Gray water and other types of untreated wastewater may also be used for irrigation. Perhaps the largest source of non-sanitary wastewater at clubs having pool facilities is filter backwash. If reuse of backwash is desired, choose a time to backwash when chlorine concentration is at a minimum, like first thing in the morning. Backwash solids should then be allowed to settle for about 24 hours in a tank before the water is used. A septic tank may be satisfactory for this purpose. In using reclaimed water, gray water, non-sanitary wastewater or if draining a pool, care must be taken not to create a discharge to surface water, otherwise a DEQ permit is required.

BMP #18 Schedule Irrigation to Reduce Water Demands

Golf courses can lessen costs, protect natural resources and conserve water with efficient scheduling irrigation. Irrigation requires significant investments in equipment and recurring electricity or fuel costs required to pump water for each watering. Excessive irrigation can increase pesticide and fertilizer costs, as they may wash away.

Several irrigation scheduling practices are available. For most efficient use, water should be applied early in the day or late in the evening to minimize evaporative losses. Morning is preferable – it reduces dew, allowing grass blades to dry more rapidly and decreasing the risk of disease. This is particularly important for greens and other areas that may have species more susceptible to disease.

Soil moisture sensors can be installed in representative areas of fairways as scheduled irrigation tools. They can be monitored daily to maintain soil moisture within a range of 50 to 90 percent of field capacity. Types of sensors available include tensiometers, gypsum blocks and neutron probes. Sensors give current water status of soils. They do not predict future weather patterns, so operator judgment and common sense are critical elements. For example, if soil moisture levels were approaching irrigation trigger points, it would be prudent to delay the irrigation if general rainfall is predicted within 24 hours.

A qualified contractor should install an irrigation system. The most efficient systems use irrigation heads spaced 60 to 70 feet on center, rather than greater distances, and are designed to provide 100 percent overlap. When used in double or triple rows on fairways, the pattern results in relatively even applications of water, minimizing areas receiving less than the optimum amount of water. Nozzles that produce extremely fine droplet sizes should be avoided since they promote more off-site drift and greater evaporation.

Overwatering a course can cause more problems than not watering at all, particularly if the soil drains poorly. Irrigation systems should be configured to prevent watering after the soil has reached "field capacity," the point where any additional irrigation or rainfall would push water downward past the turf's root zone. Thorough and infrequent watering will favor root growth resulting in a more drought-tolerant turf. Under normal conditions, after half an inch of rainfall, irrigation should be turned off and not restarted until a need is seen. To prevent watering during sudden showers, consider adding an automatic rainfall sensor to shut off the system. Research indicates daily irrigation without regard to plant water needs can result in three times more water used than if the water needs were determined by monitoring devices.

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