BEST MANAGEMENT PRACTICES FOR GEORGIA GOLF COURSES

Striving for environmental, economic and social sustainability

Georgia Chapter GCSAA GCSAA

ACKNOWLEDGEMENTS

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GEORGIA GOLF COURSE SUPERINTENDENTS ASSOCIATION

With around 800 members, the Georgia Golf Course Superintendents Association is one of the largest affiliated chapters of the Golf Course Superintendents Association of America. The association and its members enhance the game of golf and the golf course management profession through education, environmental stewardship and advocacy.

GOLF COURSE SUPERINTENDENTS ASSOCIATION OF AMERICA

The Golf Course Superintendents Association of America (GCSAA) is the professional association for the men and women who manage and maintain the game's most valuable resource — the golf course. Today, GCSAA and its members are recognized by the golf industry as a key contributor in elevating the game and the industry as a whole.

Since 1926, GCSAA has been the leading professional association for those who manage golf courses in the United States and worldwide. From its headquarters in Lawrence, Kansas, the association provides education, information and representation to more than 17,000 members in more than 72 countries. GCSAA's mission is to serve its members, advance their profession and enhance the enjoyment, growth and vitality of the game of golf.

ENVIRONMENTAL INSTITUTE FOR GOLF

The Environmental Institute for Golf (EIFG) fosters sustainability by providing funding for research grants, education programs, scholarships and awareness of golf's environmental efforts. Founded in 1955 as the GCSAA Scholarship and Research Fund for the Golf Course Superintendents Association of America, the EIFG serves as the association's philanthropic organization. The EIFG relies on the support of many individuals and organizations to fund programs to advance stewardship on golf courses in the areas of research, scholarships, education, and advocacy. The results from these activities, conducted by GCSAA, are used to position golf courses as properly managed landscapes that contribute to the greater good of their communities. Supporters of the EIFG know they are fostering programs and initiatives that will benefit the game and its environment for years to come.

GEORGIA GOLF ENVIRONMENTAL FOUNDATION

The Georgia Golf Environmental Foundation (GGEF) promotes sustainable environmental stewardship through the advancement of education and research in the field of turfgrass improvement and management; the collection and dissemination of information; environmental protection; and the promotion of public awareness and safety.

As the philanthropic organization of the Georgia Golf Course Superintendents Association, the GGEF relies upon the support of clubs, many individuals and organizations to fund programs and projects that help golf courses fulfill the environmental, recreational and economic needs of their communities. These efforts include scientific research, education, information collection and outreach to promote best management practices in environmental stewardship.

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Using this Document

This document was developed using the latest science-based information and sources at the time of publishing, December 2018. Readers should be aware that advances in research and changes in regulations can occur frequently. Additionally, website addresses are sometimes modified or disabled. Readers are therefore encouraged to seek further information where applicable.

INTRODUCTION

Georgia's nearly 400 golf courses are, on average, 96 percent recreational open spaces of grasslands, woods or water bodies. These lands are functionally excellent at harvesting and storing water that falls on them, eliminating or reducing erosion, sequestering carbon and nitrogen, and improving the physical properties of soils. In addition to noise abatement and cooling the atmosphere, these green spaces, often in highly-developed urban areas, are also biologically diverse habitats for plants and animals ranging from large native species to soil microorganisms.

In addition to their environmental role, these spaces host an industry that also generates significant economic benefit. In Georgia, golf drives $2.4 billion in economic impact every year and supports nearly 57,000 jobs. Through televised tournaments and championships such as The Masters Tournament at Augusta National Golf Club and the PGA Tour Championship at East Lake Golf Club, the game draws enormous national and international interest in, and visitation to our state.

As platforms for gathering and for physical activity, golf courses from major cities to rural towns also provide enormous social benefits for their communities.

These parcels of Mother Earth are carefully managed by golf course superintendents, individuals who, by the nature of their career choice, care about and understand natural life systems and the environment. Better than anyone, they appreciate the fact that their work space is a living, breathing organism that must be nurtured with care. They are stewards of the acreage in their charge, but they are also economic stewards on behalf of their facilities. It is in the best interests of both roles that they use the minimum resources to present the best possible conditions.

Today's superintendents draw on more environmental science than any generation before them. Their training includes biological sciences, chemistry, horticulture, soils, environmental sciences, and many related disciplines, uniquely qualifying them for their duties. With the help of their professional organizations such as the Georgia Golf Course Superintendents Association and the Golf Course Superintendents Association of America, these individuals pursue ongoing education and professional improvement. They constantly update their knowledge through seminars at conferences, at educational meetings and online. In growing numbers, through programs such as the Audubon Cooperative Sanctuary Program and the Georgia GCSA's own Best Management Practices for Water Conservation and Water Quality, they commit to environmental standards greater than those required by law.

This document is designed to allow stakeholders in the performance of golf courses to achieve outcomes that serve comprehensive best interests – economically, environmentally and socially. Not all facilities can retrofit their golf courses to meet all of the Best Management Practices suggested within. The intent, therefore, should be to establish a performance baseline for each course, and then measure future performance or progress against that individual baseline. The very diversity of golf course sites means each one is a unique blend of soils, microclimate, vegetative types, construction methods and materials, irrigation water quality and quantity, maintenance budgets, and intended purpose. No two golf courses are alike, so no comprehensive, one-size-fits-all series of BMPs are necessarily applicable.

Golf courses, for the most part, are self-sustaining businesses paid for by user groups. Therefore, not all courses have the same resources of manpower, money or materials to work with to achieve a market competitive product. This is a major reason why golf courses are closing at a far greater rate than new ones are being built. To further burden an economically stressed golf facility is not the intent of these BMPs; it is quite the opposite. Carefully adopted BMPs can potentially improve the financial sustainability of the golf course, as well as the environmental sustainability. This is why industry and government interests must cooperatively and intelligently select which BMP will achieve the greatest benefit for everyone.

KEY COMPONENTS OF GEORGIA'S GOLF COURSE BMPS

BMPs are methods or techniques found to be the most effective and practical means of achieving an objective, such as preventing water quality impacts or reducing pesticide usage. Priority topics addressed in this document include the use of nutrients and pesticides, the potential for erosion and sedimentation, water conservation, and emerging concerns related to pollinators. Each area is described briefly below and addressed throughout this document.

NUTRIENT AND PESTICIDE USAGE

The proper use of nutrients and pesticides promotes healthy plant growth which then promotes ecosystem health. When applied properly and in the correct amounts, nutrients are taken up by plants and create a dense, healthy turf that resists diseases and weed encroachment. When properly applied, pesticides are directed to and absorbed or taken up by the target. For example, foliar applied sprays are absorbed by plant leaves, while soil-applied pesticides may be taken up by plant roots. Once in plant tissue, pesticides may be broken down. However, the components of fertilizers (nitrogen and phosphorus) and characteristics of pesticides (toxicity, solubility, and chemical breakdown rate) can impact water quality and non-target species through off-site movement and exposure.

Best management practices reduce the potential for water quality impacts from fate and transport mechanisms such as runoff, leaching, and drift. For example, nutrient BMPs describe the appropriate amounts of fertilizers that should be applied and when they should be applied to maintain a healthy turf and plants without over-fertilizing. Maintaining vegetated buffer strips along waterways, a key BMP, allows for the deposition of nutrients, pesticides, or sediment in vegetation before reaching a waterway. Pesticide BMPs provide the necessary guidance for the proper transport, storage, mixing, and application of pesticides to address target pests and minimize impacts to non-target species.

EROSION AND SEDIMENTATION

Erosion is the action of surface processes that remove soil, rock, or dissolved material from one location and transport it to another. Sedimentation is the deposition of eroded material. Eroded soil and sediments can introduce pollutants into surface waters such as organic matter, nutrients, chemicals (such as pesticides), and other wastes. For example, phosphorus is immobile in most soils and concentrates in the top few inches of the soil, where it is very susceptible to erosion and thus likely to be present in sediment. Design and construction BMPs and stormwater management BMPs address the potential for erosion and sedimentation and ways to mitigate that potential.

WATER USAGE

Water is a fundamental element for physiological processes in turf such as photosynthesis, transpiration, and cooling, as well as for the diffusion and transport of nutrients. Turf quality and performance depend on an adequate supply of water through either precipitation or supplemental irrigation. Too little water induces drought stress and weakens the plant, while too much causes anaerobic conditions that stunt plant growth and promote disease. Excessive water can also lead to runoff or leaching of nutrients and pesticides into groundwater and surface water. The design and maintenance of irrigation systems, as well as proper irrigation scheduling, careful selection of turfgrass cultivars, and incorporation of cultural practices that increase the water holding capacity of soil are addressed through these BMPs.

POLLINATORS

Protecting bees and other pollinators is important to the sustainability of agriculture. Minimizing the impacts of pesticides on bees and other pollinators, as well as beneficial arthropods, is addressed in this document in two ways: (1) by promoting the use of integrated pest management (IPM) methods to reduce pesticide usage and minimize the potential of exposure when pesticides are needed and (2) by providing specific guidance for pesticide applicators to follow when chemical control is needed. Superintendents can also directly support healthy pollinator populations by providing and/or enhancing habitat for pollinator species and supplying food sources, nesting sites, and nesting materials.

LIST OF IMAGES

1. PLANNING, DESIGN AND CONSTRUCTION

The construction phase of any industry's infrastructure poses the greatest risk of ecosystem alteration. With proper planning and design, golf facilities can be constructed and maintained with minimal impact on existing wildlife and habitat. Furthermore, facilities should be designed and constructed to maximize energy efficiency and minimize resource consumption.

REGULATORY CONSIDERATIONS

Local and state regulations may be in place in your location. Early engagement among developers, designers, local community groups, and permitting agencies such as Georgia's Department of Natural Resources and Environmental Protection Division, as well as local and county governments is essential to designing and constructing a golf facility that minimizes environmental impact and meets the approval process.

PLANNING

Principles

Proper planning will minimize expenses resulting from unforeseen construction requirements. Good planning provides opportunities to maximize/integrate environmentally favorable characteristics into the property. This often requires the involvement of golf course architects, golf course superintendents, civil engineers, soil scientists, agronomists, irrigation designers, ecologists, etc.

Good planning provides opportunities to maximize/integrate environmentally favorable characteristics into the property. *Photo credit: Nelson Caron.*

Best Management Practices

- Assemble a qualified team
  - Golf course architect
  - Golf course superintendent
  - Clubhouse architect
  - Irrigation engineer
  - Environmental engineer
  - Energy analyst
  - Economic consultant
  - Civil engineer
  - Soil scientist
  - Geologist
  - Golf course builder
  - Legal team
- Determine objectives
- Complete a feasibility study
  - Are needs feasible given existing resources?
  - Financial
  - Environmental
  - Water
  - Energy
  - Labor
  - Materials
  - Governmental regulatory requirements/restrictions
- Select an appropriate site that is capable of achieving the needs of stakeholders.
- Identify strengths and weakness of the selected site.
- ` Identify water basin and special regulatory requirements for that particular basin: Georgia Soil and Water Conservation Commission
- Identify any rare, protected, endangered, or threatened plant or animal species on the site: Georgia Threatened and Endangered Species

DESIGN

Principles

Proper design will meet the needs of the stakeholders, protect the location's environmental resources, and be economically sustainable.

Best Management Practices

- Retain a qualified golf course superintendent/ project manager at the beginning of the design and construction process to integrate sustainable maintenance practices in the development, maintenance, and operation of the course.
- Design the course to minimize the need to alter or remove existing native landscapes. The routing should identify the areas that provide opportunities for restoration: Georgia Soil and Water Conservation Commission
- Design the course to retain as much natural vegetation as possible. Where appropriate, consider enhancing existing vegetation through the supplemental planting of native vegetation/materials next to long fairways, out-of-play areas, and along water sources supporting fish and other water-dependent species.
- Design out-of-play areas to retain or restore existing native vegetation where possible. Nuisance, invasive, and exotic plants should be removed and replaced with native species that are adapted to that particular site.
- Greens
  - Select a location that has adequate sunlight and air movement to meet plant specific needs and provide sufficient drainage.
  - Choose a green size and sufficient number of hole locations large enough to accommodate traffic and play, but not so large that it is not sustainable with your resources.
  - Select an appropriate root-zone material as designated by the USGA.
  - Consider the number, size, and construction method of bunkers as it relates to resources available for daily maintenance.
  - Greens should be irrigated separately from surrounding turf.
  - Select a turf species/variety that meets the needs of the stakeholders while adhering to the principle of "right plant, right place."
- Plant only certified turfgrass: Georgia Crop Improvement Association
- Decide what type of drainage bunkers will contain.
- Consider bunker entry and exit points. Consider wear patterns and create adequate space for ingress/ egress points on greens, tees, fairways, and bunkers.
- Select the proper color, size, and shape of bunker sand that meets your needs.
- Define play and non-play maintenance boundaries.

Proper design will meet the needs of the stakeholders, protect the location's environmental resources, and be economically sustainable. *Photo credit: Nelson Caron.*

CONSTRUCTION

Principles

Construction should be completed with care to minimize environmental impact and maximize economic efficiency at the same time.

Best Management Practices

- Conduct a pre-construction conference with stakeholders.
- Construction should be scheduled to maximize turfgrass establishment and site drainage.
- Use environmentally sound construction techniques.
- Use soil stabilization techniques to minimize soil erosion and maximize sediment containment.
- Maintain a construction progress report and communicate the report to the proper permitting agencies.
- Use only qualified contractors who are experienced in the special requirements of golf course construction.
- Schedule construction and turf establishment to allow for the most efficient progress of the work, while optimizing environmental conservation and resource management.

When using sod, nutrient applications should be delayed until sod has sufficiently rooted. *Photo credit: John McMullan*

- Temporary construction compounds should be built in a way that minimizes environmental impacts.
- For more information on soil and water conservation and soil erosion control techniques and regulations: Georgia Soil and Water Conservation Commission

GROW-IN

Principles

Turfgrass establishment is a unique phase in turfgrass management, and can require greater quantities of water and nutrients than established turfgrasses. To this end, the establishment phase should be considered carefully to minimize environmental risk.

Best Management Practices

- The area to be established should be properly prepared and cleared of pests (weeds, pathogens, etc.).
- Ensure erosion and sediment control devices are in place and properly maintained.
- Sprigs should be "knifed-in" and rolled to hasten root establishment.
- When using sprigs, application rates for nitrogen, phosphorous, and potassium should correspond to percent of ground cover (i.e., increasing rate as ground coverage increases): University of Georgia Extension
- Sod should be topdressed to fill any gaps between sod pieces. This hastens establishment and provides a smoother surface.
- When using sod, nutrient applications should be delayed until sod has sufficiently rooted: Texas A&M AgriLife Extension
- Use appropriate seeding methods for your conditions.
- Slow-release nitrogen or light, frequent soluble-nitrogen sources should be used during grow-in.
- Nutrients should be applied — in either foliar or granular formulations — to the turf surface. Incorporating nutrients into the root zone does not result in faster establishment but does increase environmental risk.
- Mow as soon as the sod has knitted-down, when sprigs have rooted at the second to third internode, and seedlings have reached a height of one-third greater than intended height-of-cut. This will hasten establishment and prevent turf damage.

EROSION AND SEDIMENT CONTROL

Principles

- Soil carried by wind and water erosion can transport contaminants with it. Contaminants can dislodge, especially on entering water bodies, where they can cause pollution.
- Erosion and sediment control is a critical component of construction and grow-in of a golf course.

Best Management Practices

- Develop a working knowledge of erosion and sediment control management. Each state has its own specifications including types of acceptable structures, materials, and design features: Georgia Soil and Water Conservation Commission - Erosion Control
- Develop and implement strategies to effectively control sediment, minimize the loss of topsoil, protect water resources, and reduce disruption to wildlife, plant species, and designed environmental resource areas.
- Hydro-seeding or hydro-mulching offer soil stabilization.

WETLANDS

Principles

- Most states consider wetlands as "waters of the state," a designation that carries significant legal ramifications. Furthermore, permitting requirements for wetlands can have multiple overlapping jurisdictions of federal, state, and local agencies. At the federal level alone, the U.S. Army Corps of Engineers (USACOE), EPA, U.S Fish and Wildlife Service (FWS), National Oceanic and Atmospheric Administration (NOAA), and maritime agencies may all be involved.
- Wetlands act both as filters for pollutant removal and as nurseries for many species of birds, insects, fish, and other aquatic organisms. The biological activity of plants, fish, animals, insects, and especially bacteria and fungi in a healthy, diverse wetland is the recycling factory of our ecosystem.
- When incorporated into a golf course design, wetlands should be maintained as preserves and separated from managed turf areas with native vegetation or structural buffers. Constructed or disturbed wetlands may need to be permitted to be an integral part of the stormwater management system.

Native vegetation can provide an effective riparian buffer for wetlands. *Photo credit: Vince Wood.*

Best Management Practices

- Ensure that proper permitting has been obtained before working on any wetlands. These permits must be obtained from the U.S. Army Corps of Engineers and then requires a coordinated project review by the Georgia EPD.
- Ensure that wetlands have been properly delineated before working in and around any wetlands.

DRAINAGE

Principles

- Adequate drainage is necessary for growing and maintaining healthy grass.
- A high-quality BMP plan for drainage addresses the containment of runoff, adequate buffer zones, and filtration techniques in the design and construction process to achieve desirable water quality.
- Drainage of the golf course features is only as good as the system's integrity. Damaged, improperly installed, or poorly maintained drainage systems will result in inferior performance that negatively impacts turfgrass quality, playing conditions and increases risks to water quality.

Best Management Practices

- When constructing drainage systems, pay close attention to engineering details such as subsoil preparation, the placement of gravel, slopes, and backfilling.
- Internal golf course drains should not drain directly into an open waterbody, but should discharge through pre-treatment zones and/or vegetative buffers to help remove nutrients and sediments.
- Drainage should discharge through proper drainage and stormwater management devices, for example, vegetative buffers, swales, etc.
- The drainage system should be routinely inspected to ensure proper function.

Wetland areas incorporated into the golf course design. *Photo credit: Jeff Miller.*

Drainage systems should be routinely inspected to ensure proper function. *Photo credit: Ronald McWhorter.*

SURFACE WATER: STORMWATER, PONDS, LAKES

Principles

- Stormwater is the conveying force behind nonpoint source pollution.
- Controlling stormwater on a golf course is more than preventing the flooding of facilities and play areas. In addition to controlling the amount and rate of water leaving the course, stormwater control also involves storing irrigation water, controlling erosion and sediment, enhancing wildlife habitat, removing waterborne pollutants, and addressing aesthetic and playability concerns. Keep in mind that not all stormwater on a golf course originates there. Often it is generated from adjoining lands, including residential or commercial developments.

Best Management Practices

- Stormwater treatment is best accomplished by a "treatment train" approach, in which water is conveyed from one treatment to another by conveyances that themselves contribute to the treatment.
- Eliminate or minimize as much directly connected impervious area (DCIA) as possible.
- Use vegetated swales to slow, infiltrate, and filter water and trap pollutants in the soil, where they can be naturally destroyed by soil organisms.
- Use depressed landscape islands in parking lots to catch, filter, and infiltrate water, instead of letting it run off. When hard rains occur, an elevated stormwater drain inlet allows the island to hold the treatment volume and settle out sediments, while allowing the overflow to drain away.
- Maximize the use of pervious pavements, such as brick or concrete pavers separated by sand and planted with grass. Special high-permeability concrete is available for cart paths or parking lots.
- Disconnect runoff from gutters and roof drains from impervious areas, so that it flows onto permeable areas that allow the water to infiltrate near the point of generation.

MAINTENANCE FACILITIES

Principles

Maintenance facilities must incorporate BMPs to minimize the potential for contamination of soil and water resources. The pesticide mixing and storage facility, the equipment wash pad, and the fuel center are focal points.

Best Management Practices

- Design and build pesticide storage structures to keep pesticides secure and isolated from the surrounding environment.
- Store pesticides in a roofed, concrete or metal structure with a lockable door.
- Construct floors of seamless metal or concrete sealed with a chemical-resistant paint.
- Ensure that flow from floor drains does not discharge directly to the ground and that drains are not connected to the sanitary sewer line or septic system.
- Equip the floor with a continuous curb to retain spilled materials.
- Do not store pesticides near burning materials or hot work (welding, grinding), or in shop areas.
- Provide storage for personal protective equipment (PPE) where it is easily accessible in the event of an emergency, but do not store in the pesticide storage area.

- Provide adequate space and shelving to segregate herbicides, insecticides, and fungicides.
- Use shelving made of plastic or reinforced metal. Keep metal shelving painted.
- Provide appropriate exhaust ventilation and an emergency wash area.
- Always place dry materials above liquids, never liquids above dry materials.
- Never place liquids above eye level.
- Locate operations well away from groundwater wells and areas where runoff may carry spilled pesticides into surface waterbodies.
- Do not build new facilities on potentially contaminated sites.
- An open building must have a roof with a substantial overhang (minimum 30° from vertical, 45° recommended) on all sides.
- In constructing a concrete mixing and loading pad, it is critical that the concrete have a water-to-cement ratio no higher than 0.45:1 by weight.
- The sump should be small and easily accessible for cleaning.
- Ensure that workers always use all personal protection equipment as required by the pesticide label and are provided appropriate training.
- Assess the level of training and supervision required by staff.
- Any material that collects on the pad must be applied as a pesticide according to the label or disposed of as a (potentially hazardous) waste according to state laws and regulations.
- Clean up spills immediately!
- Always store nitrogen-based fertilizers separately from solvents, fuels, and pesticides, since many fertilizers are oxidants and can accelerate a fire. Ideally, fertilizer should be stored in a concrete building with a metal or other type of flame-resistant roof.
- Always store fertilizers in an area that is protected from rainfall. The storage of dry bulk materials on a concrete or asphalt pad may be acceptable if the pad is adequately protected from rainfall and from water flowing across the pad.
- Sweep up any spilled fertilizer immediately.
- Do not wash equipment unnecessarily.
- Clean equipment over an impervious area, and keep it swept clean.
- Brush or blow equipment with compressed air before, or instead of, washing.
- Use spring shutoff nozzles.

Golf courses can gain valuable recognition for their conservation efforts through environmental education for golfers, surrounding property owners and the public at large. *Photo credit: : Trent Bouts.*

Golf-centric environmental management programs can help protect and promote pollinators like monarch butterflies. *Photo credit: Mark Hoban.*

- Use a closed-loop recycling system for wash water.
- Recycle system filters and sludge should be treated and disposed appropriately.
- Each piece of equipment should have an assigned parking area. This allows oil or other fluid leaks to be easily spotted and attributed to a specific machine so that it can be repaired.
- Use solvent-recycling machines or water-based cleaning machines to cut down on the use of flammable and/or toxic solvents.
- Use a service to remove the old solvents and dispose of them properly.
- Design pesticide storage to keep pesticides secure and isolated from the environment.

EXTERNAL CERTIFICATION PROGRAMS

Principles

- Golf-centric environmental management programs or environmental management systems can help golf courses protect the environment and preserve the natural heritage of the game.
- These programs help people protect the natural areas and wildlife habitats that golf courses provide, improve efficiency, and minimize potentially harmful impacts of golf course operations.
- Golf courses can gain valuable recognition for their environmental education and certification efforts through groups such as the Golf Environmental Organization and Audubon International.

Best Management Practices

- Obtain and review materials to ascertain whether the facility should seek certification.
- Work with staff to establish facility goals that lead to certification.
- Establish goals to educate members about the certification program.

WILDLIFE CONSIDERATIONS

Principles

- Golf courses occupy large land areas, generally in urban areas, providing critical links between urban and rural/natural environments: Golf Is Greenspace
- Maintaining wildlife habitat on golf courses better maintains biological diversity, which is especially important in the urban environment.
- Most golfers enjoy observing non-threatening wildlife as they play the game.

Golfers enjoy observing birds and wildlife during their round. *Photo credit: Tenia Workman.*

As green spaces often are in or adjacent to urban areas, golf courses provide safe haven for a wide variety of wildlife.
Photo credit: Tenia Workman.

Best Management Practices

- Identify the different types of habitat specific to the site.
- Identify the habitat requirements (food, water, cover, space) for identified wildlife species.
- Identify species on the site that are considered threatened or endangered by the federal or state government, including species the state deems "of special concern:" Georgia Threatened and Endangered Species
- Preserve critical habitat.
- Identify and preserve regional wildlife and migration corridors.
- Design and locate cart paths to minimize environmental impacts. Construct the paths of permeable materials, if possible.
- Avoid or minimize crossings of wildlife corridors. Design unavoidable crossings to accommodate wildlife movement.
- Remove nuisance and exotic/invasive plants and replace them with native species that are adapted to a particular site.
- Maintain clearance between the ground and the lowest portion of a fence or wall to allow wildlife to pass, except in areas where feral animals need to be excluded.
- Retain dead tree snags for nesting and feeding sites, provided they pose no danger to people or property.
- Construct and place birdhouses, bat houses, and nesting sites in out-of-play areas.
- Plant butterfly gardens and similar pollinator habitats around the clubhouse and out-of-play areas.
- Retain riparian buffers along waterways to protect water quality and provide food, nesting sites, and cover for wildlife.
- Minimize stream or river crossings to protect water quality and preserve stream banks.

2. IRRIGATION

The supplemental use of water for course play and non-play areas is essential to supporting healthy turfgrass and landscape plant health. It is also necessary to sustaining optimal course playability, aesthetics, marketability, club membership and golfer participation.

The purpose of this section is to identify best management practices related to water use that conserve and protect water resources. It is important to keep in mind that, while new technology makes many tasks easier or less labor-intensive, the principles discussed in this section are important to understand and apply to protect water quality, water quantity and surrounding natural resources.

Additionally, irrigation BMPs may provide an economic, regulatory compliance, and environmental stewardship advantage to those who make them part of their irrigation management plan. BMPs are not intended to increase labor or place an undue burden on the owner/superintendent. If applied appropriately, BMPs can help stabilize labor cost, extend equipment life, and limit repair and overall personal and public liability.

The monetary investment in non-structural BMPs should not be a burden to implement in a daily course water-use plan and the cost should be minimal or nothing at all. Other advantages to using BMPs includes: reduced administrative management stress, improved employee communication and direction, and effective facilities training procedures.

Several benefits of adopting BMPs are:

- Conserving available water supply
- Maintaining or improving water quality for on-course and off-course water sources
- Maintaining optimal ball roll and playing conditions
- Conserving electricity
- Increasing longevity of equipment such as pumps
- Demonstrating responsible environmental stewardship
- Training knowledgeable and effective employees

The supplemental use of water for course play and non-play areas is essential to supporting healthy turfgrass and landscape plant health. *Photo credit: Mark Hoban.*

Hand watering can be a critical tool in managing isolated hot spots. *Photo credit: Joe Hollis.*

WATER MANAGEMENT APPROACHES

Conservation and Efficiency

Conservation and efficiency consider the strategic use of appropriate irrigation design for the course, plant selection, computerized and data-integrated scheduling, and alternative water supply and water quality options that maximize plant health benefits and reduce the potential for negative impacts on natural resources.

Resource Protection

Resource protection is an integrated approach that embraces irrigation practices as part of the course design, pesticide and nutrient practices, and regulatory compliance measures and structural measures as they relate to environmental stewardship and regulations.

REGULATORY CONSIDERATIONS

Principles

- Golf course owners are responsible for contacting federal, state, and local water use authorities at the pre-and post-construction phase to determine annual or specific water consumption (water rights), permitting guidelines, and other requirements allowed by regulators.
- Superintendents have a responsibility to adhere to water-quality standard rules regarding groundwater and surface water flows resulting from the removal of water for irrigation use.

Best Management Practices

- Design and/or maintain a system to meet site's peak water requirements under normal conditions and also be flexible enough to adapt to various water demands and local restrictions.
- Develop an annual water budget for the golf course.
- Look for ways to increase efficiency and reduce energy use associated with irrigation systems and practices.
- Demonstrate good stewardship practices by supplementing watering only for the establishment of new planting and new sod, hand watering of critical hot spots, and watering-in of chemicals and fertilizers (if permissible).
- Protect aquatic life and impairment of water systems by adhering to state and local water withdrawal allocations (gallons/day).
- Design an irrigation system that delivers water with maximum efficiency.

IRRIGATION WATER SUITABILITY

Golf course designers and managers should endeavor to identify and use alternative water sources to conserve groundwater and surface water supplies, promote plant health, and protect the environment. When identifying alternative water supplies, these may include but not be limited to reclaimed water from treatment plants, stormwater capture in ponds, and drainage water to name a few. The routine use of potable water supply is not a preferred practice; therefore, municipal drinking water should be considered only when there is no alternative.

Understanding water supplies is recommended for irrigation systems, as are studies of waterbodies or flows on, near, and under the property. All may be helpful to properly design a course's stormwater systems, water features, and to protect water resources. In Georgia, the Georgia Environmental Protection Division (EPD) of the Department of Natural Resources (DNR) has worked with the 10 Regional Water Councils which were formed under the Georgia Water Stewardship Act of 2008 and the Metropolitan North Georgia Regional Water Planning District to collect data, run models and provide information on water supplies in Georgia. For more detailed information for specific Regional Water Council Plans: Georgia Water Planning

When necessary, sodic water system treatment options should be included in the budget to address water quality and equipment maintenance.

Best Management Practices

General

- Account for the nutrients in effluent (reuse/reclaimed) water when making fertilizer calculations.
- Monitor the quantity of water withdrawn from surface water sources to avoid aquatic life impairment.
- Identify appropriate water supply sources that meet seasonal and bulk water allocations for grow-in and routine maintenance needs.

Sodic

- Use alternative water supplies/sources that are appropriate and sufficiently available to supplement water needs.
- Use salt-tolerant varieties of turf and plants to mitigate saline conditions resulting from available water supply.
- Amend sodic water systems appropriately (with gypsum or an appropriate ion) to minimize sodium buildup in soil.
- Flush with freshwater or use amending materials regularly to move salts out of the root zone and/or pump brackish water to keep salts moving out of the root zone.

Post signage in accordance with local utility and state requirements when reclaimed water is in use. *Photo credit: John McMullan.*

Existing golf courses can convert out-of-play areas with native plants and grasses to reduce maintenance, conserve water and provide visual interest. *Photo credit: Kyle Marshall.*

- Monitor sodium and bicarbonate buildup in the soil using salinity sensors.
- Routinely monitor shallow groundwater table of freshwater for saltwater intrusion or contamination of heavy metals and nutrients.
- Where practical, use reverse-osmosis filtration systems to reduce chlorides (salts) from saline groundwater.

Reclaimed

- Monitor reclaimed water tests regularly for dissolved salt content.
- Reclaimed, effluent, and other non-potable water supply mains must have a thorough cross-connection and backflow prevention device in place that is operating correctly.
- Reclaimed water use in Georgia is regulated and administered by the Environmental Protection Division of Georgia's Department of Natural Resources (EPD), which produces a manual: Guidelines for Water Reclamation and Urban Water Reuse.
- In the Metropolitan North Georgia Water Planning District, reclaimed water is defined and usage should follow the guidelines in Section 7: Reuse.
- Post signage in accordance with local utility and state requirements when reclaimed water is in use.

WATER CONSERVATION AND EFFICIENT USE PLANNING

Principles

- Document actual watering practices, especially to show savings in water use over averages. Communication should be maintained with water managers, golfers and members, and the public, to explain what you are doing and why.
- BMPs and educational programs can help correct public misperceptions about golf course water use and increase the likelihood of future water use regulation being made on the basis of science rather than emotion.
- Potable water supplies in many areas of the United States are limited, and demand continues to grow. Our challenge is to find solutions to maintain the quality of golf while using less water.
- Some courses are being designed to minimize the amount of maintained turf required for play. An example would be including a waste area or natural area between the tee and the beginning of the fairway landing area.

Courses can sometimes identify areas between the tee and the landing area to introduce native or low-maintenance areas. *Photo credit: Scott Slemp.*

- Existing golf courses can convert out-of-play areas into naturally adapted native plants, grasses, or ground covers to reduce water use and augment the site's aesthetic appeal.
- Many courses can be maintained according to the principle of "firm and fast" where irrigation is minimized by a focus on playability more than aesthetics.

Best Management Practices

- Selecting drought-tolerant varieties of turfgrasses can help maintain an attractive and high-quality playing surface, while minimizing water use.
- Non-play areas may be planted with drought-resistant native or other well-adapted, non-invasive plants that provide an attractive and low-maintenance landscape.
- Native plant species are important in providing wildlife with habitat and food sources. After establishment, site-appropriate plants normally require little to no irrigation.
- The irrigation system should be operated to provide only the water that is actually needed by the plants, or to meet occasional special needs such as salt removal or after applications that require watering-in.
- If properly designed, rain and runoff captured in water hazards and stormwater ponds may provide supplemental water under normal conditions, though backup sources may be needed during severe drought.
- During a drought, closely monitor soil moisture levels. Whenever practicable, irrigate at times when the least amount of evaporative loss will occur.
- Control invasive plants or plants that use excessive water.

IRRIGATION SYSTEM DESIGN

Principles

- Irrigation systems should be properly designed and installed to maximize water use efficiency.
- A well-designed irrigation system should also be operated to minimize energy use, reduce labor and conserve and protect natural resources.
- An efficient irrigation system maximizes water use, reduces operational cost, conserves water supply and protects water resources.

Best Management Practices

- Design should account for optimal distribution efficiency and effective root-zone moisture coverage. Target 80% or better Distribution Uniformity (DU).
- Design should allow the putting surface, slopes and surrounds to be watered independently.
- The design package should include a general irrigation schedule with recommendations and instructions on modifying the schedule for local climatic and growing conditions. It should include the base evapotranspiration (ET) rate for the particular location.
- The application rate must not exceed the infiltration rate, which is the ability of the soil to absorb and retain the water applied during any one application. Perform saturated hydraulic conductivity tests periodically to ensure infiltration rates have not changed as a result of management practices.
- The design operating pressure must not be greater than the available source pressure or pressure available from pumping system.
- The design operating pressure must account for peak-use times and supply line pressures at final buildout for the entire system.
- The system should be flexible enough to meet a site's peak water requirements and allow for operating modifications to meet seasonal irrigation changes or local restrictions.
- Turf and landscape areas should have their own irrigation zones. Specific use areas to be zoned separately include greens, tees, primary roughs, secondary roughs, fairways, native, trees, shrubs, etc.
- Design should account for the need to leach out salt buildup from poor-quality water sources by providing access to freshwater.
- Only qualified specialists should install the irrigation system.
- Construction must be consistent with the design.
- The designer must approve any design changes before construction.
- Construction and materials must meet regulatory requirements and should meet leading industry standards.
- Prior to construction, all underground cables, pipes, and other obstacles must be identified and their locations flagged.

- Permanent irrigation sprinklers and other distribution devices should be spaced according to the manufacturer's recommendations.
- Heads for turf areas should be spaced for head-to-head coverage.
- The spacing of distribution devices should be based on average wind conditions during irrigation.
- For variable wind directions, triangular spacing is more uniform than square spacing.
- The first and last distribution device on a line should have no more than a 10% difference in flow rate. This usually corresponds to about a 20% difference in pressure.
- Distribution devices (such as sprinklers, rotors, and micro-irrigation) in a given zone must have the same precipitation rate.
- Water supply systems (for example, wells and pipelines) should be designed for varying control devices, rain shutoff devices, and backflow prevention.
- Water conveyance systems should be designed with thrust blocks and air-release valves.
- Flow velocity must be 5 feet per second or less.
- Pipelines should be designed to provide the system with the appropriate pressure required for maximum irrigation uniformity.
- Pressure-regulating or compensating equipment must be used where the system pressure exceeds the manufacturer's recommendations.
- Equipment with check valves must be used in low areas to prevent low head drainage.
- Isolation valves should be installed in a manner that allows critical areas to remain functional.
- Manual quick-coupler valves should be installed near greens, tees, and bunkers so these areas can be hand-watered to prevent turf loss during periods of intense heat and severe drought.
- Install part-circle heads along lakes, ponds, and wetlands margins.
- Use part-circle or adjustable heads to avoid overspray of impervious areas such as roadways and sidewalks.
- Update multi-row sprinklers with single head control to conserve water and to enhance efficiency.
- Incorporate multiple nozzle configurations to add flexibility and enhance efficiency/distribution.
- Ensure heads are set at level ground and not on slopes.

IRRIGATION PUMPING SYSTEM

- Golf courses whose water supply is either groundwater or surface water with no additional off-site water supply have to move water through the use of pumps. Even if using an alternative water supply where the water is stored in onsite ponds, that water has to be moved with pumps. When designing pumping stations, they should be sized to provide adequate flow and pressure. They should be equipped with control systems that protect distribution piping, provide for emergency shutdown necessitated by line breaks, and allow maximum system scheduling flexibility.
- Variable frequency drive (VFD) pumping systems should be considered if dramatically variable flow rates are required, if electrical transients (such spikes and surges) are infrequent, and if the superintendent has access to qualified technical support.
- Design pumping systems for energy conservation.

Best Management Practices

- The design operating pressure must not be greater than the available source pressure or available pump pressure.

Soil moisture meters help superintendents determine irrigation needs according to location. *Photo credit: Lydell Mack.*

Even if using an alternative water supply where the water stored in onsite ponds, that water has to be moved with pumps. *Photo credit: Tim Busek.*

- The design operating pressure must account for peak-use times and supply-line pressures at final buildout for the entire system.
- Maintain the air-relief and vacuum-breaker valves by using hydraulic-pressure-sustaining values.
- Install VFD systems to lengthen the life of older pipes and fittings until the golf course can afford a new irrigation system.
- Pumps should be equipped with control systems to protect distribution piping.
- An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.
- Pumps should be sized to provide adequate flow and pressure.
- System checks and routine maintenance on pumps, valves, fittings, and sprinklers should follow the manufacturer's recommendations. Updates to programs should be made as recommended by the manufacturer.
- Monitor pumping station power consumption. Monthly bills should be monitored and compared over time to detect issues in power usage.
- Compare the power used with the amount of water pumped. Requiring more power to pump the same amount of water may indicate a problem with the pump motor(s), control valves, or distribution system.
- Quarterly checks of amperage by qualified pump personnel may more accurately identify increased power usage and thus potential problems.
- Install a water meter to monitor water used.

IRRIGATION SYSTEM PROGRAM AND SCHEDULING

Principles

- Irrigation scheduling must take plant water requirements and soil intake capacity into account to prevent excess water use that could lead to leaching and runoff.
- Plant water needs are determined by evapotranspiration (ET) rates, recent rainfall, recent temperature extremes and soil moisture.
- Irrigation should not occur on a calendar-based schedule but should be based on ET rates and soil moisture replacement.
- An irrigation system should be operated based on the moisture needs of the specific area being watered. In the "Irrigation System Design" section it was mentioned that the system should be zoned to account for different areas needing different water amounts. These areas would include greens, tees, primary roughs, secondary roughs, fairways, native, trees, shrubs, or other areas particular to a course. The scheduling could also include the use of irrigation to water-in fertilizer or chemical applications as directed by the label.
- Responsible irrigation management conserves water resources while also reducing the movement of nutrients and pesticides either on the surface or through the soil profile.
- Time-clock-controlled irrigation systems preceded computer-controlled systems, and many are still in use today. Electric/mechanical time clocks cannot automatically adjust for changing ET rates. Therefore, superintendents should be aware that frequent adjustments may be necessary to compensate for the needs of individual turfgrass areas in order to conserve and protect water resources.

Best Management Practices

- The reliability of older clock-control station timing depends on the calibration of the timing devices; this should be done periodically, and at least seasonally.
- An irrigation system should have rain sensors to shut off the system after a 0.25 to 0.5 inch of rain is received. Computerized systems allow a superintendent to call in and cancel the program if it

is determined that the course has received adequate rainfall. Since courses are spread over multiple acres and thunderstorms have the potential to have high precipitation rates on one part of a course and smaller amounts or none on other parts of the course, consider having rain sensors located around the course to correspond with those sections of the course irrigated through different valves.

- Install control devices to allow for maximum system scheduling flexibility.
- Generally, granular fertilizer applications should receive 0.25 inch of irrigation to move the particles off the leaves while still minimizing runoff.
- Irrigation quantities should not exceed the available moisture storage in the root zone.
- Irrigation rates should not exceed the maximum holding capacity of the soil to absorb and hold the water applied at any one time.
- Irrigation schedules should coincide with other cultural practices (for example, the application of nutrients, herbicides, or other chemicals).
- When using a water supply that might contain nutrients (i.e. reclaimed water, effluent from a known process and other sources of effluent water), these nutrients should be factored into the nutrient application calculations.
- Irrigation should occur in the early morning hours before air temperatures rise and relative humidity drops.
- Base plant water needs should be determined by ET rates, recent rainfall, recent temperature extremes, and measured soil moisture.
- Use mowing, verticutting, aeration, nutrition, and other cultural practices to minimize water loss and to encourage conservation and efficiency.
- Visually monitor for localized dry conditions or hot spots to identify poor irrigation efficiency or a failed system device. This visual monitoring can provide important information on locations where distribution devices (i.e. sprinklers) are not operating properly. If such areas are noticed, before increasing the watering time, investigate by observing or periodically performing catch-can uniformity tests to determine if there is a malfunctioning sprinkler, low pressure or some other reason such as a broken pipe leading to that sprinkler or set of sprinklers.
- Use predictive models to estimate soil moisture and the best time to irrigate.
- Avoid use of a global setting; make adjustments to watering times per head.
- Base water times on actual site conditions for each head and zone.
- Adjust irrigation run times based on current local meteorological data.
- Use computed daily ET rate to adjust run times to meet the turf's moisture needs.
- Manually adjust automated ET data to reflect wet and dry areas on the course.
- Use soil moisture sensors to assist in scheduling or to create on-demand irrigation schedules. Handheld soil moisture sensors should be used on greens and tees.
- Use multiple soil moisture sensors to reflect soil moisture levels.
- Install soil moisture sensors in the root zone for each irrigation zone to enhance scheduled timer-based run times.
- Place soil moisture sensors in a representative location within each irrigation zone where possible. If it is not possible to install soil moisture sensors in all zones, soil moisture sensors should be installed in zones that have the potential of being drier or wetter than others. This will allow the drier and wetter zones to receive proper amounts of water while the other zones should receive optimum water.
- Wired soil moisture systems should be installed in a manner that prevents damage from aerification.
- Reducing dry spots and soil compaction improves water infiltration, which in turn reduces water use and runoff in other areas.
- Install emergency shutdown devices to address line breaks.

An irrigation system should be operated based on the moisture needs of the specific area being watered. *Photo credit: Jeff Miller.*

TURF DROUGHT RESPONSE

Principles

- The presence of visual symptoms of moisture stress is a simple way to determine when irrigation is needed.
- Use a hand-held soil moisture meter to determine moisture needs of greens and tees.
- Managers of golf greens cannot afford to wait until symptoms occur, because unacceptable turf quality may result.
- Prepare for extended drought/restrictions by developing a written drought management plan.

Best Management Practices

- Waiting until visual symptoms appear before irrigating is a method best used for low-maintenance areas, such as golf course roughs and, possibly, fairways. Use soil moisture meters to determine moisture thresholds and plant needs.
- Irrigating too shallowly encourages shallow rooting, increases soil compaction, and favors pest outbreaks. Irrigating less frequently with higher precipitation rates encourages deeper root growth and reduces the effect of drought. Be aware, however, of the precipitation rate and infiltration rate of the soil to prevent overwatering. If possible, split applications of irrigation could be an alternative for slow infiltration soils.
- For golf greens and tees, the majority of roots are in the top several inches of soil.
- For fairways and roughs, use infrequent, deep irrigation to supply sufficient water for plants and to encourage deep rooting.
- Proper cultural practices such as mowing height, irrigation frequency, and irrigation amounts should be employed to promote healthy, deep root development and to reduce irrigation requirements.
- Use appropriate turfgrass species adapted to the location of the golf course being managed.
- Create a drought management plan for the facility, which identifies steps to be taken to reduce irrigation/water use and protects critical areas. In Georgia, drought levels are determined by the Georgia Department of Natural Resources' Environmental Protection Division (GA EPD). Those superintendents and managers responsible for irrigation should be aware of the drought levels issued by the GA EPD and the rules associated with the different drought levels. The rules are outlined in the Rules and Regulations of the State of Georgia Drought Management and can be found under Subject 391-3-30 Drought Management. [NOTE: when you click on the link there will be a webpage asking for your name and a verification. Once you complete this, you can see the Rules for Drought.]
- Golf Courses are affected by Drought Levels as follows:
  - Drought Level 1 - No effect except that courses using municipal water will be made aware of conditions and asked to follow water conservation measures.
  - Drought Level 2 - Same as Drought Level 1, with exception of those using municipal water in which the utility may impose restrictions as they deem necessary.
  - Drought Level 3 - Golf courses are spelled out in Rule 391-3-30-.07 (4)(b)4. The wording is: "Irrigation of golf courses shall be conducted in accordance with the "Golf Irrigation Prediction and Estimation Worksheet" and only between the hours of 4:00 p.m. and 10:00 a.m., provided, however, irrigation of golf course greens may occur at any time of day;". If on municipal water, other than this rule, there will be other rules and conditions set by the utility. Also, if the golf course is using reclaimed waste water, the course will also fall under Rule 391-3-30-.07 (4)(b)5 which states "Use of reclaimed waste water by a designated user from a system permitted by the Division to provide reclaimed waste water shall not be allowed for general outdoor watering as described in Rule 391-3-30-.03(1)(a). It shall be allowed for any use described in Rule 391-3-30-.03(1)(b) subject to the limitations in Rule 391-3-30-.07(4)(b);"

IRRIGATION SYSTEM QUALITY

Principles

- Irrigation system maintenance on a golf course involves four major efforts: calibration or auditing, preventive maintenance (PM), corrective maintenance, and record keeping.
- Personnel charged with maintaining any golf course irrigation system face numerous challenges. This is particularly true for courses with older or outdated equipment.
- Good system management starts with good preventive maintenance (PM) procedures and record keeping. Maintaining a system is more than just fixing heads.
- Corrective maintenance is simply the act of fixing what is broken. It may be as simple as cleaning a clogged orifice, or as complex as a complete renovation of the irrigation system.

- As maintenance costs increase, the question of whether to renovate arises. Renovating a golf course irrigation system can improve system efficiencies, conserve water, improve playability, and lower operating costs.

Best Management Practices

- Respond to day-to-day failures in a timely manner, maintain the integrity of the system as designed, and keep good records of failures and repairs.
- System checks and routine maintenance on pumps, valves, fittings, and sprinklers should follow the manufacturer's recommendations. Updating programs as needed for changing conditions is also required.
- The system should be inspected daily for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads. A visual inspection should be carried out for leaks, misaligned or inoperable heads, and chronic wet or dry spots, so that adjustments can be made.
- Systems need to be observed in operation at least weekly. This can be done during maintenance programs such as fertilizer or chemical applications where irrigation is required, or the heads can be brought on-line for a few seconds and observed for proper operation. This process detects controller or communications failures, stuck or misaligned heads, and clogged or broken nozzles.
- Check filter operations frequently. An unusual increase in the amount of debris may indicate problems with the water source. Clogged filters will also cause undue wear on pumps and reduce water delivery to the irrigation system.
- Even under routine conditions, keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.
- Keep records of filter changes, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.
- Application/distribution efficiencies should be checked annually. Implement a PM program to replace worn components before they waste fertilizer, chemicals, and water.
- Conduct a periodic professional irrigation audit, at least once every five years.
- Document equipment run-time hours. Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Gather together all of the documentation collected as part of the PM program, along with corrective maintenance records for analysis.
- Correctly identifying problems and their costs helps to determine what renovations are appropriate.
- Collecting information on the cost of maintaining the system as part of system's overall evaluation, allows for planning necessary upgrades, replacement etc. and to compare after changes are made.

POND LOCATION AND DESIGN

Principles

- Understanding natural lake processes and accommodating them in the design and management of a pond can create significant aesthetic value and reduce operational costs.
- Lakes and ponds have several distinct defining characteristics. Their size, shape, and depth may all affect how they respond to various environmental inputs.
- Most golf courses plan their built lakes and water hazards to be a part of the stormwater control and treatment system. This usually works well for all concerned. However, natural waters may not be considered treatment systems and must be protected.
- Lakes and ponds may be used as a source of irrigation water. It is important to consider these functions when designing and constructing the ponds.
- Careful design may significantly reduce future operating expenses for lake and aquatic plant management.

Best Management Practices

- Consult with a qualified golf course architect, working in conjunction with a stormwater engineer, to develop an effective stormwater management system that complies with the requirements of the water management district/department or other permitting agency. In Georgia, stormwater management is governed by the Georgia Stormwater Management Manual (GSMM) and the Coastal Supplement to the GSMM.
- When constructing drainage systems, pay close attention to engineering details such as subsoil preparation, the placement of gravel, slopes, and backfilling.
- Where practical, internal golf course drains should discharge through pretreatment zones and/or vegetative buffers to help remove nutrients and sediments.

- Studies of water supplies are needed for irrigation systems, and studies of waterbodies or flows on, near, and under the property are needed to properly design a course's stormwater systems and water features, and to protect water resources.
- Peninsular projections and long, narrow fingers into ponds may prevent water mixing. Ponds that are too shallow may reach high temperatures, leading to low oxygen levels promoting algal growth and excess sedimentation.
- In shallow or nutrient-impacted ponds, the use of aeration equipment may be required to maintain acceptable dissolved oxygen (DO) levels in the water.

POND USE AND MAINTENANCE

Principles

- Successful pond management should include a clear statement of goals and priorities to guide the development of the BMP necessary to meet those goals. Some of the challenges facing superintendents in maintaining the quality of golf course ponds are as follows:
  - Low dissolved oxygen
  - Sedimentation
  - Changes in plant populations
  - Nuisance vegetation
  - Maintenance of littoral shelves
  - Vegetation on the lakeshore
- Each pond has regions or zones that significantly influence water quality and are crucial in maintaining the ecological balance of the system. It is important for the manager to understand their function and how good water quality can be maintained if these zones (riparian zone, littoral zone, limnetic zone, and benthic zone) are properly managed.
- Surface water sources can present problems with algal and bacterial growth. Algal cells and organic residues of algae can pass through irrigation system filters and form aggregates that may plug emitters.
- Pond leaks should be controlled and managed properly.
- Use an expert in aquatic management to help develop and monitor pond management programs.

Best Management Practices

- Use leak controls in the form of dike compaction, natural-soil liners, soil additives, commercial liners, drain tile, or other approved methods.

Most golf courses plan their built lakes and water hazards to be a part of the stormwater control and treatment system. *Photo credit: Ronald McWhorter.*

- Maintain a riparian buffer to filter the nutrients and sediment in runoff.
- Reduce the frequency of mowing at the lake edge and collect or direct clippings to upland areas.
- Prevent overthrowing fertilizer into ponds. Practice good fertilizer management to reduce nutrient runoff into ponds, which causes algae blooms and ultimately reduces DO levels.
- Establish a special management zone around pond edges.
- Dispose of grass clippings where runoff will not carry them back to the lake.
- Encourage clumps of native emergent vegetation at the shoreline.
- Maintain water flow through lakes, if they are interconnected.
- Establish wetlands where water enters lakes to slow water flow and trap sediments. If wetlands are used to trap sediment, have plans to maintain wetlands by removing sediment as needed.
- Maintain appropriate silt fencing and BMPs on projects to reduce soil erosion and any resulting sedimentation in lakes, ponds, and streams.
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered DO levels.
- Aerate ponds and dredge or remove sediment before it becomes a problem.

POND WATER-LEVEL MONITORING

Principle

Evaporation losses are higher in some regions than others and vary from year to year and within the year. However, evaporative losses could approach six inches per month during the summer. Aquatic plants are more difficult to control in shallow water. Evaporation rates for your area can be found on the UGA Weather Network.

Best Management Practices

- Ideally, in order to help golf courses cope with exceptional rain events, irrigation retention ponds should be designed with an overflow outlet drain that is set to 90 percent of the pond's total water holding capacity.
- Provide an alternative source for ponds that may require supplemental recharge from another water source such as a well during high-demand periods. If using a well to supplement water needs, make sure the water being supplied from the well will be enough to overcome the amount being evaporated from the surface of the pond.
- Estimated losses from evaporation and seepage should be added to the recommended depth of the pond.

METERING

Principles

- Rainfall may vary from location to location on a course; the proper use of rain gauges, rain shut-off devices, flow meters, soil moisture meters, and/or other irrigation management devices should be incorporated into the site's irrigation schedule. This goes hand-in-hand with the "Irrigation System Design" section.
- It is also important to measure the amount of water that is actually delivered through the irrigation system, via a water meter or a calibrated flow-measurement device.
- If a permit has been issued from EPD, a meter should be installed on the pipe from the pump as stated in the permit.
- Knowing the flow or volume will help determine how well the irrigation system and irrigation schedule are working.
- Knowing the irrigation system requirements and the metered flow can be another way to determine if the system is delivering the proper amount of water to the zoned areas.
- Using a metering system along with periodic audits of the irrigation system can help diagnose issues in the overall irrigation system, from the over-application of water to under-application of water.

Best Management Practices

- Calibrate equipment periodically to compensate for wear in pumps, nozzles, and metering systems.
- Properly calibrated flow meters, soil moisture sensors, rain shut-off devices, and/or other automated methods should be used to manage irrigation.
- Flow meters should have a run of pipe that is straight enough — both downstream and upstream — to prevent turbulence and bad readings. The run of straight pipe will be specified by the manufacturer of the water meter. This run of pipe should be adhered to in order to get the proper results from the flow meter.
- Flow meters can be used as a tool to determine how much water is applied to an irrigation zone.

IRRIGATION LEAK DETECTION

Principles

- Irrigation systems are complex systems that should be closely monitored to ensure leaks are quickly detected and corrected.
- Golf courses without hydraulic pressure-sustaining valves are much more prone to irrigation pipe and fitting breaks because of surges in the system, creating more downtime for older systems. A good preventive maintenance program is very important.
- The use of flow meters can assist in detecting leaks based on known water need by zone and measured water pumped to that zone.

Best Management Practices

- Monitor water meters or other measuring devices for unusually high or low readings to detect possible leaks or other problems in the system. Make any needed repairs.
- An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.
- The system should be monitored daily for malfunctions and breaks. It is also a good practice to log the amount of water pumped each day.
- Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings). If the system requires frequent repairs, determine why these failures are occurring. Pipe failures may be caused not only by material failure, but also by problems with the pump station.
- Ensure that control systems provide for emergency shutdowns caused by line breaks, and allow maximum system scheduling flexibility.
- Continuous dry or wet spots where irrigation occurs can be an indication of irrigation system leaks. Wet spots where irrigation does not occur can also indicate irrigation system leaks.
- In colder regions where freezing is a potential, an irrigation system should be checked for leaks prior to expected use of irrigation system. If flow meters are used, these can help diagnose if extra water is being pumped than expected.
- Irrigation leaks can be the result of broken pipes or broken water delivery devices such as sprinklers or the connections of sprinklers to the main pipes.

Irrigation systems must be observed in operation at least weekly to help detect failures, clogging or misalignment. *Photo credit: Jeff Miller.*

SPRINKLER MAINTENANCE

Principles

- Good system management starts with good preventive maintenance (PM) procedures and record keeping. This can be done during maintenance programs such as fertilizer or chemical applications where irrigation is required, or the heads can be brought on-line for a few seconds and observed for proper operation.
- Maintaining a system is more than just fixing heads. It also includes documenting system- and maintenance-related activities so that potential problems can be addressed before expensive repairs are needed. It also provides a basis for evaluating renovation or replacement options.
- Be proactive; if the system requires frequent repairs, it is necessary to determine why these failures are occurring.
  - Pipe failures can be caused not only by material failure, but also by problems with the pump station.
  - Wiring problems could be caused by corrosion, rodent damage, or frequent lightning or power surges.
  - Control tubing problems could result from poor filtration.

Best Management Practices

- System checks and routine maintenance on pumps, valves, programs, fittings, and sprinklers should follow the manufacturer's recommendations.
- The system should be inspected routinely for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads.
- A visual inspection should be carried out for leaks, misaligned or inoperable heads, and chronic wet or dry spots, so that adjustments can be made or equipment replaced.
- Flush irrigation lines regularly to minimize emitter clogging. To reduce sediment buildup, make flushing part of a regular maintenance schedule. If fertigating, prevent microbial growth by flushing all fertilizer from the lateral lines before shutting down the irrigation system.
- Clean and maintain filtration equipment.
- Systems must be observed in operation at least weekly. This process detects controller or communication failures, stuck or misaligned heads, and clogged or broken nozzles.
- Check filter operations frequently. An unusual increase in the amount of debris may indicate problems with the water source.
- Even under routine conditions, keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.
- Keep records of filter changes, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.
- Application/distribution efficiencies should be checked annually. Conduct a periodic professional irrigation audit at least once every five years. Implement a PM program to replace worn components before they waste fertilizer, chemicals, and water.
- Document equipment run-time hours.
- Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Monitor pump station power consumption. Monthly bills should be monitored over time to detect a possible increase in power usage. Compare the power used with the amount of water pumped. Requiring more power to pump the same amount of water may indicate a problem with the pump motor(s), control valves, or distribution system. Quarterly checks of amperage by qualified pump personnel may more accurately indicate increased power usage and thus identify potential problems.
- Monitor and record the amount of water being applied, including both system usage and rainfall. By tracking this information, you can identify areas where minor adjustments can improve performance. Not only is this information essential in identifying places that would benefit from a renovation, but it is also needed to compute current operating costs and compare possible future costs after a renovation.
- Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings).

SYSTEM MAINTENANCE

Principles

- Course owners/superintendents do routine maintenance to ensure water quality and responsible use of the water supply.
- System checks and routine maintenance include: pumps, valves, programs, fittings, and sprinklers.
- To ensure an irrigation system is performing as intended, it should be calibrated regularly by conducting periodic irrigation audits to check actual water delivery and nozzle efficiency.

Best Management Practices

- Irrigation audits should be performed by trained technicians.
- A visual inspection should first be conducted to identify necessary repairs or corrective actions. It is essential to make repairs before carrying out other levels of evaluation.
- Pressure and flow should be evaluated to determine that the correct nozzles are being used and that the heads are performing according to the manufacturer's specifications. A notebook of manufacturer specifications should be available for personnel working on maintenance of sprinklers.
- Pressure and flow rates should be checked at each head to determine the average application rate in an area. Manufacturer specifications will provide information on the proper application rates at given pressures.
- Catch-can tests should be run to determine the uniformity of coverage and to accurately determine irrigation run times.
- Catch-can testing should be conducted on the entire golf course to ensure that the system is operating at its highest efficiency.
- Conduct an irrigation audit annually to facilitate a high-quality maintenance and scheduling program for the irrigation system.
- Inspect for interference with water distribution.
- Inspect for broken and misaligned heads.
- Check that the rain sensor is present and functioning. If multiple rain sensors are used, ensure all are operating properly.
- Inspect the backflow prevention device to determine that it is in place and in good repair.
- Examine turf quality and plant health for indications of irrigation malfunction or needs for scheduling adjustments.
- Schedule documentation; make adjustments and repairs on items diagnosed during the visual inspection before conducting pressure and flow procedures.

Preventive Maintenance

- In older systems, inspect irrigation pipe and look for fitting breaks caused by surges in the system.
- Install thrust blocks to support conveyances.
- The system should be inspected daily for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads. A visual inspection should be carried out for leaks, misaligned or inoperable heads, and chronic wet or dry spots so that adjustments can be made.
- Maintain air-relief and vacuum-breaker valves.
- Systems need to be observed in operation at least weekly to detect controller or communication failures, stuck or misaligned heads, and clogged or broken nozzles.
- Check filter operations frequently; keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.
- Keep records of filter changes, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.
- Application/distribution efficiencies should be checked annually.
- Conduct a periodic professional irrigation audit at least once every five years.
- Document equipment run-time hours. Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Monitor the power consumption of pump stations for problems with the pump motors, control valves, or distribution system.
- Qualified pump personnel should perform quarterly checks of amperage to accurately identify increased power usage that indicates potential problems.
- Monitor and record the amount of water being applied, including system usage and rainfall. By tracking this information, you can identify areas where minor adjustments can improve performance.
- Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings). If the system requires frequent repairs, it is necessary to determine why these failures are occurring.
- Increase frequency of routine inspection/calibration of soil moisture sensors that may be operating in high-salinity soils.
- Winterize irrigation system to prevent damage.

Corrective Maintenance

- Replace or repair all broken or worn components before the next scheduled irrigation.
- Replacement parts should have the same characteristics as the original components.
- Record keeping is an essential practice; document all corrective actions.
- If replacing sprinklers, make sure the same product is used for replacement. If this is not possible, make sure the application rate of the new device matches that of the device being replaced.

System Renovation

- Appropriate golf course renovations can improve system efficiencies, conserve water, improve playability, and lower operating costs.
- Correctly identify problems and their cost to determine which renovations are appropriate.
- Determine the age of the system to establish a starting point for renovation.
- Identify ways to improve system performance by maximizing the efficient use of the current system.
- Routinely document system performance to maximize the effectiveness of the renovation.
- Evaluate cost of renovation and its return on benefits both financial and management.

WINTERIZATION AND SPRING STARTUP

Principle

Winterization of the irrigation system is important to protect the system and reduce equipment failures resulting from freezing.

Spring start-up checks can be used to check for any initial irrigation issues that could have occurred through the winter months. Spring start-up is also the initial preventative and corrective maintenance period for personnel managing the irrigation system and the system itself.

Best Management Practices (Winterizing)

- Conduct a visual inspection of the irrigation system: inspect for mainline breaks, low pressure at the pump, and head-to-head spacing. Any problems should be noted and repaired during winter/non-irrigation months.
- Conduct a catch-can test to audit the system.
- Flush and drain above-ground irrigation system components that could hold water. This would include pumps, pump casings, filters and other above grounds components specific to a course.
- Use compressed air or open drain plugs at the lowest point on the system to remove water from all conveyances and supply and distribution devices that may freeze.
- Clean filters, screens, and housing; remove drain plug and empty water out of the system.
- Secure systems and close and lock covers/ compartment doors to protect the system from potential acts of vandalism and from animals seeking refuge.
- Record metering data before closing the system.
- Secure or lock irrigation components and electrical boxes. Check electric wiring and components for rodent or other animal damage.
- Perform pump and engine servicing/repair before winterizing.

Best Management Practices (Spring)

- Replace plugs removed for winter in irrigation equipment.
- Check fluids in all pumping equipment.
- Check all electric components for rodent or other animal damage.
- Recharge irrigation in the spring with water and inspect for maintenance issues.
- Conduct a visual inspection of the irrigation system: inspect for mainline breaks, low pressure at the pump, and head-to-head spacing. Those areas noted during the winterizing of the system and fixed during winter months should be specifically inspected to ensure proper repair and operation.
- Conduct a catch-can test to audit the system.
- Ensure proper irrigation system drainage design.

SENSOR TECHNOLOGY

Principles

- Sensor technology consists of mainly three different type sensors: resistance, capacitance or Time Domain Reflectometry (TDR). Each of these three different types provides information on the soil moisture but measures it in different ways, as follows:
  - Resistance sensors measure the electrical resistance between two wires across a ceramic plate. Since water conducts electricity the soil moisture is proportional to the amount of resistance between wires. Resistance sensors measure the potential of water movement in the soil and provide a potential reading for the soil, units of kPa or centibars.
  - Capacitance sensors use an electric charge to build an electric field in the soil profile (around the sensor). The datalogger attached to the sensor then reads the capacitance of the soil profile which is proportional to the moisture content. Capacitance sensors measure the dielectric constant of the soil profile and provide a volumetric soil moisture reading or value, units are a percentage soil moisture.

Soil moisture sensors and other irrigation management tools inform good irrigation decisions. *Photo credit: Tim Busek.*

  - TDR sensors measure the time domain or time it takes waves to move through the soil profile. The measurement is a function of the voltage reflected from the sensor and is proportional to the soil moisture, units are percentage soil moisture.
- Irrigation management and control devices need to be installed correctly for proper irrigation management.
- Soil moisture sensors and other irrigation management tools should be installed in representative locations and maintained to provide the information necessary for making good irrigation management decisions.
- Rain gauges are necessary measurement tools to track how much rain has fallen at a specific site on the golf course. On some courses, multiple gauges may be necessary to get a complete measure of rainfall or evaporation loss. The use of soil moisture probes and inspections for visual symptoms such as wilting turf, computer models, and tensiometers may supplement these measurements. Computerized displays are available to help visualize the system.
- Predictive models based on weather station data and soil types are also available. These are relatively accurate and applicable, especially as long-term predictors of annual turf water requirements.
- Weather data such as rainfall, air and soil temperature, relative humidity, and wind speed are incorporated into certain model formulas, and soil moisture content is estimated. Models, however, are only as effective as the amount of data collected and the number of assumptions made.
- It is best to have an on-site weather station to access weather information and ET to determine site specific water needs on a dialy basis.

Best Management Practices

- Irrigation controllers/timers should be reset as often as practically possible to account for plant growth requirements and local climatic conditions.
- Properly calibrated flow meters, soil moisture sensors, rain shut-off devices, and/or other automated methods should be used to manage irrigation.
- Irrigation rates should not exceed the maximum ability of the soil to absorb and hold the water applied in any one application.
- Irrigation should not occur on a calendar-based schedule, but should be based on ET rates and soil moisture replacement.
- Computerized control systems should be installed on all new course irrigation systems to help ensure efficient irrigation application. These allow for timing adjustments at every head.
- Rain shut-off devices and rain gauges should be placed in open areas to prevent erroneous readings.
- Use multiple soil moisture sensors/meters for accuracy and to reflect soil moisture levels.

On-site weather stations access weather information and ET rates to determine site-specific water needs.
Photo credit: Lukus Harvey.

MAINTAINED TURF AREAS

Principle

Courses should use well-designed irrigation systems with precision scheduling based on soil infiltration rates, soil water-holding capacity, plant water-use requirements, the depth of the root zone, and the desired level of turfgrass appearance and performance in order to maximize efficient watering.

Best Management Practices

- The irrigation system should be designed and installed so that the putting surface, slopes, and surrounding areas can be watered independently.
- When using alternative water sources which may have measurable nutrient content, the nutrients in the water supply should be accounted for when making nutrient calculations.
- Install part-circle heads that conserve water and reduce unnecessary stress to greens and surrounds.
- Avoid use of a global setting; make adjustments to watering times per head.
- Base water times on actual site conditions for each head and zone.
- Adjust irrigation run times based on current local meteorological data.
- Use computed daily ET rates to adjust run times to meet the turf's moisture needs. In Georgia, ET data can be retrieved online from the GA Weather Network.
- Manually adjust automated ET data to reflect wet and dry areas on the course.
- Install rain switches to shut down the irrigation system if enough rain falls in a zone.
- Use soil moisture sensors to bypass preset or to create on-demand irrigation schedules.
- Permanent irrigation sprinklers and other distribution devices should be spaced according to the manufacturer's recommendations.
- Spacing should be based on average wind conditions during irrigation.
- Triangular spacing is more uniform than square spacing.
- Periodically perform catch-can uniformity tests.
- Reducing dry spots and soil compaction improves water infiltration, which in turn reduces water use and runoff in other areas.
- Irrigation should occur in the early morning hours before air temperatures rise and relative humidity drops.

Wetting agents promote conservation by helping maximize the benefits of any water applied to the golf course. *Photo credit: Lydell Mack.*

- Base plant water needs on evapotranspiration rates, recent rainfall, recent temperature extremes and soil moisture.
- Use mowing, verticutting, aeration, wetting agents, nutrition, and other cultural practices to control water loss and to encourage conservation and efficiency.
- Depending on physical soil characteristics and turf type, using solid-tine aeration equipment in place of verticutting is an option.
- Slicing and spiking help relieve surface compaction and promote better water penetration and aeration.
- Visually monitor for localized dry conditions or hot spots to identify poor irrigation efficiency or a failed system device.
- Use predictive models to estimate soil moisture and the best time to irrigate.
- Install in-ground (wireless) soil moisture sensors or use hand-held moisture meters in the root zone for each irrigation zone to enhance scheduled timer-based run times.
- An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.
- Place soil moisture sensors in a representative location of the irrigation zone.
- Install soil moisture sensors in the driest irrigation zone and wettest irrigation zone, if possible, to provide better irrigation control.
- Wireless soil moisture systems should be installed in a manner that avoids damage from aeration. If wired sensors are used, installation of wires should be below the depth of any aeration or mechanical operations that penetrate the soil profile.

Incorporating natural vegetation in non-play areas can enhance aesthetic appeal and minimize irrigation needs. *Photo credit: Mark Hoban.*

NON-PLAY AND LANDSCAPE AREAS

Principles

- Map any environmentally sensitive areas such as sinkholes, wetlands, or flood-prone areas, and identify species classified as endangered or threatened by federal and state governments, and state species of special concern.
- Natural vegetation should be retained and enhanced for non-play areas to conserve water.
- The most efficient and effective watering method for non-turf landscape is micro-irrigation.
- Older golf courses might have more irrigated and maintained acres than are necessary. With the help of a golf course architect, golf professional, golf course superintendent, and other key personnel, the amount of functional turfgrass can be evaluated and transitioned into non-play areas.

Best Management Practices

- Designate 50% to 70% of the non-play area to remain in natural cover according to "right-plant, right-place," a principle of plant selection that favors limited supplemental irrigation and on-site cultural practices.
- Incorporate natural vegetation in non-play areas.
- Use micro-irrigation and low-pressure emitters in non-play areas to supplement irrigation.
- Routinely inspect non-play irrigation systems for problems related to emitter clogging, filter defects, and overall system functionality.

WELLHEAD PROTECTION

Principles

- Wellhead protection is the establishment of protection zones and safe land-use practices around water supply wells in order to protect aquifers from accidental contamination. It also includes protecting wellheads from physical impacts, keeping them secure, and sampling wells according to the monitoring schedule required by the regulating authority, which is often a local health department or state department of environmental quality.
- When installing new wells, contact the regulating authority to determine the permitting and construction requirements and the required isolation distances from potential sources of contamination. Wells with pumps having a capacity of 69 gallons per minute or more should be permitted through the Georgia Department of Natural Resources' Environmental Protection Divisions' Agricultural Permitting Section.
- Locate new wells up-gradient as far as possible from likely pollutant sources, such as petroleum storage tanks, septic tanks, chemical mixing areas, or fertilizer storage facilities.
- Licensed water-well contractors may be needed to drill new wells to meet state requirements, local government code, and water management districts' well-construction permit requirements.

Best Management Practices

- Use backflow-prevention devices at the wellhead, on hoses, and at the pesticide mix/load station to prevent contamination of the water source.
- Properly plug abandoned or flowing wells.
- Surround new wells with bollards or a physical barrier to prevent impacts to the wellhead.
- Inspect wellheads and the well casing at least annually for leaks or cracks; make repairs as needed.
- Maintain records of new well construction and modifications to existing wells.
- Obtain a copy of the well log for each well to determine the local geology and how deep the well is; these factors will have a bearing on how vulnerable the well is to contamination.
- Sample wells for contaminants according to the schedule and protocol required by the regulating authority.
- Never apply a fertilizer or pesticide next to a wellhead.
- Never mix and load pesticides next to a wellhead if not on a pesticide mix/load pad.

3. SURFACE WATER MANAGEMENT

Although golf courses are typically large properties ranging in size from 60 to 200 acres, they can be just one link in a stormwater management chain. Generally, a quantity of stormwater enters the golf course area, supplemented by what falls on the golf course proper, and then the stormwater leaves the golf course. Therefore, based on the location of the golf course and its ability to capture and retain a portion of stormwater received, golf courses realistically have only a small impact on major stormwater flow. That impact should be to add only small increments of water over a given period of time. Engineers refer to the function of holding water on-site as "detention."

When golf courses are designed and built, their drainage capability concept is guided by an average rainfall event of a given frequency. For example, typically, a golf course drainage system is designed to detain a two- or five-year rain event. In other words, when that rain event happens, the golf course will be able to be reasonably drained in a matter of hours, as excess water not absorbed by the soil flows through the drainage system, is temporarily held, and finally leaves the property. In some instances, golf courses and other recreational facilities are mandated to be designed to handle a 20-, 50- or 100-year rain event, which means the golf course must detain more water for perhaps a longer period of time. This ability to detain large amounts of water requires accurate engineering and extensive construction to prevent physical or financial damage to the facility.

Best Management Practices are intended to prolong the detention process as long as is practicable, harvest as much of the stormwater in surface or underground storage as is reasonable, and to improve the quality of water leaving the property whenever possible.

STORMWATER CAPTURE

Principles

- When the golf course is properly designed to capture runoff water from surface or tile drains, the rain and runoff captured in water hazards and stormwater

Engineers refer to the function of holding water on-site as "detention" and lakes and ponds can play an important role in mitigating stormwater impacts. *Photo credit: Scott Slemp.*

ponds may provide most or all of the supplemental (i.e. irrigation) water necessary under normal conditions, though backup sources may still be needed during drought conditions.

- Capture systems should be considered part of the overall treatment of runoff water to remove sediment, nutrients, and pesticides.
- Stormwater capture use is desirable where a lower-quality water can be used to conserve potable water, maintain hydrologic balance, and improve water treatment.
- This practice uses natural and constructed systems to remove pollutants such as sediment or nutrients from the runoff water as well as provide some level of treatment.

Best Management Practices

- Install berms and swales to capture pollutants and sediments from runoff before it enters the irrigation storage pond. This is termed a forebay and is used to slow water down prior to the storage pond and allows for an easier means and place of removing sediment.
- Monitor pond water level for water loss (seepage) to underground systems. If seepage is occurring, it may be necessary to line or seal the pond or install pumps to relocate water. If there is a large issue with seepage, the location of the seepage should be investigated to ensure it is not through a dam or other structure that could cause problems downstream of the pond.
- Install water-intake systems that use horizontal wells placed in the subsoil below the storage basin. Use a post pump to filter particulate matter.
- A backup source of water, as an alternative to captured stormwater, should be incorporated into the water management plan.
- Inspect irrigation pumps, filtration systems, conveyances and control devices to prevent/correct system issues. For more information see the Irrigation Managment Section of this Manual.

REGULATORY CONSIDERATIONS

Principle

Course owners and superintendents should investigate regulatory requirements that apply to the golf facility to protect surface and groundwater quality. In Georgia, the agency responsible for water quality is

Vegetative buffers act as natural biofilters that protect surface water quality. *Photo credit: Jeff Miller.*

the Environmental Protection Division (EPD) or the Department of Natural Resources. Water Quality Standards are listed in Chapter 391-3-6-.03(2)(b) of the Georgia Rules and Regulations for Water Quality Control (Rules). Since runoff from golf courses is considered non-point source pollution, information related to the water quality rules of Georgia and non-point source pollution can also be found in the document Georgia's Statewide Nonpoint Source Management Plan.

Best Management Practices

- Aquatic management of plants may be regulated under construction permitting and regulatory licensing requirements. Consult with federal, state, and local water management agencies before managing golf course lakes and wetland areas. When managing aquatic plants with pesticides, make sure they are labeled for use around and in water.
- Consult with federal, state, and local water management agencies, and/or consult an approved management plan before performing cultural practices such as fertilization, installation of plants, hand removal of plants, or mechanical harvesting.
- The introduction of aquatic triploid grass carp, biological controls, aeration, and chemical controls (herbicide/algaecide) must be approved and monitored according to permit and licensing protocols and compliance.
- The disposal of sediments from surface water ponds (stormwater detention) may be subject to regulation. Check with the regional EPD office prior to removal and use/disposal.
- Golf course management may be affected by Total Maximum Daily Loading (TMDL), mitigation, and watershed basin management action plans (BMAP). Be aware of any such plans that are in effect for the streams on the golf course, or where water may exit the golf course and into a stream. The list of streams with such plans can be requested from the GA EPD.
- Wetlands are protected areas; consult with federal and state agencies before altering natural aquatic areas.
- Constructed wetlands should have an impervious bottom to prevent groundwater contamination.
- Studies of water supplies are needed for irrigation systems, including studies of waterbodies or flows on, near, and under the property to properly design a course's stormwater system and water features to protect water resources. The Regional Water Plans for the area where the golf course is located can provide some information on water supplies in the region where the course is located.

WATER QUALITY PROTECTION

Principles

- An aquatic plant management strategy should address the intended uses of the waterbody to maintain water quality. In Georgia, the intended uses of the water can be found in the Water Quality Rules (Chapter 391-3-6-.03(2)(b) of the Georgia Rules and Regulations for Water Quality Control (Rules). Proper documentation should be made of the site's physical attributes and location, the presence of invasive or weedy species, aesthetics, watershed and groundwater assessments, and other environmental considerations.
- Only licensed individuals or contractors should be allowed to select and apply aquatic pesticides. Any pesticide sprayed to manage aquatic weeds should be labeled for such.
- Every golf course should have a plan to monitor the state of the environment and effects that the golf course might have on the environment.
- Monitoring is used to determine whether outside events are changing the water quality entering the golf course, or whether the golf course is having a positive, neutral, or negative effect on water quality. It also provides a body of evidence on the golf course's environmental impact.
- A water-quality monitoring plan should be prepared to ensure the ongoing protection of groundwater and surface-water quality after construction has been completed. The same sites should be monitored during the preconstruction phase, although the monitoring plan can be modified based on site-specific conditions.
- Sampling parameters are determined based on golf course operation and basin-specific parameters of concern (these may be identified by local/state Total Maximum Daily Load (TMDL) Programs). Typically, samples should be analyzed for nutrients, pH and alkalinity, sediments, and suspended solids, dissolved oxygen (DO), heavy metals, and any pesticides expected to be used on the golf course.
- Ongoing, routine water sampling provides meaningful trends over time. A single sample is rarely meaningful in isolation.
- Post-construction sampling of surface water quality should begin with the installation and maintenance of golf course turf and landscaping. Samples should be collected a minimum of three times per year. After three years, water samples should be collected and analyzed for water quality parameters as feasible, but should be twice annually at a minimum. Water quality samples should also be collected if a significant change has been made in course

operation or design that could affect nearby water quality. There are many different labs in Georgia that can perform water quality tests.

- If there is no discharge on the scheduled sample date, samples should be taken during the next discharge event.
- Sampling parameters should be determined based on golf course operation and any basin-specific parameters of concern (identified by the TMDL program or local regulators).
- The purpose of quality assurance/quality control (QA/QC) is to ensure that chemical, physical, biological, microbiological, and toxicological data are appropriate and reliable. Data should be collected and analyzed using scientifically sound procedures.
- However, even if the data are only for proprietary use and are not reported to any regulatory agency, it is strongly recommended that a certified laboratory be used and all QA/QC procedures followed.
- Golf course management must have good data to make good decisions and the data should be kept in a place to be able to refer to from year to year. If a golf course should ever want or need to produce data for an agency or go to court to defend the facility from unwarranted charges, those data must meet QA/QC standards to be defensible as evidence.

Best Management Practices

- Accommodate natural lake processes in the construction of lakes and ponds; include herbaceous and woody vegetation and emergent and submergent shoreline plants to reduce operational costs.
- Use integrated pest management (IPM) strategies and native or naturalized vegetation wherever practical.
- Apply appropriate herbicides to minimize damage to non-target littoral plantings.
- Maintain a narrow band of open water at the pond edge to control the expansion of plants into more desirable littoral plantings.
- Use appropriate aquatic herbicides to prevent turfgrass injury and to protect water quality and wildlife habitat.
- Irrigation should not directly strike or run off to waterbodies, and no-fertilization buffers should be maintained along water edges.
- Outline goals and priorities to guide the development of BMPs necessary to support the lake/aquatic management plan.
- Superintendents should monitor designated waters in their area for the persistence of toxic herbicides and algaecides in the environment.
- Secondary environmental effects on surface water and groundwater from the chemical control of vegetation should be monitored and recorded.
- Apply fertilizer and reclaimed (reuse) irrigation/fertigation appropriately to avoid surface water and groundwater contamination.
- Apply copper products per label instructions to reduce the risk of impairing water quality and causing negative biological impacts.
- Identify where in the watershed the golf course is located to better understand how actions on the course could affect downstream water resources.
- Identify overall goals and validate concerns of the local watershed. In Georgia, there are 11 Regional Water Councils and Districts. Understanding the management practices in these regional water plans can help comprehend the goals of the larger regional watershed.
- Identify surface water and flow patterns.
- On a map of the golf course, indicate stormwater flow as well as existing and potential holding capacity.
- On a map of the golf course, indicate impervious surfaces, such as buildings, parking lots, or pathways.
- On a map of the golf course, indicate major drainages and catch basins that connect to local surface water bodies.
- Identify and understand depth to water tables and soil types.
- Locate and protect wellheads.

DISSOLVED OXYGEN

Principles

- Dissolved oxygen (DO) should be checked in ponds consistently to have a good idea of how the ponds can be managed in relation to organic matter, fish, and the season. Checking DO in the pond during times of high organic matter (those times of the year with high levels of grass or leaves from runoff or falling from trees) can help better understand or better manage the pond. If there are fish in the pond, knowing DO levels can provide information on what fish can best survive in the pond. For more information on oxygen in ponds see UGA Publication Oxygen Depletion in Ponds.
- Dissolved oxygen levels will also change during the year depending on temperature. Higher temperatures result in lower DO while lower temperatures result in higher DO.

Best Management Practices

- Establish dissolved oxygen (DO) thresholds to prevent fish kills (occur at levels of 2 ppm), for example, use artificial aeration (diffusers).
- Reduce stress on fish; keep DO levels above 3 ppm.
- Select algaecides containing hydrogen peroxide instead of copper or endothall to treat high populations of phytoplankton.
- Use IPM principles to limit excess use of pesticides.
- Spot-treat filamentous algae or frequently remove algae by hand to prevent lowering oxygen concentrations in water.
- Use dyes and aeration to maintain appropriate light and DO levels.
- Apply algaecides to small areas to prevent fish mortality; do not treat the entire pond at once.
- Coordinate construction/renovation activities to minimize the amount of disturbed area and possible risk of contamination via runoff.
- Plan construction/renovation activities in phases to limit soil disruption and movement.
- Sod, sprig, or reseed bare or thinning turf areas.
- Mulch areas under tree canopies to cover bare soil.
- Mow lake and pond collars at a higher height to slow and filter overland flow to waterbodies. Avoid the use of trimmers along the edge of the water body to reduce the risk of cutting grass too short.
- Remove excess sediments to reduce irrigation system failures.
- Treat dredged materials as a toxic substance. Avoid contact with turf.
- Locate littoral shelves at the pond's inlets and outlets to reduce problems with the playability and maintainability of a water hazard.
- Seek professional assistance from an environmental specialist to design an appropriate water sample collection strategy.
- Determine which sites will be analyzed, and use reputable equipment and qualified technicians.
- Demonstrate responsible land and water use practices based on water data.
- Define data values appropriately based on the associated BMP used to protect water quality.
- Record observations of fish, wildlife, and general pond conditions.

AQUATIC PLANTS

Principles

- Phytoplankton, which give water its green appearance, provide the base for the food chain in ponds. Tiny animals called zooplankton use phytoplankton as a food source.
- Large aquatic plants (aquatic macrophytes) can grow rooted to the bottom and supported by the water (submersed plants), rooted to the bottom or shoreline and extended above the water surface (emersed plants), rooted to the bottom with their leaves floating on the water surface (floating-leaved plants), or free-floating on the water surface (floating plants). Different types of aquatic macrophytes have different functions in ponds.
- Plant life growing on littoral shelves may help to protect receiving waters from the pollutants present in surface water runoff, and a littoral shelf is often required in permitted surface water-retention ponds. Floating plants suppress phytoplankton because they absorb nutrients from the pond water and create shade.
- The use of aquatic plants to improve the appearance of a pond (aquascaping) can be included as part of the overall landscape design.
- Ponds may be constructed on golf courses strictly as water hazards or for landscape purposes, but they often have the primary purpose of drainage and stormwater management, and are also often a source of irrigation water.

Best Management Practices

- Properly designed ponds with a narrow fringe of vegetation along the edge are more resistant to problems than those with highly maintained turf surrounds.
- In ponds with littoral plantings, problem plants should be selectively controlled without damaging littoral shelves.
- Encourage clumps of native emergent vegetation at the shoreline.
- A comprehensive lake management plan should include strategies to control the growth of nuisance vegetation that can negatively affect a pond's water quality and treatment capacity.
- Frequently remove filamentous algae by hand and/or frequently apply algaecide to small areas of algae (spot treatment).
- To reduce the risk of oxygen depletion, use an algaecide containing hydrogen peroxide instead of one with copper or endothall.

HUMAN HEALTH CONCERNS

Principles

- The use of pesticides should be part of an overall pest management strategy that includes biological controls, cultural methods, pest monitoring, and other applicable practices, referred to altogether as Integrated Pest Management or IPM.
- Address areas where standing water may provide habitat for nuisance organisms.

Best Management Practices

- Use IPM principles to address insects that may pose a hazard to human health.
- Drain areas of standing water during wet seasons to reduce insect populations.
- Use *Bacillus thuringiensis (Bt)* products according to label directions to manage waterborne insect larvae.

FLOODPLAIN RESTORATION

Principles

- Reestablishment of natural water systems helps mitigate flooding and control stormwater. Natural water systems would include benches along rivers or streams. Additionally, having floodplains along rivers and streams can help maintain and reduce flooding problems on the golf course or downstream of the golf course.
- Address high sediment and nutrient loads and vertical and lateral stream migration causing unstable banks, flooding, and reductions in groundwater recharge. High sediment loads and increased velocities in channels could be the result of increased impervious surfaces upstream of the golf course or on the course itself. Reestablishing floodplains can help reduce increased velocity and unstable banks.
- Land use decisions and engineering standards must be based on the most recent research and science.

Best Management Practices

- Install stream buffers to restore natural water flows and flooding controls.
- Install buffers in play areas to stabilize and restore natural areas that will attract wildlife species.
- Install detention basins to store water and reduce flooding at peak flows.
- Where unstable banks form, determine if reestablishing a floodplain can be incorporated into golf course. Reestablishing floodplains or incorporating a stormwater feature can help slow down water flow and reduce additional sediment dislodgement and movement.

Stream buffers can restore natural water flows, slow stormwater and prevent erosion. *Photo credit: Joe Hollis.*

STORMWATER, PONDS, AND LAKES

Stormwater is the conveying force behind what is called nonpoint source pollution. Nonpoint pollution, which is both natural and caused by humans, comes not from a pipe from a factory or sewage treatment plant, but from daily activity. Pollutants commonly found in stormwater include the microscopic wear products of brake linings and tires; oil; shingle particles washed off of roofs; soap, dirt, and worn paint particles from car washing; leaves and grass clippings; pet and wildlife wastes; lawn, commercial, and agricultural fertilizers; and pesticides. The Georgia Environmental Protection Division of the Department of Natural Resources has a document titled Georgia's Statewide Nonpoint Source Management Plan. Managing stormwater helps reduce non-point source pollution and can provide a source of irrigation water. The Georgia Stormwater Management Manual (GSMM) and the Coastal Supplement to the GSMM can be used to help design stormwater practices and the manual (Volume 2) has information on how the different practices are designed and should operate.

Principles

- The control of stormwater on a golf course is more than just preventing the flooding of the clubhouse, maintenance, and play areas. In addition to controlling the amount and rate of water leaving the course, it involves storing irrigation water, controlling erosion and sediment, enhancing wildlife habitat, removing waterborne pollutants, and addressing aesthetic and playability concerns.
- Most golf courses plan their lakes and water hazards to be a part of the stormwater control and treatment

system. However, natural waters of the state cannot be considered treatment systems and must be protected.

- Lakes and ponds may also be used as a source of irrigation water.
- It is important to consider these functions when designing and constructing the ponds. Peninsular projections and long, narrow fingers may prevent mixing. Ponds that are too shallow may reach high temperatures, leading to low oxygen levels and promoting algal growth and excess sedimentation.
- Stormwater treatment is best accomplished by a treatment train approach, in which water is conveyed from one treatment to another by conveyances that themselves contribute to the treatment.
- Source controls are the first car on the BMP treatment train. They help to prevent the generation of stormwater or introduction of pollutants into stormwater. The most effective method of stormwater treatment is not to generate stormwater in the first place, or to remove it as it is generated.

Best Management Practices

- Install swales and slight berms where appropriate around the water's edge, along with buffer strips, to reduce nutrients and contamination entering the waterbody.
- Design stormwater treatment trains to direct stormwater across vegetated filter strips (such as turfgrass), through a swale into a wet detention pond, and then out through another swale to a constructed wetland system.
- Ensure that no discharges from pipes go directly to water.
- Eliminate or minimize directly connected impervious areas.
- Use vegetated swales to slow and infiltrate water and trap pollutants in the soil, where they can be naturally destroyed by soil organisms.
- Use depressed landscape islands in parking lots to catch, filter, and infiltrate water, instead of letting it run off. When hard rains occur, an elevated stormwater drain inlet allows the island to hold the treatment volume and settle out sediments, while allowing the overflow to drain away.
- Maximize the use of pervious pavements, such as brick or concrete pavers separated by sand and planted with grass. Special high-permeability concrete is available for cart paths or parking lots.
- Disconnect runoff from gutters and roof drains from impervious areas, so that it flows onto permeable areas that allow the water to infiltrate near the point of generation.
- Golf course stormwater management should include "natural systems engineering" or "soft engineering" approaches that maximize the use of natural systems to treat water.
- Use a treatment train approach.
- Institute buffers and special management zones.

Most golf courses plan their lakes and water hazards to be a part of the stormwater control and treatment system. *Photo credit: Nelson Caron.*

4. WATER QUALITY MONITORING AND MANAGEMENT

REGULATORY CONSIDERATIONS

Principle

Golf course owners and superintendents should investigate regulatory requirements that may exist in their location to protect surface and groundwater quality. In Georgia, water quality is regulated by the Georgia Environmental Protection Division of the Department of Natural Resources (EPD). Water Quality regulations can be found under the EPD Rules in Section 391-3-6-.03 (Water Use Classifications and Water Quality Standards.

Best Management Practices

- Aquatic management of plants may be regulated under construction permitting and regulatory licensing requirements. Consult with federal, state, and local water management agencies before managing golf course lakes and wetland areas.
- Consult with federal, state, and local water management agencies, and/or consult an approved management plan before performing cultural practices: fertilization; installation of plants; hand removal of plants or mechanical harvesting.
- The introduction of aquatic triploid grass carp, biological controls, aeration, and chemical controls (herbicide/algaecide) must be approved and monitored according to permit and licensing protocols and compliance.
- The disposal of sediments from surface-water ponds (stormwater detention) may be subject to regulation.
- Golf course owners are responsible for Total Maximum Daily Loading (TMDLs), mitigation, and watershed basin management action plans (BMAP).
- Wetlands are protected areas; consult with federal and state agencies before altering natural aquatic areas.
- Constructed wetlands should have an impervious bottom to prevent groundwater contamination.
- Studies of water supplies including studies of waterbodies or flows on, near, and under the property are needed to properly design a course's irrigation system, stormwater system, and water features to protect water resources. Consult the Regional Water Plan for the area where the golf course is located to get more information on water supply and planning.

SITE ANALYSIS

Principle

Design an aquatic plant management strategy that addresses the intended uses of the waterbody to maintain water quality. Identify the site's physical attributes and location, the invasive or weedy species present, aesthetics, watershed and groundwater assessments, and other environmental considerations.

Best Management Practices

- Accommodate natural lake processes in the construction of lakes and ponds; include herbaceous and woody vegetation and emergent and submergent shoreline plants to reduce operational costs.
- Use Integrated Pest Management (IPM) and native or naturalized vegetation wherever practical.
- Apply appropriate herbicides to minimize damage to non-target littoral plantings.
- Maintain a narrow band of open water at the pond edge to control the expansion of plants into more desirable littoral plantings.
- Use appropriate aquatic herbicides to avoid turfgrass injury.
- Irrigation should not directly strike or runoff to waterbodies and no-fertilization buffers should be maintained along edges.
- Outline goals and priorities to guide the development of the BMP necessary to support the lake/aquatic management plan.
- Superintendents should monitor designated waters in their area for the persistence of highly toxic herbicides and algaecides in the environment.
- Secondary environmental effects on surface water and groundwater from the chemical control of vegetation should be monitored and recorded.
- Apply fertilizer and reclaimed (reuse) irrigation/fertigation appropriately to avoid surface and groundwater contamination.
- Apply copper products per label instructions to reduce the risk of negative biological impacts and impairing water quality.
- Identify position of golf course in relation to its watershed or watersheds.
- Identify overall goals and qualify concerns of the local watershed, some of which can be found in the Regional Water Plans and local watershed

management plans. Contact EPD Watershed Managment Branch or local watershed groups to determine if such plans have been developed. There may also be some TMDLs in place that can help guide you in watershed goals.

- Indicate surface water and flow patterns.
- Indicate stormwater flow as well as existing and potential holding capacity.
- Indicate impervious surfaces, such as buildings, parking lots, or pathways.
- Indicate major drainages and catch basins that connect to local surface water bodies.
- Identify and understand depth to water tables and soil types.
- Locate and protect wellheads.

WATER QUALITY SAMPLING PROGRAM

Principles

- Every golf course should have a plan to monitor the state of the environment and the effects the golf course may be having on the environment.
- Monitoring is the method used to determine whether outside events are impacting the water quality entering the golf course, and whether the golf course is having a positive, neutral, or negative effect on water quality on and leaving the course. It also provides a body of evidence on the golf course's environmental impact.
- A water quality monitoring plan should be prepared to ensure the ongoing protection of groundwater and surface water quality after construction is completed. The same sites should be monitored during the preconstruction phase, although the monitoring plan can be modified based on site-specific conditions.
- Sampling parameters are determined based on golf course operation and basin-specific parameters of concern (these may be identified by local/state Total Maximum Daily Load (TMDL) programs). Typically, samples should be analyzed for nutrients, pH and alkalinity, sediments, suspended solids, dissolved oxygen (DO), heavy metals, and any pesticides expected to be used on the golf course.
- Ongoing, routine water sampling provides meaningful trends over time. A single sample is rarely meaningful in isolation. A schedule should be established where water can be sampled and the data stored in a place where it is easy to compare sampling date to sampling date over time.
- Post-construction surface-water quality sampling should begin with the installation and maintenance of golf course turf and landscaping. Samples should be collected a minimum of three times per year. Sampling locations should be spread across the course and account for water entering the golf course property, leaving the property and somewhere on the course that provides information on the quality of the water being used for irrigation purposes and stormwater management.
- Should there be no discharge on the scheduled sample date, samples should be taken during the next discharge event.
- Post-construction surface-water quality sampling should continue through the first three years of operation and during the wet and dry seasons every third year thereafter, provided that all required water quality monitoring has been completed and the development continues to implement all current management plans. It may also be wise to sample if a significant change has been made in course operation or design that could affect nearby water quality.
- Sampling parameters should be determined based on golf course operation and any basin-specific parameters of concern (identified by the TMDL program or local regulators).
- Golf courses should also sample for macroinvertebrates as recommended by water quality specialists.

Best Management Practices

- Establish dissolved oxygen (DO) thresholds to prevent fish kills (occur at levels of 2 ppm). For example, use artificial aeration (diffusers).
- Reduce stress on fish; keep DO levels above 3 ppm.
- Select algaecides containing hydrogen peroxide instead of one containing copper or endothall to treat high populations of phytoplankton.
- Use IPM principles to limit excess use of pesticides.
- Spot-treat filamentous algae or frequently remove algae by hand to prevent lowering oxygen concentrations in water.
- Use dyes and aeration to maintain appropriate light and DO levels.
- Apply algaecides to small areas to prevent fish mortality; do not treat the entire pond at once.
- Coordinate construction/renovation activities to minimize the amount of disturbed area and possible risk of contamination via runoff.
- Plan construction/renovation activities in phases to limit soil disruption and movement.
- Sod, sprig, or reseed bare or thinning turf areas.
- Mulch areas under tree canopies to cover bare soil.

- Avoid the use of trimmers along the edge of the water body.
- Mow lake and pond collars at two inches or higher to slow and filter overland flow to water bodies.
- Remove excess sediments to reduce irrigation system failures.
- Treat dredged materials as a toxic substance. Avoid contact with turf. Have dredge material tested and contact local EPD office on use of "clean" dredge material to fill in eroded areas.
- Locate littoral shelves at the pond's inlets and outlets to reduce problems with the playability and maintainability of a water hazard.

SAMPLING PARAMETERS, COLLECTION, AND ANALYSIS

Principles

- A water quality monitoring program must include monitoring of surface water, groundwater, and pond sediments. It should be implemented in three phases: background, construction, and long-term management.
- Sampling of all watershed ingress and egress points is important to know what is coming into the property to identify potential impacts and a baseline of water quality data.

Environmental specialists can help design appropriate water sample collection strategies to provide relevant, high-quality data. *Photo credit: Scott Griffith.*

- The purpose of quality assurance/quality control (QA/QC) is to ensure that chemical, physical, biological, microbiological, and toxicological data are appropriate and reliable, and are collected and analyzed using scientifically sound procedures.
- It is strongly recommended that a certified laboratory be used even if the data are only for proprietary use and are not reported to any regulatory agency. There is high quality, lab scale equipment that can be used to test for basic parameters such as nitrogen (all forms), phosphorus (all forms) and other chemicals. These testing methods could be used as part of the monitoring program with the data being saved along with samples analyzed in a certified lab. However, a couple samples per year should be analyzed by a certified lab to cross reference and certify the values obtained from the lab scale equipment is in line with the certified lab values.
- QA/QC procedures should be followed. Golf course management must have good data to make good decisions, and if a golf course should ever choose to produce data for an agency or in court to defend the facility from unwarranted charges, those data must meet QA/QC standards to be defensible as evidence.

Best Management Practices

- Seek professional assistance from an environmental specialist to design an appropriate water sample collection strategy.
- Determine what sites will be analyzed and use reputable equipment and qualified technicians.
- Demonstrate responsible land and water use practices based on water data.
- Define data values appropriately based on the associated BMP used to protect water quality.
- Record observations of fish, wildlife, and general pond conditions.

BUFFER ZONES

Principles

- Buffers around the shore of a waterbody or other sensitive areas filter and purify runoff as it passes across the buffer. Ideally, plant buffers with native species provide a triple play of water quality benefits, pleasing aesthetics, and habitat/food sources for wildlife. As discussed in previous Chapters and Sections, it is important to continue these plantings into the water to provide emergent vegetation for aquatic life, even if the pond is not used for stormwater treatment.
- Effective BMPs in buffer zones filter and trap sediment, provide sources of site-specific natural/

organic fertilization, limit the use of pesticides, and primarily focus on controlling invasive species.

- Golf course stormwater management should include "natural systems engineering" or "soft engineering" approaches that maximize the use of natural systems to treat water.

Best Management Practices

- Riparian buffer areas are above the high-water mark and should be unfertilized and left in a natural state.
- Reduce the frequency of mowing at the lake edge and collect or direct clippings to upland areas.
- Institute buffers and special management zones around waterbodies and waterways where appropriate to help in the removal of pollutants.
- The placement of bunkers and the shaping of contours surrounding a green should allow proper drainage and provide for the treatment and absorption of runoff from the green.
- If possible, allow this drainage water to flow through a grassed waterway to reduce the potential for nutrients - that could be leached from green mixes - to enter a water body.
- If drainage occurs on other course locations (low spots, for example) try to direct this water into a grassed channel.
- If the drain water runs into a pond or stormwater pond, this should be monitored to determine if nutrient concentrations are present that could affect the water quality in the receiving body of water.
- Use turf and native plantings to enhance buffer areas. Increase height of cut in the riparian zone to filter and buffer nutrient movement to the water.
- Use a deflector shield to prevent fertilizer and pesticide prills from contacting surface waters.
- Apply fertilizer and pesticides based on the effective swath; keep application on target and away from buffers or channel swales.
- Use a swale and berm system to allow for resident time (ponding) for water to infiltrate through the root zone to reduce lateral water movement to the surface water body.
- Maintain a riparian buffer to filter the nutrients in stormwater runoff.
- An appropriate-sized buffer (steeper slope requires great buffer width) of turf mowed at a higher height of cut and minimally fertilized with enhanced-efficiency fertilizers can provide an effective buffer.
- Use plant buffers with native species to provide pleasing aesthetics, habitat, and food sources for wildlife.
- Ideally, littoral zones should have a slope of about 1 foot vertical to 6-10 foot horizontal.
- Encourage clumps of native emergent vegetation at the shoreline.
- Establish special management zones around pond edges.
- Reverse-grade around the perimeter to control surface water runoff into ponds and reduce nutrient loading to the ponds.
- Planting on slopes with less than a 6-foot horizontal to a 1-foot vertical may not be as successful over the long term.
- Construct random small dips and ridges of a few inches to a foot to promote diversity within the plant community and provide a healthier and more productive littoral zone.
- All or most of the out-of-play water bodies should have shoreline buffers planted with native or well-adapted non-invasive vegetation to provide food and shelter for wildlife.
- Practice good fertilizer management to reduce the nutrient runoff into ponds that causes algae blooms and ultimately reduces DO levels.
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered DO levels.
- Aerate shallow lakes less than 6 feet in depth to maintain acceptable DO levels.
- Where applicable, aerate at night to control oxygen depletion in any pond.
- Install desirable plants to naturally buffer DO loss and fluctuation.
- Dispose of grass clippings where runoff and wind will not carry them back to the lake or water body.
- Nutrient rich runoff encourages alga blooms and other phytoplankton; apply appropriate fertilizer rates and application setbacks.
- Dredge or remove sediment to protect beneficial organisms that contribute to the lake's food web and overall lake health.

WETLAND PROTECTION

Principles

- Wetlands in Georgia are included in the definition of "Waters of the State" in Chapter 391-3-6 of the Rules of the State of Georgia. Likewise, wetlands are protected by Section 404 of the Clean Water Act and as such any disturbance, dredging, filling or other activity requires a permit to be issued by the U.S. Army Corps of Engineers, and then requires a

coordinated project review by the Georgia EPD.

- Wetlands are protected in that they act both as filters for pollutant removal and as nurseries for many species. Many people do not realize the vital role they play in purifying surface waters.
- The biological activity of plants, fish, animals, insects, and especially bacteria and fungi in a healthy, diverse wetland serve as the recycling factory of our ecosystem. While wetlands do pose a special concern, their mere presence is not incompatible with the game of golf. With care, many golf holes have been threaded through sensitive areas, and with proper design and management golf can be an acceptable neighbor.
- When incorporated into a golf course design, wetlands should be maintained as preserves and separated from managed turf areas with native vegetation or structural buffers.
- Constructed or disturbed wetlands may be permitted to be an integral part of the stormwater management system.

Best Management Practices

- Establish wetlands where water enters lakes to slow water flow, trap sediments, and remove nutrients.
- Maintain appropriate silt fencing and BMPs on projects upstream to prevent erosion and sedimentation. When disturbing more than one acre of land, an Erosion and Sedimentation Control permit is required.
- When the soil is disturbed for construction projects, proper BMPs should be instituted. In Georgia, approved BMPs for erosion and sediment control are listed in the Green Book published by the Georgia Soil and Water Conservation Commission.
- Natural waters cannot be considered treatment systems and must be protected. (Natural waters do not include constructed treatment wetlands.)
- Establish a low- to no-maintenance level within a 75-foot buffer along non-tidal and tidal wetlands.
- Establish and maintain a 100-foot riparian buffer around wetlands, springs, and spring runs.

STORMWATER MANAGEMENT

Principles

Controlling stormwater on a golf course is more than just preventing the flooding of the clubhouse, maintenance, and play areas. In addition to controlling the amount and rate of water leaving the course, stormwater involves storing irrigation water, controlling erosion and sedimentation, enhancing wildlife habitat,

Silt fencing during construction projects is a critical element of BMPs to prevent erosion and sedimentation. *Photo credit: Brandon Hayes.*

removing waterborne pollutants, and addressing aesthetic and playability concerns. Keep in mind that not all stormwater on a golf course originates there; some may be from adjoining lands, including residential or commercial developments.

Using stormwater BMPs on a golf course can help remove nutrients and other pollutants as well as store water as an alternative water source on courses. A good resource is the Georgia Stormwater Management Manual.

The list of practices includes the practice design, removal rates of different pollutants and a schematic of how it is designed.

Best Management Practices

- Use vegetated swales to slow and infiltrate water and trap pollutants in the soil, where they can be naturally destroyed by soil organisms.
- Maximize the use of pervious pavements, such as brick or concrete pavers separated by sand and planted with grass.
- Special high-permeability concrete is available for cart paths or parking lots. As a note, pervious concrete is available, but there is some maintenance required.
- Design stormwater control structures to hold stormwater for appropriate retention times in order to remove total suspended solids.
- Use a stormwater treatment train to convey water from one treatment structure to another.

- Eliminate or minimize directly connected impervious areas as much as possible.
- Disconnect runoff from gutters and roof drains from impervious areas, so that it flows onto permeable areas that allow the water to infiltrate near the point of generation.
- Use depressed landscape islands in parking lots to catch, filter, and infiltrate water, instead of letting it run off. When hard rains occur, an elevated stormwater drain inlet allows the island to hold the treatment volume and settle out sediments, while allowing the overflow to drain away.
- Ensure that no discharges from pipes go directly to water.

SEDIMENT

Principle

During construction and/or renovation, temporary barriers and traps must be used to prevent sediments from being washed off-site into water bodies. Wherever possible, keep a vegetative cover on the site until it is actually ready for construction, and then plant, sod, or otherwise cover it as soon as possible to prevent erosion. Approved BMPs for erosion and sediment control can be found in the Green Book which is published by the Georgia Soil and Water Conservation Commission.

Best Management Practices

- Use shoreline grasses to prevent bank erosion.
- Use dry detention basins/catchments to buffer flooding and excessive runoff that may contain sediment.
- When constructing drainage systems, pay close attention to engineering details such as subsoil preparation, the placement of gravel, slopes, and backfilling.
- Internal golf course drains should not drain directly into an open water body, but should discharge through pretreatment zones and/or vegetative buffers to help remove nutrients and sediments. See the Stormwater section of this Chapter.
- Maintain a vegetative cover on construction sites until it is actually ready for construction.

SODIC/SALINE CONDITIONS

Principles

- All natural waters contain soluble salts; however, the amount and type of salts they contain vary greatly. This is also going to vary depending on the location in the State.
- Irrigation water should be monitored for sodic or saline conditions. Golf courses located along the coast could potentially have some issue with sodic or saline water from the wells as a result of proximity to salt marshes or other bodies of water that have a high salt concentration. A simple water test can be conducted using hand-held meters to assess the salinity of the water being pumped. A record of results from the hand-held meters should be kept to determine if any seasonal conditions occur with irrigation water.
- Saline water typically is unsuitable for irrigation because of its high content of TDS.

Best Management Practices

- Mix surface water with affected groundwater to lower the total salt concentration.
- Routinely monitor water quality to ensure that salt concentrations are at acceptable levels.
- Consider fertilizer that uses soluble nitrogen forms with a relatively low concentration of salts in frequent applications.
- Consider a controlled-release fertilizer to reduce salt injury.
- Identify salt additions and saline sources that contribute to the total salt concentration.
- Base management plans on routine soil tests to determine sodium adsorption ratio (SAR), exchangeable sodium percentage (ESP), electrical conductivity saturated paste method/unit (ECe), and free calcium carbonate content.
- Select alternative turfgrass and landscape plants that are more salt-tolerant.
- Reduce salt accumulations in the soil by flushing soils as needed with a higher-quality water source.
- Design irrigation systems to account for flushing of salt accumulation from soil.
- Amend soil and water to remove salt ions from affected areas.
- Evaluate BMPs to determine effectiveness toward managing sodic/saline conditions.

5. NUTRIENT MANAGEMENT

Proper nutrient management plays a key role in the reduction of environmental risk and increases course profitability. Among other benefits, applied nutrients inflate the available pool of nutrients and allow turfgrass to recover from damage, increase its resistance to stress, and increase its playability. However, the increase in available nutrients also increases the potential risk of environmental impact. Nutrients may move beyond the turfgrass via leaching or runoff, which may directly impact our environment. Other organisms also respond to increases in nutrients and, in some cases, these organisms may deleteriously alter our ecosystem. The goal of a proper nutrient management plan should be to apply the minimum necessary nutrients to achieve an acceptable playing surface and apply these nutrients in a manner that maximizes their plant uptake.

REGULATORY CONSIDERATIONS

Principles

- Local and state regulations are in place to better manage nutrient risks based on the unique conditions that exist in your location. Designing a nutrient management plan within these regulations addresses local concerns and minimizes risk within your unique ecosystem.
- Depending on your location, regulatory agencies may include federal, state, or local policies.
- In general, if your location is regulated by nutrient policies (such as nutrient management plans), all of your nutrient BMP will be designed according to these policies.
- Understand the importance of nutrient licensing.

Best Management Practices

- Identify who must be licensed.
- Describe differing licenses, if applicable.
- Provide the minimum requirement.
- Detail the Continued Education Unit required to maintain the license.
- Understand the value of training programs.
- Contact local and state organizations for regulatory restrictions.

Helpful References

- A Turfgrass Management Calendar for Georgia
- Georgia Department of Agriculture - Fertilizers
- EPA - Agriculture
- University of Georgia Extension - Pesticide Safety Commerical Applicators
- University of Georgia Extension - Pesticide Safety, Private Applicators

SOIL TESTING

Principles

- Soil testing may or may not provide the appropriate answers to your nutrient management questions. Consult with your local land-grant university to get the most current information and to better understand which soil test values are relevant in your location.
- Through proper sampling, laboratory analysis, interpretation of results, recommendations, and record keeping, soil testing can be used to manage nutrients more efficiently.

Best Management Practices

- Accurate and consistent sampling is essential to providing useful soil test information over time.
- Divide the course into logical components such as greens, fairways, tees, roughs, etc., for each hole.
- Ten to 15 soil samples should be randomly taken from each section and blended together to provide a representative, uniform soil sample.
- Each soil sample should be taken from the same depth.
- Use an extractant appropriate for your soils.
- The same extractant must be used for each test in order to compare soil test results over time.
- The purpose of a soil test is to provide the grower with a prediction of a plant's response to an applied nutrient.
- If the location has correlation data between a given nutrient applied to soil and a response to that nutrient by turfgrass, then recommendations may provide expected results.
- If your location does not have correlation data, then soil test recommendations may be of little value.

- Keeping soil tests from prior years will allow you to observe changes over time.
- This practice can provide good evidence of the impact of your nutrient management plan.

PLANT TISSUE ANALYSIS

Principles

- Because of the mobility and conversion of elements within the soil; soil sampling can be less predictable than tissue testing. Tissue testing provides a precise measurement of nutrients within the plant. Tissue test sufficiency ranges are only as good as the correlation data of a given element to an acceptable quality level of a given turfgrass. Typically, tissue correlation data are more prevalent than soil test correlation data and, therefore, programs designed around tissue testing may provide more reliable results.
- Through proper sampling, consistent intervals, and record keeping, tissue sampling may be used to measure existing turf health.

Best Management Practices

- Tissue samples may be collected during regular mowing.
- Do not collect tissue after any event that may alter the nutrient analysis. Such events may include fertilization, topdressing, pesticide applications, etc.
- Place tissue in paper bags, not plastic.
- If possible, allow tissue samples to air-dry at your facility before mailing them.
- Poor-quality turfgrass that is of concern should be sampled separately from higher-quality turfgrass.
- When turfgrass begins to show signs of nutrient stress, a sample should be collected immediately.
- More frequent tissue sampling allows a more accurate assessment of your turfgrass nutrient status changes over time.
- The quantity of tissue analysis you choose to use is entirely up to you and your needs. However, two to four tests per year are common on greens and one to two tests per year are common on tees and fairways.

Soil testing can be used to manage nutrients more efficiently. *Photo credit: Scott Griffith.*

- Keeping tissue tests from prior years will allow you to observe changes over time.
- Tissue testing can provide good evidence of the impact of your nutrient management plan.

FERTILIZERS USED IN GOLF COURSE MANAGEMENT

Principles

Understanding the components of fertilizers, the fertilizer label, and the function of each element within the plant are all essential in the development of an efficient nutrient management program.

Terminology

- Grade or analysis is the percent by weight of Nitrogen (N), Phosphorous fertilizer (P_2O_5) and Potassium fertilizer (K_2O) that is guaranteed to be in the fertilizer.
- A complete fertilizer contains N, P_2O_5, and K_2O.
- The laws governing the labeling of fertilizer vary greatly among states. Consult your land-grant university or the appropriate state agency regarding the laws in your location.

Label

- The label is intended to inform the user about the contents of the fertilizer which, if understood and followed, will result in little to no environmental risk.
- The fertilizer label may contain:
  - Brand
  - Grade
  - Manufacturer's name and address
  - Guaranteed analysis
  - "Derived from" statement
  - Net weight

Macronutrients

Macronutrients are required in the greatest quantities and include nitrogen (N), phosphorus (P), and potassium (K).

Understanding the role of each macronutrient within the plant should provide you with a greater understanding of why these nutrients play such a key role in proper turfgrass management.

The role of nitrogen (N)

Nitrogen is required by the plant in greater quantities than any other element except carbon (C), hydrogen (H), and oxygen (O). Nitrogen plays a role in numerous plant functions including an essential component of amino acids, proteins and nucleic acids.

- *Fate and transformation of N*
  The goal of all applied nutrients is to maximize plant uptake while minimizing nutrient losses. Understanding each process will increase your ability to make sound management decisions and ultimately lead to an increase in course profitability and a reduction in environmental risk.
- *Nitrogen processes*
  - Mineralization: the microbial mediated conversion of organic N into plant-available NH_4
  - Nitrification: the microbial-mediated conversion of NH_4 to NO_3
  - Denitrification: the microbial mediated conversion of NO_3 to N gas; this primarily occurs in low-oxygen environments and is enhanced by high soil pH
  - Volatilization: the conversion of NH_4 to NH_3 gas
  - Leaching: the downward movement of an element below the rootzone
  - Runoff: the lateral movement of an element beyond the intended turfgrass location
- The release mechanism and factors influencing N release from available N sources

Understanding how certain N sources should be blended and applied is an essential component in an efficient nutrient management plan. In many cases, N sources are applied without regard to their release characteristics. This is an improper practice and increases the risk of negative environmental impact. Each N source (particularly slow-release forms) is unique and therefore should be managed accordingly. Applying a polymer-coated urea in the same manner one would apply a sulfur-coated urea greatly reduces the value of the polymer-coated urea. Similarly, applying 2 pounds of N from ammonium sulfate may cause burning, while applying 2 pounds of N from certain polymer-coated ureas may not provide the desired turfgrass response. Rate, application date, location, and turfgrass species all should be included in your nutrient application decision.

- *Soluble nitrogen sources*
  - Urea (46-0-0)
  - Ammonium nitrate (34-0-0)
  - Ammonium sulfate (21-0-0)
  - Diammonium phosphate (18-46-0)
  - Monoammonium phosphate (11-52-0)
  - Calcium nitrate (15.5-0-0)
  - Potassium nitrate (13-0-44)
- *Slow-release nitrogen sources*

A slow-release N source is any N-containing fertilizer where the release of N into the soil is delayed either by requiring microbial degradation of the N source, by coating the N substrate which delays the dissolution of N, or by reducing the water solubility of the N source.

These include:

- Sulfur-coated urea
- Polymer/resin-coated
- Isobutylidene diurea
- Urea-formaldehyde/ureaformaldehyde reaction products
- Natural organic
- Urease and nitrification inhibitors
  - Urease inhibitors reduce the activity of the urease enzyme resulting in a reduction of volatilization and an increase in plant-available N.
  - Nitrification inhibitors reduce the activity of Nitrosomonas bacteria, which are responsible for the conversion of NH_4 to NO_2. This reduced activity results in a reduction of N lost via denitrification and an increase in plant-available N.

The role of phosphorous (P)

Phosphorus can be a growth-limiting factor for many unintended organisms and is a major contributor to eutrophication of water bodies. Thus, proper timing and rates should be implemented to reduce the risk of off-site movement of phosphorus.

Phosphorus forms high-energy compounds that are used to transfer energy within the plant. Phosphorus may remain in an inorganic form or may become incorporated into organic compounds. Phosphorous application rates should be based upon soil test results derived from documented correlations demonstrating a turf response to soil test phosphorous levels.

- *P deficiency symptoms*
  - Initially, reduced shoot growth and dark green color may be observed
  - Later, lower leaves may turn reddish at the tips and then the color may progress down the blade
- *P sufficiency ranges*
  - Consult your land-grant university for sufficiency ranges in your location.
- *P fertilizer sources*
  - Diammonium phosphate
  - Concentrated superphosphate
  - Monoammonium phosphate
  - Natural organics

The role of potassium (K)

Potassium is of no environmental concern, but can be an economic concern, particularly when potassium is over-utilized, which can be quite common. Generally, potassium concentrations in turfgrass tissue are about ⅓ to ½ that of nitrogen.

Potassium is not a component of any organic compound and moves readily within the plant. Potassium is a key component of osmoregulation which has been documented to increase stress resistance.

- *K deficiency symptoms*

  Except under severe, documented deficiencies, K may not have an observable influence on turfgrass quality. Yellowing of older leaves followed by tip dieback and scorching of leaf margins have been reported.
- *K sufficiency ranges*
  Consult your land grant university for sufficiency ranges in your location.
- *K fertilizer sources*
  - Potassium sulfate
  - Potassium chloride
  - Potassium nitrate

SECONDARY MACRONUTRIENTS

Secondary macronutrients are essential to plant function and are required in quantities less than N, P, and K, but more than micronutrients. These include calcium (Ca), magnesium (Mg), and sulfur (S).

The role of calcium (Ca)

- Primarily a component of cell walls and structure
- Consult your land grant university for sufficiency ranges in your location
- Found in gypsum, limestone, and calcium chloride

The role of magnesium (Mg)

- Central ion in the chlorophyll molecule and chlorophyll synthesis
- Consult your land grant university for sufficiency ranges in your location
- Found in S-Po-Mg, dolomitic limestone, and magnesium sulfate

The role of sulfur (S)

- Metabolized into the amino acid, cysteine, which is used in various proteins and enzymes
- Consult your land grant university for sufficiency ranges in your location
- Found in ammonium sulfate, elemental sulfur, gypsum, potassium sulfate

MICRONUTRIENTS

Understanding the role of each micronutrient within the plant should provide you with a greater understanding of why these nutrients play such a key role in proper turfgrass management.

Micronutrients are just as essential for proper turfgrass health as macronutrients, but they are required in very small quantities compared to macronutrients. Micronutrients include iron (Fe), manganese (Mn), boron (B), copper (Cu), zinc (Zn), molybdenum (Mo), and Chlorine (Cl).

Consult your land grant university for micronutrient sufficiency ranges in your location.

The role of iron (Fe)

- Is part of the catalytic enzymes and is required for chlorophyll synthesis
- Affects photosynthesis, nitrogen fixation, and respiration
- Consult your land grant university for sufficiency ranges in your location

The role of manganese (Mn)

- Involved in photosynthesis
- Required as a cofactor for ~35 enzymes
- Lignin biosynthesis depends on Mn

The role of boron (B)

- Found in the cell wall; probably required for the structural integrity of the cell wall

The role of copper (Cu)

- Cu-protein plastocyanin is involved in photosynthesis
- Cofactor for a variety of oxidative enzymes

The role of zinc (Zn)

- Structural component of enzymes
- Protein synthesis requires Zn
- Carbohydrate metabolism affected by Zn

The role of molybdenum (Mo)

- Primarily related to nitrogen metabolism
- Structural and catalytical functions of enzymes

The role of chlorine (Cl)

- Required for the oxygen-evolving reactions of photosynthesis
- Also appears to be required for cell division in both leaves and shoots

SOIL pH

Principle

Identifying pH levels may be the most important soil test result for turfgrass managers. In most cases, a pH of 6.3 is ideal because it provides the greatest probability of micronutrient availability. Soil pH adjustments may occur slowly and are temporary.

Best Management Practices

- To increase soil pH, apply a liming material (calcium carbonate, calcium oxide, dolomitic limestone) that contains Ca^{2+} and neutralizes acidity.
- To lower soil pH, products containing elemental sulfur should be applied.
- In some cases, utilizing injection pumps into irrigation water to address pH can be beneficial.

NUTRIENT MANAGEMENT

Principles

- Within each state, environmental conditions vary greatly including differences among soils, topography, rainfall, and temperature. These differences require that a nutrient management plan be flexible enough to allow turfgrass managers to address their unique needs.
- Understand the importance of application timing for effective use of applied nutrients.

Best Management Practices

- The objective of all nutrient applications is plant uptake and the corresponding desirable response.
- Apply nutrients when turfgrass is actively growing.
- Apply slow-release N fertilizers at the appropriate time of year to maximize the product's release characteristics. For example, an application of slow-release N to warm-season turfgrasses in fall may not be as effective as the same application applied in early summer because of the prolonged release time in fall.
- Follow N application rate recommendations from your local land grant university.
- N application rates from slow-release materials should take into consideration the release rate of the chosen material. If insufficient material is applied, the desired response may not be observed.
- Consult your local land grant university for efficient N:K in your location.
- The reduced height of cut and excessive traffic damage on putting greens results in an increased need for growth leading to an increase in nutrition.
- Tees and landing areas often have higher fertility requirements than fairways and roughs because they suffer constant divot damage.
- Fairways and roughs often require less nutrient inputs than other locations because of their increased height of cut, less damage, and clipping return.
- Exercise caution when applying nutrient applications during turfgrass establishment as these applications are particularly susceptible to loss via leaching and runoff.
- Provide appropriate rates and products to minimize N loss without reducing turfgrass establishment.
  - Increased water applications
  - Increased nutrients to hasten establishment
  - Reduced root mass
- Be aware of the different types of spreaders and understand the advantages and disadvantages of each.
- Not all fertilizers can be spread with every spreader. For example, if sulfur-coated urea was spread through a drop spreader, the sulfur coating could be damaged, essentially leading to an application of soluble urea.
- Choose the appropriate spreader for a given fertilizer material.
  - Walk-behind rotary
  - Drop spreader
  - Bulk rotary
  - Spray
- Calibration reduces environmental risk and increases profitability.
- Proper fertilizer storage, loading, and clean-up reduce environmental risk.
- Avoid applying fertilizer to soils that are at, or near, field capacity or following rain events that leave the soils wet.
- Do not apply fertilizer when the National Weather Service has issued a flood, tropical storm, or hurricane water or warning, or if heavy rains are likely.

6. CULTURAL PRACTICES

Cultivation practices are an important part of golf course turf management. Certain cultural practices such as mowing, verticutting, and rolling are necessary to provide a high-quality playing surface, while others such as aerification are required to enhance plant health.

Heavily used areas such as putting greens often deteriorate because of compacted soil, thatch accumulation, and excessive use. Soil problems from active use are usually limited to the top three inches of the soil profile and should be actively managed to enhance turf health and improve nutrient and water uptake.

Unlike annual crops, which offer the opportunity for periodic tilling of the soil profile to correct problems like soil compaction that might develop over time, turfgrass does not offer opportunities for significant physical disturbance of the soil without destroying the playing surface.

MOWING

Principles

- Mowing is the most basic yet most important cultural practice to consider when developing a management plan.
- The mowing practices implemented on a facility will have an impact on turf density, texture, color, root development, and wear tolerance.
- Mowing practices affect turfgrass growth. Frequent mowing will increase shoot density and tillering. It will also decrease root and rhizome growth as a result of plant stress associated with removal of leaf tissue.
- Infrequent mowing results in alternating cycles of vegetative growth followed by scalping, which further depletes food reserves of the plants.
- Proper mowing height is a function of the species/cultivar being managed and the intended use of the site. Other factors influencing mowing height include mowing frequency, shade, mowing equipment, time of year, root growth, and abiotic and biotic stress.
- Maintaining an optimal root-to-shoot ratio is critical. Turfgrass plants that are mowed too low

Mowing patterns influence both the aesthetic and functional characteristics of a turf surface. *Photo credit: Hoyt Ellspermann.*

will require a substantial amount of time to provide the food needed to produce shoot tissue for future photosynthesis. If turf is mowed too low in one event, an imbalance occurs between the remaining vegetative tissue and the root system, resulting in more roots being present than the plant needs physiologically. As a result, the plants will slough off the unneeded roots. Root growth is least affected when no more than 30% to 40% of leaf area is removed in a single mowing.

- Failure to mow properly will result in weakened turf with poor density and quality.

Best Management Practices

- Mowing frequency should increase during periods of rapid growth and decrease during dry, stressful periods.
- If turf becomes too tall, it should not be mowed down to the desired height all at once. Such severe scalping reduces turf density and can result in a dramatic reduction in root growth. Tall grass should be mowed frequently and height gradually decreased until desired height of cut is achieved.
- Shade affects turfgrass growth by filtering out photosynthetically active radiation. As a result, turfgrass plants respond by growing upright in an effort to capture more light to meet their photosynthetic needs. As a result, mowing height should be increased by at least 30% to improve the health of turf grown in a shaded environment.
- The use of the plant growth regulator trinexapac-ethyl has been shown to improve overall turf health when used as a regular management tool for grasses growing in shaded environments.
- Environmental stresses such as prolonged cloudy weather or drought can have a significant impact on turf health. Increase mowing heights as much as possible in order to increase photosynthetic capacity and rooting depth of plants.
- Use proper mowing equipment.
- Reel mowers are ideally suited for maintaining turfgrass stands that require a height of cut below 1.5 inches. They produce the best quality when compared to other types of mowers.
- Rotary mowers, when sharp and properly adjusted, deliver acceptable cutting quality for turf that is to be cut above one inch in height. Dull blades will result in shredding of leaf tissue, increasing water loss and the potential for disease development.
- Flail mowers are most often used to maintain utility turf areas that are mowed infrequently and do not have a high aesthetic requirement.
- Mowing patterns influence both the aesthetic and functional characteristics of a turf surface.

Consider composting clippings when there are so many they could smother the underlying grass or on golf greens where they might affect ball roll. *Photo credit: Mark Hoban.*

- Turfgrass clippings are a source of nutrients, containing 2% to 4% nitrogen on a dry-weight basis, as well as significant amounts of phosphorus and potassium.
- Nutrients contained in clippings can be sources of pollution and should be handled properly.
- Clippings should be returned to the site during the mowing process unless the presence of grass clippings will have a detrimental impact on play. Cases when clippings should be removed include times when the amount of clippings is so large that it could smother the underlying grass or on golf greens where clippings might affect ball roll.
- Collected clippings should be disposed of properly to prevent undesirable odors near play areas and to prevent fire hazards that can occur when clippings accumulate. Consider composting clippings or dispersing them evenly in natural areas where they can decompose naturally without accumulating in piles.

Georgia Specific Mowing Practices

- With the majority of Georgia falling within the turfgrass "Transition Zone" mowing practices can vary greatly depending on the region of the state in question.
- Cool season grasses grown in Georgia will typically stress during the warmer summer months of June, July, August, and even into September. During this period, turf mangers need to be attentive to their mowing habits and be careful not to over mow which can stress the plant even further.
- Conversely, warm season grasses grown in Georgia can be decimated during their dormancy period if a lack of traffic control, poor drainage, disease, and shaded environments

dominate during the winter months from December through February. During this time, mowing of warm season grasses should be limited and vary depending on the plant's growth, health and environment. As warm season grasses break dormancy the turf manager should survey the golf course in an effort to only mow what is needed and limit mower damage to any weaker areas.

CULTIVATION

Principles

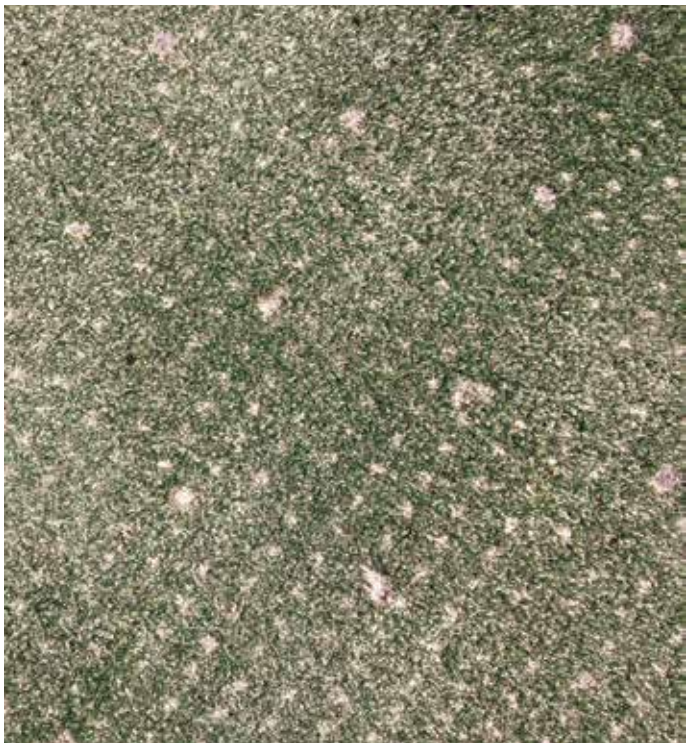
- Cultivation involves disturbing the soil or thatch through the use of various implements to achieve important agronomic goals that include relief of soil compaction, thatch/organic matter reduction, and improved water and air exchange.
- Cultivation techniques will result in disturbance of the playing surface that can require significant time for recovery.
- Frequency of cultivation should be based on traffic intensity and level of soil compaction.
- Core aerification is effective at managing soil compaction and improves soil drainage.
- Accumulation of excessive thatch and organic matter reduces root growth, encourages disease, and creates undesirable playing conditions.
- Light and frequent applications of sand will smooth the playing surface, control thatch, and potentially change the physical characteristics of the underlying soil when done in conjunction with core aerification.

Best Management Practices

- Core aerification involves removal of small cores or plugs from the soil profile. Cores are usually 0.25 to 0.75 inch in diameter. Annual core aerification programs should be designed to remove 15%-20% of the surface area. High-traffic areas may require a minimum of two to four core aerifications annually.
- Core aerification should be conducted only when grasses are actively growing to aid in quick recovery of surface density.
- Vary depth of aerification events by incorporating varying length tines to prevent development of compacted layers in the soil profile as a result of cultivation.
- Solid tines cause less disturbance to the turf surface and can be used to temporarily reduce compaction and soften surface hardness during months when the growth rate of grasses has been reduced. Benefits of solid-tine aerification are temporary because no soil is removed from the profile.
- Deep-drill aerification creates deep holes in the soil profile through use of drill bits. Soil is brought to

Cultivation disturbs the soil or thatch through the use of various implements to achieve important agronomic goals. *Photo credit: Brad Tremmier.*

Cultivation techniques will result in disturbance of the playing surface that can require significant time for recovery. *Photo credit: Brad Tremmier.*



Light, frequent applications of topdressing sand on putting greens can smooth out surface irregularities and mitigate thatch accumulation. *Photo credit: Lydell Mack.*

Daily rolling of putting surfaces following mowing can increase putting speeds by roughly 10 percent. *Photo credit: Joe Hollis.*

the surface and distributed into the canopy. Holes can be backfilled with new root-zone materials if a drill-and-fill machine is used. These machines allow replacement of heavier soils with sand or other materials in an effort to improve water infiltration into the soil profile.

- Slicing and spiking reduce surface compaction and promote water infiltration with minimal surface damage.
- Slicing is faster than core aerification but is less effective. Slicing is best accomplished on moist soils.
- A spiker can break up crusts on the soil surface, disrupt algae layers, and improve water infiltration.
- Vertical mowing (verticutting) can be incorporated into a cultural management program to achieve a number of different goals. The grain of a putting green can be reduced by setting a verticutter to a depth that just nicks the surface of the turf. Deeper penetration of knives will stimulate new growth by cutting through stolons and rhizomes while removing accumulated thatch.
- Verticutting depth for thatch removal should reach the bottom of the thatch layer and extend into the surface of the soil beneath the thatch.
- Dethatching with a verticutter is an aggressive practice that is not recommended on golf putting greens because of the damage that occurs and the extensive recovery time required.
- Initiate vertical mowing when the thatch level reaches 0.25 to 0.5 of an inch in depth. Shallow vertical mowing should be completed at least monthly on putting greens to prevent excessive thatch accumulation.
- Groomers, or miniature vertical mowers attached to the front of reels, are effective at improving management of grain and improving plant density through cutting of stolons.
- Topdress the playing surface with sand following core aerification and heavy vertical mowing to aid in recovery of turf. Rates will vary from 0.125 to 0.25 of an inch in depth and will depend on the capacity of the turf canopy to absorb the material without burying the plants.
- Light, frequent applications of topdressing sand on putting greens can smooth out minor surface irregularities, aiding in the management of thatch accumulation.
- Use only weed-free topdressing materials with a particle size similar to that of the underlying root zone.
- Use of finer materials can result in layering and can have a negative impact on water infiltration.
- Daily rolling of putting surfaces following mowing can increase putting speeds by roughly 10%, allowing for improved ball roll without lowering height of cut.
- To minimize potential for compaction caused by rolling, use light weight rollers.

Georgia Specific Cultural Practices and Timing

- Cool Season Grasses - It is important to note that cultural practices, especially the more aggressive practices of aeration and verticutting, are performed during a window of time when the turfgrass is growing and able to recover. Cool season grasses in Georgia typically grow best from March through October. For cool season grasses the typical stress period runs from June through mid-September. Any aggressive cultural practices performed during this stress period should be carefully considered and executed. Cool season grasses are growing and able to recover during the summer months but care should be taken to not overstress the plant during extreme heat. Rooting depth of the plant should be taken into consideration before performing any aggressive cultural practices.
- Warm Season Grasses - Except for the extreme southern portions of the state, warm season grasses typically experience a dormancy period during the winter months of November through February. The length of dormancy will depend on local weather, day lengths, and soil temperatures. Cultural practices on warm season grasses during this stressful period of time should be avoided. Thus, most cultural practices on warm season grasses should fall from May through August. This will give ample time for recovery going into the winter months.

OVERSEEDING WARM-SEASON TURFGRASS

Principles

- The fundamental purpose of overseeding is to establish a temporary cool-season grass into the warm-season base for improved color and playability during the fall and winter when the warm-season grass enters dormancy.
- Overseeding increases the need for irrigation and routine mowing and may result in significant thinning of the base grass during spring transition.
- Successful overseeding programs require year-long planning and incorporate all aspects of root-zone cultivation and weed control in an effort to maintain health of the warm-season turfgrass while allowing successful establishment of the overseeded cool-season grass species.

Best Management Practices

- Thatch depth greater than 0.5 inch in the warm-season turfgrass base will prevent good seed-to-soil contact and will result in sporadic germination and establishment. Remove thatch as part of an active cultivation program before overseeding.
- Reduce or eliminate fertilization of the base grass three to four weeks before the planned seeding date to minimize growth and competition.
- Core-aerify the soil four to six weeks before the planned overseeding date to open turf canopy and aid in uniform establishment of overseeded grass.
- Select grass species/cultivars that are adapted to the desired use, taking note of disease resistance and spring transition traits. Cultivars with improved heat tolerance can delay spring transition and create increased competition for water, nutrients, and light with the warm season turfgrass base.
- Irrigate newly planted overseed to maintain constant moisture levels, not allowing the soil surface to dry out. Gradually reduce irrigation once the seedlings have been mowed.
- Do not fertilize with nitrogen immediately before or during establishment of overseed as the N may encourage warm-season turfgrass competition and increase disease potential.
- Move hole locations on putting greens daily during the establishment period to minimize damage to seedlings from foot traffic.
- Reduce fertilizer rates in spring to slow growth of overseeded grass. Once warm season turfgrass regrowth is apparent, restore fertilizer applications to stimulate growth of the warm season turfgrass.
- Colorants (dyes and pigments) can be used to provide winter color to dormant grasses.
- Overseeding practices can generate significant dust that may require dust control measures.

Overseeding in Georgia

The overseeding of warm season playing surfaces with a cool season grass is typically performed during the months of September or October for optimum germination. Overseeding can be successful in the month of November as well but is risky due to the cooler temperatures and frosty mornings that affect the germination of the grass. As mentioned earlier, when overseeding "seed to soil contact" is important. So any cultural practices that can encourage "seed to soil contact" such as lowering the height of cut of warm season grass prior to seeding, verticutting to thin the host warm season grass and/or aeration weeks prior to overseeding can encourage "seed to soil contact". Be careful not to thin the host grass to a point of no return. Remember, this will constitute the playing surface as the overseeded cool season grass transitions out with warmer temperatures the following spring/summer.

In order to discourage weeds a weed management program needs to be planned well in advance of your overseeding date. Pre-emergent herbicides can and should be used months in advance of seeding to discourage weeds during establishment. Refer to herbicide labels and information relating to the overseeding of warm season turf. A mistimed herbicide application could prevent seed from germinating and/or result in an abundance of weeds during and after establishment. Poa annua is the most invasive weed when overseeding in Georgia. Post-emergent control is also an option with varying products.

SHADE AND TREE MANAGEMENT

Principles

- In general, most turfgrasses perform best in full sun.
- Excessive shade from trees and structures reduces photosynthesis and can reduce air circulation, thus increasing the susceptibility of the turf to pest and disease problems.

Best Management Practices

- Prune tree limbs and roots as needed to reduce competition for sunlight, water, and nutrients.
- When possible, trees located near closely mowed areas such as tees and greens should be removed or their canopy should be thinned to improve conditions for healthy turf growth.
- Understand the variability in sun angles at different times of the year and how this affects turf health.
- Conduct a shade audit to identify problem areas.
- Conduct a tree survey that identifies each tree's location, species, health, life expectancy, safety concerns, value and special maintenance requirements.

Other Recommendations

- Removing trees and/or thinning their canopy will certainly improve turfgrass health and density. However, trees can also be an integral part of the golf course design and beauty. When trees can't be removed, limbing is most certainly encouraged. In the event limbing of trees and pruning of tree roots does not aid turfgrass health to the level desired there are still other options.
- Enlarge the tree bed and ground cover to match the overhanging limbs and tie in with healthier grass. This can prevent the undesirable appearance of unhealthy grass. In addition, it can protect the tree and roots from unwanted mower traffic.
- Along the same lines, superintendents could mow the surrounding grass at a higher height of cut to encourage turf coverage. Due to the competition from tree roots for nutrients and water, turfgrass would be better suited when mowed less frequently and at a greater height. Regular fertilizer applications could also strengthen the desired area.
- The addition of traffic stakes, ropes or the like can also deter traffic in weakened areas. This, in combination with a larger bed, less frequent mowings, regular fertilization, and an increased height of cut, will offer the best chance to have healthy grass in and around trees, if they can't be removed.

Trees creating shade issues can sometimes be relocated to another site on the golf course. *Photo credit: Jon Hatten.*

7. PESTICIDE MANAGEMENT

Pesticide use should be part of an overall pest management strategy that includes biological controls, cultural methods, pest monitoring, and other applicable practices, referred altogether as Integrated Pest Management or IPM. When a pesticide application is deemed necessary, its selection should be based on effectiveness, toxicity to non-target species, cost, site characteristics, and its solubility and persistence in the environment.

REGULATORY CONSIDERATIONS

Principle

Pesticides contain active ingredients (the component that targets the pest) and inert ingredients such as solvents, surfactants, and carriers. Both active and inert ingredients may be controlled or regulated by federal, state, and local laws because of environmental and health concerns.

Best Management Practices

- Only apply pesticides that are legally registered at all levels of jurisdiction.
- Only apply pesticides that are legally registered for use on the facility (for example, do not apply pesticides labeled for agricultural uses even though they may have the same active ingredient).
- Apply according to manufacturer's recommendations as seen on label.

HUMAN HEALTH RISKS

Principles

Pesticides belong to numerous chemical classes that vary greatly in their toxicity. Pesticides include herbicides, insecticides, fungicides, rodenticides, bactericides, and larvicides. The human health risk associated with pesticide use is related to both pesticide toxicity and the level of exposure. Working with pesticides requires users to take precautions to protect themselves and the environment. Wearing Personal Protection Equipment (PPE) should be done by all employees tasked with handling and using pesticides. The label should have the PPE required for the pesticide use as well as First Aid in case of exposure. Since there is the potential of exposure, the applicator should be certified and understand the use of the product as specified on the label.

All chemicals have an associated Safety Data Sheet (SDS) - formerly known as Materials Safety Data Sheets (MSDS) - that provides important information. Use of the SDS along with the label will provide the applicator with information that is valuable.

More information on pesticide management, certifications, and publications can be found at the University of Georgia, College of Agricultural and Environmental Sciences webpage titled "Pesticide Safety Education." Also, for information on pesticides, handling, spraying and general use, please reference the UGA Pesticides Handbook.

Best Management Practices

- Select the least toxic pesticide with the lowest exposure potential.
- Read the label before use of the pesticide.
- Follow standard safety practices when using any pesticide.
- Use proper PPE when working with pesticides.
- Refer to label if exposure occurs.
- Know the emergency response procedure in case excessive exposure occurs.

SHELF LIFE

Principles

- Pesticides degrade over time. Do not store large quantities of pesticides for long periods.
- Utilize computer software systems to record inventory and use.

Best Management Practices

- Avoid purchasing large quantities of pesticides that require storage for more than six months.
- Adopt the "first in–first out" principle, using the oldest products first to ensure that the product shelf life does not expire.
- Many states offer "amnesty" days in order to eliminate potential public health and environmental hazards from canceled, suspended, or unusable pesticides that are being stored. In Georgia, the Georgia Department of Agriculture holds these types of days across the state when funds are available to cover the cost of disposal.
- Ensure labels are on every package and container.

Avoid purchasing large quantities of pesticides that require storage for more than six months. *Photo credit: John McMullan.*

- Consult inventory when planning and before making purchases.
- Ensure that labels remain properly affixed to their containers.
- Do not store pesticides in containers other than the original containers.

ENVIRONMENTAL FATE AND TRANSPORT

Principles

Environmental characteristics of a pesticide can often be determined by the environmental hazards statement found on pesticide product labels. The environmental hazards statement (referred to as "Environmental Hazards" on the label and found under the general heading "Precautionary Statements") provides the precautionary language advising the user of the potential hazards to the environment from the use of the product. The environmental hazards generally fall into three categories: (1) general environmental hazards, (2) non-target toxicity, and (3) endangered species protection.

Protecting the environment from pesticides involves understanding the chemical and physical characteristics of the pesticide which has an effect on its absorbability, solubility, persistence, leachability, and volatilization. Soils also have to be considered when applying pesticides. Based on the soil type (sand, silt, clay) and percentages, pesticides can have different rates of movement. This movement can be in the form of either surface runoff, leaching or both. The physical characteristic of the pesticide could also lend it to be moved by air or drift from the application site. Once applied, pesticides can move off-site as a result of water or air carrying soil particles, animals or plants moving or being transported from one area to another.

Preventing off-site movement of pesticides depends on knowledge of the specific conditions of the site where pesticides will be applied. This includes but is not limited to the soil type (sand, silt or clay), the geology of the area, the depth to groundwater, the proximity to surface water and the transmissivity of the soil, to name a few. In Georgia, the soils of the Coastal Plain are more sandy textured and have higher permeabilities and therefore have higher leaching potential for pesticides in comparison to those in Northern Georgia. However, the soils in North Georgia are more prone than South Georgia to runoff and movement of pesticides by that transport method. However, both leaching and runoff occur across the state. When applications are required, weather conditions should also be considered. Soil moisture resulting from precipitation or irrigation can result in a higher potential for runoff or leaching. Also, high winds could result in the movement of pesticides through drift.

Leaching and Runoff

Water movement through the action of leaching or runoff can result in the contamination of surface and groundwater sources. Conditions leading to the movement of pesticides either in runoff (surface movement) or leaching (groundwater movement) are the result of:

- Pesticides being spilled on unprotected soil.
- Pesticides being applied to areas that are saturated and potentially have standing water.
- Highly soluble pesticides applied on soils that have high permeabilities or pesticides applied to these soils just prior to expected heavy rains.
- Pesticides applied to dry soils followed by heavy rains.
- Spray nozzles leaking or malfunctioning leading to the application of more pesticides than expected. See Sprayer Calibration section for more information.
- Tanks overflow while filling.

Pesticides also have a higher potential of moving either in runoff or leaching if the soil/water adsorption coefficient of the pesticide is such that there is a weak attraction of the pesticide to the soil particle. Weakly sorbed pesticides (compounds with small Koc values)

are more likely to leach through the soil and reach groundwater. Conversely, strongly sorbed pesticides (compounds with large Koc values) are likely to remain near the soil surface, reducing the likelihood of leaching, but increasing the chances of being carried to surface water via runoff or soil erosion.

Drift

Pesticides can also move by the action of the wind. Particles of pesticide can move based on the droplet size, the particle size or its potential to volatilize. Three different potential methods of pesticide movement are:

- *Air drift:* drift occurs when the droplet sizes are not correct for the pesticide or the wind applications. The proper nozzle should be used to produce the proper droplet size to get the pesticide to the desired location.
- *Particle drift*: drift is caused by the movement of solid particles being blown by the wind. This can result in off-target applications.
- *Vapor drift:* drift is the result of liquid or solid pesticides being volatilized by the action of temperature, wind or other climatic conditions that cause the vapor to then drift.

Best Management Practices

- Select pesticides that have low runoff and leaching potentials.
- Before applying a pesticide, evaluate the impact of site-specific characteristics (for example, proximity to surface water, water table, and well-heads; soil type; prevailing wind; etc.) and pesticide-specific characteristics (for example, half-lives and partition coefficients).
- Select pesticides with reduced impact on pollinators.
- Select pesticides that, when applied according to the label, have no known effect on endangered species present on the facility.
- Understand the label and where, under what conditions, and when the pesticide should be applied.
- Ensure all employees tasked with pesticide applications are certified (See UGA Pesticide Safety Education for more information).
- Consider the adsorption coefficient when applying pesticides.
- Consider the soil types and locations when applying pesticides.
- Know the soil moisture conditions of the soils prior to application. Saturated soils could result in high leaching or runoff potential.
- Time applications based on wind conditions.
- Be aware of conditions that can cause drift to occur.
- Apply proper rates.

PESTICIDE TRANSPORTATION, STORAGE, AND HANDLING

Principle

Storage and handling pesticides in their concentrated form poses the highest potential risk to ground or surface waters. For this reason, it is essential that facilities for storing and handling these products be properly sited, designed, constructed, and operated. Storage of large volumes for long periods should be avoided. Also, adopting a "first-in, first-out" policy will help prevent storing pesticides too long.

Storage of pesticides should be in compliance with Georgia regulations which are administered by the Georgia Department of Agriculture. Design of storage and mixing facilities can be seen in UGA publication *B1095: Pesticide Storage and Mixing Facilities*.

Best Management Practices

- Store, mix, and load pesticides away from sites that directly link to surface water or groundwater.
- Store pesticides in a lockable concrete or metal building that is separate from other buildings.
- Locate pesticide storage facilities from other types of structure to allow fire department access in the event of an emergency.
- Storage facility floors should be impervious and sealed with a chemical-resistant paint.

Store pesticides in a lockable concrete or metal building separate from other buildings. *Photo credit: John McMullan.*

- Floors should have a continuous sill to retain spilled materials and no drains, although a sump may be included.
- Sloped ramps should be provided at the entrance to allow the use of wheeled handcarts for moving material in and out of the storage area safely.
- Shelving should be made of sturdy plastic or reinforced metal.
- Metal shelving should be kept painted to avoid corrosion. Wood shelving should never be used, because it may absorb spilled pesticides.
- Automatic exhaust fans and an emergency wash area should be provided. Explosion-proof lighting may be required. Light and fan switches should be located outside the building, so that both can be turned on before staff enter the building and turned off after they leave the building.
- Avoid temperature extremes inside the pesticide storage facility.
- Personal protective equipment (PPE) should be easily accessible and stored immediately outside the pesticide storage area.
- Do not transport pesticides in the passenger section of a vehicle.
- Never leave pesticides unattended during transport.
- Place a spill containment kit in the storage area, in the mix/load area, and on the spray rig.

EMERGENCY PREPAREDNESS AND SPILL RESPONSE

Principle

Accidents happen. Advance preparation on what to do when an accident occurs is essential to mitigate the human health effects and the impact on the environment.

Best Management Practices

- Develop a golf course facility emergency response plan which includes procedures to control, contain, collect, and store spilled materials.
- Prominently post "Important Telephone Numbers" including CHEMTREC, for emergency information on hazards or actions to take in the event of a spill.
- Ensure an adequately sized spill containment kit is readily available.
- Ensure spill containment kit is located where the greatest potential for spills may exist.
- Designate a spokesperson who will speak on behalf of the facility should an emergency occur.
- Host a tour for local emergency response teams (for example, fire fighters, etc.) to show them the facilities and to discuss the emergency response plan. Seek advice on ways to improve the plan.
- Ensure secondary containment is present to reduce the off-site movement of pesticides. Secondary containment can be pans filled with kitty litter for small volume incidents or concrete pads with walls for large volumes.
- Secondary containment for small incidents could and should reduce the amount of material that has to be properly disposed of if a spill occurs.

PESTICIDE RECORD KEEPING

Principle

Maintaining accurate records of pesticide-related activities (for example, purchasing, storage, inventory, applications, etc.) is essential.

Best Management Practices

- Keep and maintain records of all pesticides used to meet legal (federal, state, and local) reporting requirements.
- Use records to monitor pest control efforts and to plan future management actions.
- Use electronic or hard-copy forms and software tools to properly track pesticide inventory and use.
- Develop and implement a pesticide drift management plan.
- Keep a backup set of records in a safe, but separate storage area.

SPRAYER CALIBRATION

Principle

Properly calibrated application equipment is paramount to mitigating environmental and human health issues. Properly calibrating spray equipment helps ensure the proper amount of pesticide is being applied. Calibration also ensures the proper nozzle is being used to apply the pesticide.

Calibration procedures for various types of sprayers can be found in the *UGA Pest Management Handbook*. Information on obtaining a hard copy can be found on the UGA Pesticide Safety Education website's e-store. The handbook contains information on pesticides and is updated annually.

Certification for applicators is provided through UGA Extension. For information on classes, certification and more see the UGA Extension Pesticide Safety Education webpage or call your local UGA Extension Office (Phone number 1-800-ASK-UGA1).

Best Management Practices

- Personally ensure spray technicians are experienced, licensed, and properly trained.
- Minimize off-target movement by using properly configured application equipment.
- Properly calibrate all application equipment at the beginning of each season (at a minimum) or after equipment modifications.
- Check equipment daily when in use.
- Use recommended spray volumes for the targeted pest to maximize efficacy.
- Calibration of walk-behind applicators should be conducted for each person making the application to take into consideration their walking speed, etc.

TYPES OF SPRAYERS

Principle

Various types and sizes of application equipment are readily available. The size of the equipment (tank size, boom width, etc.) should be matched to the scale of the facility. The equipment should also be scaled to the size of the application. There may be situations where wide booms are applicable and places where hand sprayers are applicable. No matter the size of the sprayer, each one needs to be calibrated.

Best Management Practices

- Use an appropriately sized applicator for the size of area being treated.
- Equipment too large in size requires greater volumes to prime the system. This can result in significant waste that must be properly handled.
- Using the correct sprayer for the job can also allow better placement of the pesticide to protect water resources.

INVENTORY

Principle

Do not store large quantities of pesticides for long periods. Adopt the "first in, first out" principle, using the oldest products first to ensure that the product shelf life does not expire.

Best Management Practices

An inventory of the pesticides kept in the storage building and the Safety Data Sheets (SDS) for the chemicals used in the operation should be accessible on the premises, but not kept in the pesticide storage room itself.

LEACHING POTENTIALS

Principle

Weakly sorbed pesticides (compounds with small Koc values) are more likely to leach through the soil and reach groundwater. Conversely, strongly sorbed pesticides (compounds with large Koc values) are likely to remain near the soil surface, reducing the likelihood of leaching, but increasing the chances of being carried to surface water via runoff or soil erosion.

Best Management Practices

- Understand pesticide sorption principles so that appropriate decisions can be made.
- Understand site characteristics that are prone to leaching losses (for example, sand-based putting greens, coarse-textured soils, shallow water tables).
- Identify label restrictions that may pertain to your facility.
- Avoid using highly water-soluble pesticides.
- Exercise caution when using spray adjuvants that may facilitate off-target movement.

MIXING/WASHING STATION

Principle

Pesticide leaks or spills, if contained, will not percolate down through the soil into groundwater or run off the surface to contaminate streams, ditches, ponds, and other waterbodies. One of the best containment methods is the use of a properly designed and constructed chemical mixing center (CMC). Information on designing and managing storage and mixing stations can be found in the UGA Publication B 1095: Pesticide Storage and Mixing Facilities.

Best Management Practices

- Loading pesticides and mixing them with water or oil diluents should be done over an impermeable surface (such as lined or sealed concrete), so that spills can be collected and managed.
- Mixing station surfaces should provide for easy cleaning and the recovery of spilled materials.

- Pump the sump dry and clean it at the end of each day. Liquids and sediments should also be removed from the sump and the pad whenever pesticide materials are changed to an incompatible product (that is, one that cannot be legally applied to the same site).
- Apply liquids and sediments as you would a pesticide, strictly following label instructions.
- Absorbents such as cat litter or sand may be used to clean up small spills and then applied as a topdressing in accordance with the label rates, or disposed of as a waste.
- Sweep up solid materials and use as intended.

DISPOSAL

Principle

Wash water from pesticide application equipment must be managed properly, since it contains pesticide residues.

Best Management Practices

- Collect wash water (from both inside and outside the application equipment) and use it as a pesticide in accordance with the label instructions.
- The rinsate may be applied as a pesticide (preferred) or stored for use as makeup water for the next compatible application.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Principle

Exposure to pesticides can be mitigated by practicing good work habits and adopting modern pesticide mix/load equipment (for example, closed-loading) that reduce potential exposure. Personal Protective Equipment (PPE) statements on pesticide labels provide the applicator with important information on protecting himself/herself.

Best Management Practices

- Provide adequate PPE for all employees who work with pesticides (including equipment technicians who service pesticide application equipment).
- Ensure that PPE is sized appropriately for each person using it.
- Make certain that PPE is appropriate for the chemicals used.
- Ensure that PPE meets rigorous testing standards and is not just the least expensive.
- Store PPE where it is easily accessible but not in the pesticide storage area.
- Forbid employees who apply pesticides from wearing facility uniforms home where they may come into contact with children.
- Provide laundering facilities or uniform service for employee uniforms.
- The federal Occupational Safety and Health Administration (OSHA) requires employers to fit test workers who must wear tight-fitting respirators.
- Meet requirements for OSHA 1910.134 Respiratory Protection Program.

PESTICIDE CONTAINER MANAGEMENT

Principle

The containers of some commonly used pesticides are classified as hazardous wastes if not properly rinsed, and as such, are subject to the many rules and regulations governing hazardous waste. The improper disposal of a hazardous waste can result in very high fines and/or criminal penalties. However, pesticide containers that have been properly rinsed can be handled and disposed of as nonhazardous solid waste. Federal law (FIFRA) and some state laws require pesticide applicators to rinse all empty pesticide containers before taking other container disposal steps. Under federal law (the Resource Conservation and Recovery Act, or RCRA), A PESTICIDE CONTAINER IS NOT EMPTY UNTIL IT HAS BEEN PROPERLY RINSED. For more information on proper rinsing of containers, contact the Georgia Department of Agriculture, Pesticide Division.

Best Management Practices

- Rinse pesticide containers immediately in order to remove the most residue.
- Rinse containers during the mixing and loading process and add rinsate water to the finished spray mix.
- Rinse emptied pesticide containers by either triple rinsing or pressure rinsing.
- Puncture empty and rinsed pesticide containers and dispose of according to the label.

8. INTEGRATED PEST MANAGEMENT

The philosophy of integrated pest management (IPM) was developed in the 1950s because of concerns over increased pesticide use, environmental contamination, and the development of pesticide resistance. The objectives of IPM embrace reducing pest management expenses, conserving energy, and reducing the risk of pesticide exposure to people, animals, and the environment. Its main goal, however, is to reduce pesticide use by using a combination of tactics to control pests, including cultural, biological, genetic, and chemical controls.

Pest management on golf courses results in significant inputs of time, labor, and financial resources. To grow healthy turfgrass, it is important for golf course superintendents to know what IPM is and how to implement it for each pest group (arthropods, nematodes, diseases, and weeds). They must be well-versed in pest identification, understand pest life-cycles and/or conditions that favor pests, and know about all possible methods of controlling pests.

The Georgia Department of Agriculture is the agency in Georgia that regulates all aspects of pesticide use, sale, storage, and disposal. The GDA is also the agency that issues licenses for those persons who apply pesticides. The GDA website's pesticides page provides information on acquiring a license for applying pesticides, taking a course, taking an exam, and renewal of licenses.

REGULATORY CONSIDERATIONS

Principles

- State and Federal regulations cover practically anyone who manufactures, formulates, markets, and uses pesticides.
- Record keeping of pesticide use may be required by law. IPM principles suggest that you keep records of all pest control activity so that you may refer to information on past infestations or other problems to select the best course of action in the future.
- Always follow the directions on the label. These directions have been developed after extensive research and field studies on the chemistry, biological effects, and environmental fate of the pesticide. **The label is the single-most important document in the use of a pesticide. State and federal pesticide laws require following label directions!**

Best Management Practices

- Use records to establish proof of use and follow-up investigation of standard protocols regarding:
  - Date and time of application
  - Name of applicator
  - Person directing or authorizing the application
  - Weather conditions at the time of application
  - Target pest
  - Pesticide used (trade name, active ingredient, amount of formulation, amount of water)
  - Adjuvant/surfactant and amount applied, if used
  - Area treated (acres or square feet) and location
  - Total amount of pesticide used
  - Application equipment
  - Additional remarks, such as the severity of the infestation or life-stage of the pest
  - Follow-up to check the effectiveness of the application

IPM OVERVIEW

For a sound overview of Integrated Pest Management please refer to the UGA Integrated Pest Management website.

Principles

- The fundamental basis of an environmentally sound pest control program is a process called Integrated Pest Management (IPM).
- IPM is an overall pest management strategy that includes biological controls, cultural methods, pest monitoring, other applicable practices, and is a last measure when threshold levels are exceeded.
- IPM focuses on the basics of identifying the pests, choosing pest-resistant varieties of grasses and other plants, enhancing the habitat for natural pest predators, scouting to determine pest populations and determining acceptable thresholds, and applying biological and other less toxic alternatives to chemical pesticides whenever possible.
- Chemical controls should have minimal effect on beneficial organisms and the environment and minimize the development of pesticide resistance.

- A pest-control strategy should be used only when the pest is causing or is expected to cause more damage than what can be reasonably and economically tolerated. A control strategy should be implemented that reduces the pest numbers to an acceptable level while minimizing harm to non-targeted organisms.
- When a pesticide application is deemed necessary, its selection should be based on effectiveness, toxicity to non-target species, cost, and site characteristics, as well as its solubility and persistence.

Best Management Practices

- Chemical pesticide applications should be carefully chosen for effective and site-specific pest control with minimal environmental impact.
- Identify key pests. They could inlcude specific insects on plants, plants in the water, or plants intermixed with other plants.
- Determine the pest's life-cycle, and know which life-stage to target (for an insect pest, whether it is an egg, larva/nymph, pupa, or adult. On plants, is the pest in a stage that it will be easily killed by the pesticide being used?).
- Use cultural, mechanical, or physical methods to prevent problems from occurring (for example, prepare the site, select resistant cultivars), reduce pest habitat (for example, practice good sanitation, carry out pruning and dethatching), or to help promote biological control (for example, provide nectar or honeydew sources).
- Decide which pest management practice is appropriate and carry out corrective actions. Direct control where the pest lives or feeds.
- Use preventive chemical applications only when your professional judgment indicates that properly timed preventive applications are likely to control the target pest effectively while minimizing the economic and environmental costs.
- Determine whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.
- Observe and document turf conditions regularly (daily, weekly, or monthly, depending on the pest), noting which pests are present, so intelligent decisions can be made regarding how damaging the pests are and what control strategies are necessary.

PEST THRESHOLDS

Principles

- IPM is commonly used in agricultural crop production, where the economic thresholds for key pests have been determined. Pest levels exceeding the site's threshold warrant treatment.
- Using IPM is more challenging on golf courses than in an agricultural setting. The golf industry is sensitive to aesthetic damage, and golfers are often intolerant of anything that could affect the appearance of turfgrass and ornamental plants. Increased education of golfers and maintenance personnel could raise their tolerance of minor damage without compromising plant health, play, and aesthetics.

Best Management Practices

- Use available pest thresholds to guide pesticide application decisions (see IPM Guide).
- Use preventive chemical applications only when professional judgment indicates that properly timed preventive applications are likely to control the target pest effectively while minimizing the economic and environmental costs.
- Record and use this information when making similar decisions in the future.

MONITORING

Principles

- Monitoring, or scouting, is the most important element of a successful IPM program. Monitoring identifies the presence and development of pests, or the conditions that are conducive for pest outbreak throughout the year.
- It is essential to record the results of scouting in order to develop historical information, document patterns of pest activity, and learn the lessons of successes and failures.

Best Management Practices

- Train personnel to observe and document turf conditions regularly (daily, weekly, or monthly, depending on the pest), noting which pests are present, so intelligent decisions can be made regarding how damaging they are and what control strategies are necessary.
- Train personnel to determine the pest's life-cycle, and know which life-stage to target (for an insect pest, whether it is an egg, larva/nymph, pupa, or adult).
- Train personnel to determine whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.

- Train personnel to document, identify, and record key pest activities on key plants.
- Look for signs of the pest. These may include mushrooms, animal damage, insect frass, or webbing.
- Identify the symptoms of the pest. Look for symptoms such as chlorosis, dieback, growth reduction, defoliation, mounds, or tunnels.
- Determine the damage. Problem areas might include the edges of fairways, shady areas, or poorly drained areas.
- Document when the damage occurred. Note the time of day, year, and flowering stages of nearby plants.
- Map pest outbreak locations to identify patterns and susceptible areas for future target applications and ultimate pesticide reductions.

RECORD KEEPING

Principles

- It is essential to record the results of scouting in order to develop historical information, document patterns of pest activity, and learn the lessons of successes and failures.
- Record keeping is required to comply with the federal Superfund Amendments and Reauthorization Act (SARA, Title III), which contains emergency planning and community right-to-know legislation
- Certain pesticides are classified as restricted-use pesticides (RUPs). Very few pesticides in this category are routinely used in turf maintenance, but if you happen to use one of them, specific record-keeping requirements apply.

Best Management Practices

- Document, identify, and record key pest activities on key plants and locations.
- Determine the pest's life-cycle, and know which life-stage to target (for an insect pest, whether it is an egg, larva/nymph, pupa, or adult).
- Determine whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.
- Observe and document turf conditions regularly (daily, weekly, or monthly, depending on the pest), noting which pests are present, so intelligent decisions can be made regarding how damaging they are and what control strategies are necessary.

TURFGRASS SELECTION

Principles

- Selecting pest-resistant cultivars or plant species is a very important part of IPM, and leads to reduced pesticide usage. Species grown outside of their zone of adaptation are more prone to pest problems.
- Species and cultivars should be managed under conditions similar to their intended use (for example, not exceeding mowing height limitations that a grass was bred for or selected for).
- Educate builders, developers, golf course and landscape architects, sod producers, golfers and others on which plants are best suited to their areas.
- Turfgrasses must be scientifically selected for the eco-region of the golf course, resulting in minimized irrigation requirements, fertilization needs, and pesticide use.

Best Management Practices

- Select the most suitable turfgrass for existing conditions and one that adheres to design specifications.
- Avoid use of turfgrass in heavy shade.
- Select shade-adapted grasses for areas receiving partial sun or shade.
- Reduce pest and disease pressures by correcting dead spots and air-circulation issues by pruning understory and adjusting irrigation scheduling.
- Reduce fertilizer applications in shaded areas.
- Reduce traffic in shaded areas to protect turfgrasses and trees from injury and soil compaction, if practical.

BIOLOGICAL CONTROLS

Principles

- The biological component of IPM involves the release and/or conservation of natural predators, such as parasites and pathogens, and other beneficial organisms (pollinators).
- Natural enemies (including ladybird beetles, green lacewings, and mantids) may be purchased and released near pest infestations.
- Areas on the golf course can also be modified to better support natural predators and beneficial organisms.

Best Management Practices

- Identify areas on the golf course that can be modified to attract natural predators, provide habitat for them,

and protect them from pesticide applications.

- Install flowering plants that can provide parasitoids with nectar, or sucking insects (aphids, mealybugs, or soft scales) with a honeydew source.
- Avoid applying pesticides to roughs, driving ranges, or other low-use areas to provide a refuge for beneficial organisms.
- Release insect-parasitic nematodes to naturally suppress mole crickets and white grubs.

POLLINATORS

Refer to the Pollinator Protection chapter for additional information and links to resources.

Principles

- It is important to minimize the impacts on bees and beneficial arthropods. Pesticide applicators must use appropriate tools to help manage pests while safeguarding pollinators, the environment, and humans.
- Pollinator-protection language is a label requirement found on pesticide labels.
- Be mindful of pollinators; when applying pesticides, focus on minimizing exposure to non-target pollinators in play and non-play course areas.
- Pollinators may be negatively impacted when pesticide applications are made based on insufficient information and/or made without regard to the safety of pollinators.
- Pollinators require a diversity of flowering plant species to complete their life-cycle. Pollinator habitat contains a diversity of plant species of different flower colors, flower shapes and plant heights, with blossoms throughout the entire growing season. Pollinator habitat is also attractive to many other beneficial arthropods that can assist in pest insect control.

Best Management Practices

- When using pesticides, minimize injury and damage by following label directions.
- Follow label information concerning the application of pesticides when plants may be in bloom. Avoid applying pesticides during bloom season.
- Stay on target by using coarse-droplet nozzles and monitor wind to reduce drift.
- Do not apply pesticides when pollinators are active.
- Before applying a pesticide, scout/inspect area for both harmful and beneficial insect populations, and apply only when the indicated threshold of damage has been reached.
- Mow flowering plants (weeds) before insecticide application.
- If flowering weeds are prevalent, control them before applying insecticides.
- Use insecticides that have a lower impact on pollinators.
- Use the latest spray technologies, such as drift-reduction nozzles to prevent off-site (target) translocation of pesticide.
- Avoid applications during unusually low temperatures or when dew is forecasted.
- Use granular formulations of pesticides that are known to be less hazardous to bees.
- Consider lures, baits, and pheromones as alternatives to insecticides for pest management.

CONVENTIONAL PESTICIDES

Principles

- IPM does not preclude the use of pesticides. However, pesticides should be viewed as one of the many tools used to minimize pest problems.
- IPM involves both prevention — keeping the pest from becoming a problem — and suppression — reducing the pest numbers or damage to an acceptable level.
- A pest-control strategy using pesticides should be used only when the pest is causing or is expected to cause more damage than can be reasonably and economically tolerated.
- Pesticides are designed to control or alter the behavior of pests. When, where, and how they can be used safely and effectively is a matter of considerable public interest.
- Pesticides should be evaluated on effectiveness against the pest, mode of action, life-stage of the pest, personnel hazards, non-target effects, potential off-site movement, and cost.
- A control strategy should be implemented that reduces the pest numbers to an acceptable level while minimizing harm to non-targeted organisms.
- Always follow the directions on the label. These directions have been developed after extensive research and field studies on the chemistry, biological effects, and environmental fate of the pesticide. **The label is the single most important document in the use of a pesticide. State and federal pesticide laws require following label directions!**

Best Management Practices

- Train employees in proper pest identification and pesticide selection techniques.
- Choose the product most appropriate for the problem or pest.
- Mix only the quantity of pesticide needed in order to avoid disposal problems, protect non-target organisms, and save money.
- Spot-treat pests whenever appropriate.
- Make note of any environmental hazards and groundwater advisories included on the label.
- Rotate pesticide modes-of-action to reduce the likelihood of resistance.
- Follow guidelines and advice provided by the Fungicide Resistance Action Committee (FRAC), Herbicide Resistance Action Committee (HRAC),and Insecticide Resistance Action Committee (IRAC).

DISEASE

Principles

- In the presence of a susceptible host and a conducive environment, plant pathogens can disrupt play by damaging and destroying intensely managed turf.
- No measure can completely eliminate the threat of turfgrass disease on a golf course. However, turfgrass managers have multiple tactics and tools that can reduce the likelihood of disease.
- Cultural factors that can influence turfgrass stress and the likelihood of disease problems include organic layer management, fertility programs, water management, and mowing height selection. Healthy, well-managed turfgrass is less likely to develop disease problems.
- Disease outbreaks that do occur are less likely to be severe on turf that is healthy because it has better recuperative potential than stressed, unhealthy turf.

Best Management Practices

- Correctly identify the disease pathogen. This often involves sending samples to diagnostic clinics.
- Ensure proper cultural practices that reduce turfgrass stress are used.
- Correct conditions that produce stressful environments for the turf (for example, improve airflow and drainage, reduce or eliminate shade).
- Fungicide use should be integrated into an overall management strategy for a golf course.
- The appropriate (most effective) preventive fungicide should be applied to susceptible turfgrasses when unacceptable levels of disease are likely to occur.
- Preventively apply appropriate fungicides where diseases are likely to occur and when conditions favor disease outbreaks.
- Record and map disease outbreaks and identify trends that can help guide future treatments and focus on changing conditions in susceptible areas to reduce disease outbreaks.

WEEDS

UGA's Turfgrass website has extensive information on weed management in a turgrass settting.

Principles

- Weeds compete with desired plants for space, water, light, and nutrients and can harbor insect pests and diseases.
- Weed management is an integrated process where good cultural practices are employed to encourage desirable turfgrass ground cover, and where herbicides are intelligently selected and judiciously used. A successful weed management program consists of:
  - preventing weeds from being introduced into an area;
  - using proper turfgrass management and cultural practices to promote vigorous, competitive turf;
  - properly identifying weeds;
  - properly selecting and using the appropriate herbicide, if necessary.
- Weeds are hosts for other pests such as plant pathogens, nematodes, and insects, and certain weeds can cause allergic reactions in humans.
- Weeds reproduce from seed, root pieces, and special vegetative reproductive organs such as tubers, corms, rhizomes, stolons, or bulbs. People, animals, birds, wind, and water can distribute seeds.
- Weeds complete their life-cycles in either one growing season (annuals), two growing seasons (biennials), or three or more years (perennials). Annuals that complete their life-cycles from spring to fall are referred to as summer annuals. Those that complete their life-cycles from fall to spring are winter annuals.

Best Management Practices

- Proper weed identification is essential for effective management and control.
- Select appropriate turf species or cultivars that are adapted to the prevalent environmental conditions to reduce weed encroachment that may lead to bare soils.
- To prevent weed encroachment, adopt or maintain cultural practices that protect turfgrass from environmental stresses such as shade, drought, and extreme temperatures.
- To reduce weed infestation, address improper turf management practices, such as the misuse of fertilizers and chemicals, improper mowing height or mowing frequency, and improper soil aeration, and physical damage and compaction from excessive traffic.
- Proper fertilization is essential for turfgrasses to sustain desirable color, growth density, and vigor and to better resist diseases, weeds, and insects.
- Avoid scalping; it reduces turf density, which can lead to weed establishment.
- Weed-free materials should be used for topdressing.
- Address damage from turfgrass pests such as diseases, insects, nematodes, and animals to prevent density/canopy loss to broadleaf weeds.
- Record and map weed infestations to help identify site specific issues for preventative actions.

NEMATODES

UGA Publication number C834 titled *Guide for Interpreting Nematode Assay Results* is a valuable resource for infomation on sampling for nematodes and interpreting results.

Principles

- Plant-parasitic nematodes adversely affect turfgrass health.
- Plant-parasitic nematodes are microscopic roundworms (unsegmented), usually between 0.0156 and 0.125 inch (0.25 and 3 mm) in length, and are difficult to control.
- Nematodes debilitate the root system of susceptible turfgrasses; plant-parasitic nematodes cause turf to be less efficient at water and nutrient uptake from the soil and make it much more susceptible to environmental stresses. Additionally, weakened turf favors pest infestation, especially troublesome weeds that necessitate herbicide applications.
- Over time, turf in the affected areas thins out and, with severe infestations, may die. The roots of turfgrasses under nematode attack may be very short, with few, if any, root hairs, or they may appear dark and rotten.
- Turfgrasses usually begin showing signs of nematode injury as they experience additional stresses, including drought, high temperatures, low temperatures, and wear.

Best Management Practices

- When nematode activity is suspected, an assay of soil and turfgrass roots is recommended to determine the extent of the problem.
- The application of a nematicide on golf course turf should always be based on assay results.
- Divert traffic away from areas that are stressed by insects, nematodes, diseases, or weeds.
- Increase mowing height to reduce plant stress associated with nematodes, root-feeding insects, disease outbreaks, or peak weed-seed germination.
- Reduce/eliminate other biotic/abiotic stresses when nematodes are compromising the root system and plant health.

9. POLLINATOR PROTECTION

Most flowering plants need pollination to reproduce and grow fruit. While some plants are pollinated by wind, many require assistance from insects and other animals. In the absence of pollinators, many plant species, including the fruits and vegetables we eat, would fail to survive. The western honey bee (*Apis mellifera*) is one of the most important pollinators in the United States. Hundreds of other bee species, including the bumble bee (*Bombus* spp.), also serve as important pollinator species. Protecting bees and other pollinators is important to the sustainability of agriculture.

Pesticides are products designed to control pests (for example, insects, diseases, weeds, nematodes, etc.). Pesticides and other plant growth products, including plant growth regulators, surfactants, biostimulants, etc., are used in golf course management. The non-target effect of products used in golf course management is of increasing concern; therefore, pesticide applicators, including those on golf courses, need to be mindful of the impact that pesticides have on pollinator species and their habitat.

REGULATORY CONSIDERATIONS

Principles

- Pollinator-protection language is a label requirement found on pesticide labels; follow the label, it is the law.
- Pesticide applicators must be aware of honey bee toxicity groups and able to understand precautionary statements.

Pesticides applicators must use appropriate tools to safeguard pollinators while managing pests. *Photo credit: Mark Hoban.*

- Recordkeeping may be required by law in order to use some products. IPM principles also encourage keeping records of all infestations and pest control activity to help superintendents determine their best approach to future pest problems.

Best Management Practices

- Proper records of all pesticide applications should be kept according to local, state, or federal requirements.
- Use records to establish proof of use and follow-up investigation of standard protocols regarding:
  - Date and time of application
  - Name of applicator
  - Person directing or authorizing the application
  - Weather conditions at the time of application
  - Target pest
  - Pesticide used (trade name, active ingredient, amount of formulation, amount of water)
  - Adjuvant/surfactant and amount applied, if used
  - Area treated (acres or square feet) and location
  - Total amount of pesticide used
  - Application equipment
  - Additional remarks, such as the severity of the infestation or life stage of the pest
  - Follow-up to check the effectiveness of the application
- Those applying pesticides, and who make decisions regarding their applications should be able to interpret pollinator protection label statements.
- Those applying pesticides should be aware of honey bee biology.
- Those applying pesticides should understand the various routes of exposure (outside the hive and inside the hive).
- Those applying pesticides should understand the effects of pesticides on bees.

POLLINATOR HABITAT PROTECTION

Principles

- It is important to minimize the impacts of pesticides on bees and beneficial arthropods. Pesticides applicators must use appropriate tools to help manage pests while safeguarding pollinators, the environment, and humans.

- Be mindful of pollinators; when applying pesticides, focus on minimizing exposure to non-target insects in play and non-play course areas.
- Pollinators require a diversity of flowering plant species to complete their life cycle. Pollinator habitat contains a diversity of plant species of different flower colors, flower shapes and plant heights, with blossoms throughout the entire growing season. Pollinator habitat is also attractive to many other beneficial arthropods that can assist in pest insect control.
- Golf courses can be champions of pollinator conservation with mindful landscaping.

Best Management Practices

- Become familiar with Georgia's pollinator protection plan, *Protecting Georgia's Pollinators*. Additional information on protecting Georgia's pollinators can be found on the Georgia Department's of Agriculture website or there is a document produced by the UGA/CAES Entomology Department.
- Work with beekeepers who have honey bee hives located near the golf course. If you are not sure if or who might be a beekeeper in your area, a good place to start would be the Georgia Beekeepers Association.
- Follow label information in regards to the use of the pesticide when plants are flowering. Look for the bee hazard icon in the directions to learn the restrictions that protect insect pollinators.
- Avoid applying pesticides during bloom season.
- Stay on target by using coarse-droplet nozzles, and monitoring wind to reduce drift.
- Do not apply pesticides when pollinators are active.
- Before applying a pesticide, scout/inspect the area for both harmful and beneficial insect populations, and use pesticides only when a threshold of damage has been indicated.

The Georgia Beekeepers Association is a good source for information on how to establish hives on the golf course property like these at The Ford Plantation. *Photo credit: Nelson Caron.*

Before....

After.... Golf courses can be champions of pollinator conservation with mindful landscaping. *Photo credit: Mark Hoban.*

- Mow flowering weeds before insecticide application.
- If flowering weeds are prevalent, control them before applying insecticides.
- Use insecticides that have a minimal impact on non-target species.
- Use the latest spray technologies, such as drift-reduction nozzles to prevent off-site (target) translocation of pesticide. Avoid applications during unusually low temperatures or when dew is forecast.
- Use granular formulations of pesticides that are known to be less hazardous to bees.
- Consider lures, baits, and pheromones as alternatives to insecticide for pest management.
- Develop new pollinator habitat and/or enhance existing habitat. Research-based plant choices specific to Georgia's growing conditions are available to assist in habitat planning.
- Insect nesting boxes can be a useful addition to non-play areas. Also, non-play areas planted in bee forage could add an attractive space to the golf course.

10. MAINTENANCE OPERATIONS

Equipment maintenance, fueling, and chemical storage can have an impact on water quality on-site and off-site both during construction and during the maintenance of existing golf courses. In locations where there are liquids being stored, mixed, or equipment being cleaned or washed-down, there should be some method of capturing the water and routing it away from water bodies. The University of Georgia Extension has a publication titled Pesticide Storage and Mixing Facilities which provides information on storing and mixing pesticides to protect both surface and groundwater.

REGULATORY CONSIDERATIONS

The publication mentioned above provides general information, but the golf course superintendent should check with local authorities to determine if other regulations are in place. Early engagement among developers, designers, local community groups and permitting agencies is essential to designing and constructing a golf maintenance and storage facility that minimizes environmental impact and meets the needs for the approval process.

STORAGE AND HANDLING OF CHEMICALS

Principles

- Proper handling and storage of pesticides and petroleum-based products is important to reduce risk of serious injury or death of an operator or bystander. Fires or environmental contamination could result in large fines, clean-up costs, and civil lawsuits if these chemicals are not managed properly.
- Check federal, state, and local regulations for specific requirements related to storage of pesticides.

Best Management Practices

- Storage buildings should have appropriate warning signs and placards.
- Follow all Personal Protective Equipment (PPE) statements on pesticide labels.
- Store PPE away from pesticide storage areas in an area that is easily accessible.
- Develop an emergency response plan and educate all golf course personnel regarding emergency procedures on a regular basis.
- Individuals conducting emergency chemical clean-ups should be properly trained under requirements of federal Occupational Safety and Health Administration (OSHA).
- Store pesticides in a lockable concrete or metal building.
- Locate pesticide storage away from other buildings, especially fertilizer storage facilities.
- Floors of chemical storage buildings should be impervious and sealed with chemical-resistant paint.
- Floors of chemical storage buildings should have a continuous sill to contain spills and should not have a drain. A sump is acceptable.
- Shelving should be fabricated from plastic or reinforced metal. Metal shelving should be painted to avoid corrosion. Wood shelving should never be used because of its ability to absorb spilled pesticides.
- Secondary containment on shelves can help avoid contamination of other bottles and chemicals in case of a leak or spill on higher shelves.
- Store liquid materials below dry materials to prevent leaks contaminating dry products.
- Automatic exhaust fans and an emergency wash area should be provided.
- Explosion-proof lighting may be required. Locate fan and light switches outside the entrance to the building to facilitate ventilation of building before staff entry.
- Maintain detailed records of current pesticide inventory in the storage facility. Safety Data Sheets (SDS) for the chemicals stored on-site should be stored separate from the storage room, but readily accessible on-site.
- Do not store large quantities of pesticides or chemicals for long periods of time. Follow a “first in, first out” principle to rotate products into use to ensure products do not expire.
- Store chemicals in original containers. Never store them in containers that might be mistaken as packaging for food or drink.
- Arrange containers so the labels are clearly visible. Securely fasten loose labels to ensure containers and associated labels are kept together.
- Damaged labels should be replaced immediately.
- Store flammable pesticides separate from those that are non-flammable.

- Ensure that oil containers and small fuel containers (service containers) are properly labeled and stored within the facility.

EQUIPMENT STORAGE AND MAINTENANCE

Principle

Storing and maintaining equipment properly will extend useful life and reduce the need for repairs.

Best Management Practices

- Store and maintain equipment in a covered area complete with a sealed impervious surface to limit risk of fluid leaks contaminating the environment and to facilitate the early detection of small leaks, that may require repair, before causing significant damage to the turf or the environment.
- Seal floor drains unless they are connected to a holding tank or sanitary sewer with permission from the local wastewater treatment plant.
- Store pesticide and fertilizer application equipment in areas protected from rainfall. Rain can wash pesticide and fertilizer residues from the exterior of the equipment and possibly contaminate soil or water.
- Store solvents and degreasers in lockable metal cabinets away from ignition sources in a well-ventilated area. These products are generally toxic and highly flammable. Never store them with fertilizers or in areas where smoking is permitted.
- Keep an inventory of solvents and SDS for those materials on-site but in a different location where they will be easily accessible in case of an emergency.
- Keep basins of solvent baths covered to reduce emissions of volatile organic compounds (VOC).
- When possible, replace solvent baths with recirculating aqueous washing units. Soap and water or other aqueous cleaners are often as effective as solvent-based products and present a lower risk to the environment.
- Always use appropriate PPE when working with solvents.
- Never allow solvents or degreasers to drain onto pavement or soil, or discharge into waterbodies, wetlands, storm drains, sewers, or septic systems.
- Collect used solvents and degreasers in containers clearly marked with contents and date; schedule collection by a commercial service.
- Blow off all equipment with compressed air to reduce damage to hydraulic seals.

WASTE HANDLING

Principles

- Proper disposal of waste materials is critical for protection of water and natural resources. State or local laws and regulations related to disposal of hazardous waste products may vary. Be sure to familiarize yourself with all state and local laws related to disposal/recycling of these waste materials.
- Identify and implement waste-reduction practices.
- Look for ways to increase recycling efforts and programs.
- Purchase environmentally preferred products in bulk packaging when possible.
- Proper waste disposal will protect water resources. Contact a local disposal company for disposal of waste materials.

Best Management Practices

- Pesticides that have been mixed for application must be disposed of as waste and may be classified as hazardous waste depending on the materials involved. Contact local authorities for guidance regarding proper disposal. Also, contact EPD for more information on disposal of hazardous waste materials.
- Collect used oil, oil filters, and antifreeze in separate marked containers and recycle them as directed by local and state authorities.
- Antifreeze may be considered hazardous waste by state or local laws and should be handled accordingly. Commercial services are available to collect and recycle antifreeze.
- Lead-acid batteries are classified as hazardous waste unless they are properly recycled.
- Store old batteries on impervious services where they are protected from rainfall and recycle as soon as possible.
- Recycle used tires.
- Recycle or dispose of fluorescent tubes and other lights according to state requirements.

EQUIPMENT WASHING

Principle

Wash water generated from equipment-washing facilities can be a source of both surface-water and groundwater pollution. Steps should be taken to prevent pollution.

Best Management Practices

- Equipment washing areas should drain to an oil/water separator before draining to a sanitary sewer or holding tank.
- Consider the use of a closed-loop wash-water recycling system.
- Grass-covered equipment should be brushed or blown off with compressed air before being washed.
- Wash equipment with a bucket of water and a rag to minimize the amount of water used and use only the least amount of water required to rinse the machine.
- Spring-operated shut-off nozzles should be used.
- Do not allow any wastewater to flow directly into surface waters or storm drains.

FUELING FACILITIES

Principle

Safe storage of fuel, including use of above-ground tanks and containment facilities, is critical to the protection of the environment. State or local laws and regulations related to storage of fuel may vary.

Best Management Practices

- Locate fueling facilities under roofed areas with a concrete (not asphalt) pavement. Areas should be equipped with spill-containment and recovery facilities.
- Use of above ground fuel tanks is preferred.
- Ensure fuel tanks are located in secondary containment areas.

Equipment washing areas should drain to a recycling system to remove pollutants. *Photo credit: Lukus Harvey.*

POLLUTION PREVENTION

Principles

- Plan appropriately to minimize the possibility of an elicit discharge and need for disposal. Monitor the water to be discharged for contamination; never discharge to the environment any contaminated water. If the water is not contaminated, it can be reused or discharged to a permitted stormwater treatment system.
- Pesticide leaks or spills, if contained, will not percolate down through the soil into groundwater or run off the surface to contaminate streams, ditches, ponds, and other water bodies.
- Wash water from pesticide application equipment must be managed properly, since it contains pesticide residues. This applies to wash water from both the inside and the outside of the application equipment. Material should be collected and used as a pesticide in accordance with the label instructions for that pesticide.
- An equipment-washing facility can be a source of both surface water and groundwater pollution, if the wash water generated is not properly handled. All equipment used in the maintenance of golf courses and associated developments should be designed, used, maintained, and stored in a way that eliminates or minimizes the potential for pollution.
- One of the key principles of pollution prevention is to reduce the unnecessary use of potential pollutants. Over time, the routine discharge of even small amounts of solvents can result in serious environmental and liability consequences, because of the accumulation of contaminants in soil or groundwater.
- The proper handling and storage of pesticides is important. Failure to do so correctly may lead to the serious injury or death of an operator or bystander, fires, environmental contamination that may result in large fines and clean-up costs, civil lawsuits, the destruction of the turf you are trying to protect, and wasted pesticide product.
- Generating as little as 25 gallons per month of used solvents for disposal can qualify you as a "small-quantity generator" of hazardous waste, triggering EPA and state reporting requirements. For more information on generation quantities see GA EPD Rules for Hazardous Waste.
- Hazardous waste is regulated in the Land Protection Branch of the Georgia EPD under Rules 391-3-11.
- Pesticides that have been mixed so they cannot be legally applied to a site in accordance with the label must be disposed of as a waste. Depending on the materials involved, they may be classified as hazardous waste.
- Provide adequate protection from the weather. Rain can wash pesticide and fertilizer residues from the exterior of the equipment, and these residues can contaminate soil or water.
- Never allow solvents to drain onto pavement or soil, or discharge into water bodies, wetlands, storm drains, sewers, or septic systems, even in small amounts.
- Office paper, recyclable plastics, glass, and aluminum should be recycled. Place containers for recycling aluminum cans and glass or plastic soft drink bottles at convenient locations on the golf course.

Best Management Practices

- Pesticides should be stored in a lockable concrete or metal building.
- Pesticide storage and mixing facility floors should be impervious and sealed with a chemical-resistant paint. Floors should have a continuous sill to retain spilled materials and no drains, although a sump may be included.
- For valuable information about constructing chemical mixing facilities, reference the Midwest Plan Service book, Designing Facilities for Pesticide and Fertilizer Containment (revised 1995); the Tennessee Valley Authority (TVA) publication, Coating Concrete Secondary Containment Structures Exposed to Agrichemicals (Broder and Nguyen, 1995); and USDA–NRCS Code 703.
- Use a chemical mixing center (CMC) as a place for performing all operations where pesticides are likely to be spilled in concentrated form—or where even dilute formulations may be repeatedly spilled in the same area—over an impermeable surface. (A CMC is a concrete pad treated with a sealant and sloped to a liquid-tight sump where all of the spilled liquids can be recovered.)
- Flush wash pad with clean water after the equipment is washed. Captured wash water can be used as a dilute pesticide per labeled site, or it may be pumped into a rinsate storage tank for use in the next application.
- FIFRA, Section 2(ee), allows the applicator to apply a pesticide at less than the labeled rate.
- The sump should be cleaned of any sediment before another type of pesticide is handled.
- Discharge of wash water should be done to a treatment system that is permitted under industrial wastewater rules.

- Never discharge to a sanitary sewer system without written permission from the receiving utility.
- Never discharge wash water to a septic tank.
- Use a closed-loop wash-water recycling system and follow appropriate BMPs.
- Use non-containment wash water for field irrigation.
- Do not discharge non-contaminated wastewater during or immediately after a rainstorm, since the added flow may cause the permitted storage volume of the stormwater system to be exceeded.
- Whenever practical, replace solvent baths with recirculating aqueous washing units (which resemble heavy-duty dishwashers).
- Use soap and water or other aqueous cleaners; these products are often as effective as solvent-based ones.
- Blowing off equipment with compressed air instead of washing with water is often easier on hydraulic seals and can lead to fewer oil leaks. Use compressed air to blow off grass-covered equipment. This is less harmful to the equipment's hydraulic seals, eliminates wastewater, and produces dry material that is easier to handle.
- It is best to wash equipment with a bucket of water and a rag, using only a minimal amount of water to rinse the machine.
- Clean up spills as soon as possible.
- Keep spill clean-up equipment available when handling pesticides or their containers.
- If a spill occurs of a pesticide covered by certain state and federal laws, you may need to report any accidental release if the spill quantity exceeds the "reportable quantity" of active ingredient specified in the law.
- Large spills or uncontained spills involving hazardous materials may best be remediated by hazardous material clean-up professionals.
- For emergency (only) information on hazards or actions to take in the event of a spill, call CHEMTREC, at (800) 424-9300. CHEMTREC is a service of the Chemical Manufacturers Association. For information on whether a spilled chemical requires reporting, call the CERCLA/RCRA help line at (800) 424-9346.
- Do not allow any wash water to flow directly into surface waters or storm drains.
- Avoid washing equipment in the vicinity of wells or surface water bodies.
- Wash equipment over a concrete pad that allows the water to be collected. After the residue dries on the pad, collect, compost, or spread in the field.
- If applicable, allow runoff onto a grassed area to soak into the ground, but never into a surface water body or canal.
- Handle clippings and dust separately. After the residue dries on the pad, it can be collected and composted or spread in the field.
- Minimize the use of detergents. Use only biodegradable, non-phosphate detergents.
- Minimize the amount of water used to clean equipment. This can be done by using spray nozzles that generate high-pressure streams of water at low volumes.
- Do not discharge wash water to surface water or groundwater either directly or indirectly through ditches, storm drains, or canals.
- Do not conduct equipment wash operations on a pesticide mixing and loading pad. (This keeps grass clippings and other debris from becoming contaminated with pesticide).
- Solvents and degreasers should be used over a collection basin or pad that collects all used material.
- Oil/water separators can be used but must be managed properly to avoid problems. Do not wash equipment used to apply pesticides on pads with oil/water separators.
- Collect used solvents and degreasers, place them into containers marked with the contents and the date, and then have them picked up by a service that properly recycles or disposes of them. Never mix used oil or other liquid material with the used solvents.
- Collect used oil, oil filters, and antifreeze in separate marked containers and recycle them. Arrange pick up of used oil, or deliver to a hazardous waste collection site.
- Do not mix used oil with used antifreeze or sludge from used solvents. Antifreeze must be recycled or disposed of as a hazardous waste.
- Store batteries on an impervious surface and preferably under cover.
- Spent lead-acid batteries must be recycled if they are to be exempt from strict hazardous waste regulations.
- Lead-acid storage batteries are classified as hazardous wastes unless they are recycled. Check with your supplier of batteries to see if they will accept for a core-trade or for recycling.

- Equipment used to apply pesticides and fertilizers should be stored in areas protected from rainfall.
- Pesticide application equipment can be stored in the chemical mixing center (CMC), but fertilizer application equipment should be stored separately.
- Blow or wash loose debris off equipment to prevent dirt from getting on the CMC pad, where it could become contaminated with pesticides.
- Ensure that all containers are sealed, secured, and properly labeled. Use only regulatory agency-approved, licensed contractors for disposal.
- Rinse pesticide containers as soon as they are empty. Pressure rinse or triple-rinse containers, and add the rinse water to the sprayer.
- Shake or tap non-rinseable containers, such as bags or boxes, so that all dust and material fall into the application equipment.
- After cleaning pesticide containers by triple rinsing, puncture them to prevent reuse (except glass and refillable mini-bulk containers).
- Keep the rinsed containers in a clean area, out of the weather, for disposal or recycling.
- Store the containers in large plastic bags/tubs to protect the containers from collecting rainwater.
- Recycle rinsed containers in counties where an applicable program is available, or take them to a landfill for disposal. Check with your local landfill before taking containers for disposal, as not all landfills will accept them.

11. LANDSCAPE

Landscape (non-play) areas are an essential part of the overall course design, providing enhanced course aesthetics, wildlife habitat, external sound/noise abatement, and natural cooling and freeze protection.

An environmental landscape design approach addresses environmentally safe and energy-saving practices; therefore, environmentally sound landscape management is also economically important. Non-play areas require a mix of sun and shade, optimal soil conditions and adequate canopy air movement to sustain growth and function.

SPECIES SELECTION AND SIZE CONSIDERATIONS

Principles

- The fundamental principle for the environmentally sound management of landscapes is "right plant, right place." The ideal plant from an environmental standpoint is the one that nature and evolution placed there. It has adapted specifically to the soil, microclimate, rainfall, and light patterns, insects, and other pests, and endemic nutrient levels over thousands of years.
- Know the ultimate sizes and growth rates of trees, shrubs, and ground covers. This reduces the need for pruning and debris removal and lowers maintenance costs.
- The addition of proper soil amendments can improve soil's physical and chemical properties, increase its water-holding capacity, and reduce the leaching of fertilizers. Amendments may be organic or inorganic; however, soil micro-organisms rapidly decompose organic amendments such as peat or compost.
- The goal of species-selection BMPs is to maintain as close to a natural ecosystem as practical, while meeting the needs of a golf course.
- Landscape areas should be fundamentally designed to facilitate rapid plant establishment to conserve water and lower nutritional input requirements once mature. Plants within areas that are not in play or are not critical to the design of the course may be removed and replanted with native plant material that requires little to no maintenance after establishment. Additionally, 50% to 70% of the non-play areas should remain in natural cover. As much natural vegetation as possible should be retained and enhanced through the supplemental planting of native trees, shrubs, and herbaceous vegetation to provide wildlife habitat in non-play areas, and along water sources to support fish and other water-dependent species. By leaving dead trees (snags) where they do not pose a hazard, a well-developed understory (brush and young trees), and native grasses, the amount of work needed to prepare a course is reduced while habitat for wildlife survival is maintained.

Best Management Practices

- Base plant selection as close to a natural ecosystem as is practical, while meeting the needs of the golf course. The ideal plant has adapted specifically to the soil, microclimate, rainfall, light patterns, insects and other pests, and endemic nutrient levels over many years.
- Select trees, plants, and grass species to attract birds seeking wild fruits, herbs, seeds, and insects.
- Know the ultimate sizes and growth rates of trees, shrubs, and ground covers.
- Use plants that are adapted for the site based on the United States Department of Agriculture (USDA) plant-hardiness map.

DESIGN AND FUNCTION

Principles

- Aesthetic gardens, window boxes, and container gardens should include a variety of plants of different heights that provide nectar for hummingbirds and butterflies. Again, "right plant, right place" is the key to success.
- When integrating turf areas into the landscape around the clubhouse, entries, and other areas, design them for ease of maintenance and keep in mind that turfgrasses grow best in sunny areas. Consider the effect that tree canopy and other design features may have on the health and function of the turf.
- Garden plants, shrubbery, ground covers, or native plants may provide a pleasing view and also provide useful food, cover, or other environmental benefits to wildlife; they may also require reduced maintenance.
- Trees and shrubs along streams provide temperature moderation through shade, which lowers water temperature in summer and increases it in winter.

Best Management Practices

- Well-designed forested buffers should contain a mixture of fast- and slow-growing native trees, shrubs, and grasses to provide a diverse habitat for wildlife.
- Use forested buffers to trap and remove upland sources of sediments, nutrients, and chemicals.
- Use forested buffers to protect fish and wildlife by supplying food, cover, and shade.
- Use forested buffers to maintain a healthy riparian ecosystem and stable stream channel.
- Leave dead tree snags whenever possible for nesting and food source to wildlife. However, make sure that these snags are a safe distance away from playing surfaces in case they get blown over.
- Use turf as a landscape element where needed.
- Design and use natural vegetation where possible to prevent erosion, filter and remove nutrients and pesticides from runoff and sub-surface flow water prior to it entering waterbodies.
- Use hardscapes is another tool to prevent runoff and erosion.

PLANTING METHODS

Principles

- The ideal plant from an environmental standpoint is the one that nature and evolution placed there. It has adapted specifically to the soil, microclimate, rainfall, light patterns, insects, and other pests, and endemic nutrient levels over hundreds or thousands of generations. Where these factors have changed, the challenge is finding other suitable plants. A BMPs goal is to maintain as close to a natural ecosystem as practical, while meeting the needs of the golf course.
- The use of organic mulches in gardens and aesthetic areas increases the moisture-holding capacity of plantings and prevents weed growth when applied in sufficient depth. Organic amendments are decomposed by soil microorganisms and add to soil tilth.
- Keep mulch two to three inches away from plants, to prevent fungal growth from excess dampness.
- Excess mulch or compacted mulch may be detrimental, causing water to shed away from the root zone and encourage overwatering. Compaction or excessive mulch build-up should be avoided, especially when annual re-mulching is performed.

Best Management Practices

- The plant palette and irrigation system should be appropriate for site conditions, taking into account that, in some cases, soil improvement can enhance water-use efficiency.
- Related to plants and plantings, ensure the irrigation system is compatible with plants being planted. The timing of irrigation system on-times may have to be adjusted if and when plants are changed.
- Plants should be grouped together based on irrigation demand.
- The percentage of landscaped area in irrigated high-water-use hydrozones should be minimized. Local government ordinances should address the percentage of irrigated landscaped area that may be included in high-water-use hydrozones. These high water-use limits should not apply to landscaped areas requiring large amounts of turf for their primary functions (for example, ball fields and playgrounds).
- In most instances, established, drought-tolerant landscape plants have a root system substantial enough to keep them alive with little or no supplemental irrigation.
- Pruning and fertilizing will also benefit landscape plants while they are becoming established.
- Add proper soil amendments in garden areas to improve the soil's physical and chemical properties, increase its water-holding capacity, and reduce the leaching of fertilizers.
- Use drip irrigation where applicable to maximize efficient water consumption.

12. ENERGY

According to the GCSAA Golf Course Environmental Profile, Vol. IV (GCSAA 2012), six major energy sources were identified for golf course use: electricity, gasoline, diesel, natural gas, propane and heating oil. In addition, operational uses were segmented to meet irrigation, turf maintenance, buildings, clubhouse operations, swimming pools and various amenity needs.

The overall conclusion of the study suggests that golf facility managers must take steps toward identifying options for conservation, efficiency, and cost savings.

To address current needs and future energy reduction opportunities, managers should evaluate current energy conservation performance practices based on the following categories:

- General energy conservation position statements on policy and planning
- Buildings and amenities statements – buildings, infrastructure and facility amenities such as the clubhouse, swimming pool, restaurant, parking lot, kitchen, offices, maintenance building(s), tennis courts, etc.
- Golf course statements – the golf course and surrounding landscapes, pump station, irrigation system and related agronomic operations (playing surfaces, equipment, turfgrass maintenance etc.)

ENERGY CONSERVATION

Principles

- Determine goals and establish an energy policy that is part of the facility's overall environmental plan.
- Establish an energy management plan for the facility based on current energy use baselines to optimize efficiency.
- Communicate policy to all staff regarding use patterns and management practices to effect change.
- Relate the policy to the entire facility, including the services the facility provides to its customers and community.
- Incorporate quality management elements for continual improvement (plan, do, check, and act) to reduce environmental and economic impacts.
- Understand that the irrigation pump is the largest user of energy. A well-engineered pump station is critical to reducing energy consumption.

Best Management Practices

- Conduct an energy audit.
- Conduct a lighting audit.
- Conduct a carbon footprint analysis.
- Add insulation where needed.
- Use non-demand electrical hour rates: charge golf carts, and use pumps to acquire water, charge maintenance equipment, and other items later in the day or early in the morning.
- Limit high-consumption activities during periods when demand is high.
- Use alternative energy from natural sources, such as solar, geothermal and wind energy generation.
- Upgrade or install National Electrical Manufacturers Association's (NEMA) premium efficiency-rated pump motors.
- Seek output reduction by watering less area, through minimizing the amount of maintained turf.
- Prioritize "firm and fast" conditioning over aesthetics.
- Install LED lighting and/or retrofit devices.
- Install motion sensors for lights where appropriate.
- Install a programmable thermostat.
- Install solar/geothermal pumps for pools and spa.

EVALUATION

Principles

- Continually track and measure energy use at the facility based on energy assessment units, for example, kilowatt-hour.
- Tracking the energy use of items such as pumps and other large users can help identify problems.
- Benchmark practices to evaluate existing facility consumption with other local golf facilities of similar size.

Best Management Practices

- Monitor energy use: track data, evaluate billing meters.
- Install adequate meters, gauges, etc.
- Develop an equipment inventory incorporating individual equipment's energy use, use/traffic patterns, etc. (maintenance records, operation hours, etc.).

- Establish a baseline for performance parameters to optimize irrigation pumps.
- Consider benchmarking performance against similar-sized facilities.

EFFICIENCY

Principles

- Evaluate energy efficiency performance.
- Evaluate electric equipment/operations and ensure proper selection, operation, charging, and maintenance.

Best Management Practices

- Evaluate all energy providers (electricity, natural gas and liquid petroleum fuels) for costs, efficiency/assistance programs, and incentives.
- Identify and categorize operations for energy efficiency opportunity and conservation analysis.
- Perform assessments of all the facility's infrastructure and operations.
- Perform appropriate audits throughout the facility depending on operation, infrastructure, and planning stage.
- Identify efficiency and conservation elements of infrastructure/hard items and behavioral/process-oriented items.
- Consider alternative equipment, products, and practices.

DESIGN AND RENOVATION

Principles

- Incorporate an analysis of the assessments, audits, and data.
- Incorporate first cost consideration (initial investment and long-term gain).
- Redesign – evaluate future projects with a priority for energy conservation.
- According to system and compliance standards, communicate with utility provider, insurance company, and any state or local regulatory officials.

Best Management Practices

- Identify buildings, amenities, and operations including existing, new construction, or renovation activities where energy efficiency enhancements are needed.
- Identify the golf course, course infrastructure, and related agronomic operations including existing and future developments or renovations that would benefit from energy efficiency improvements.
- When upgrading or renovating items on the course, look for the energy efficient models.

IMPLEMENTATION PLAN

Principles

- Set goals for buildings/amenities and the golf course operation; develop an implementation plan.
- Set energy-use goals according to efficiency/conservation of the building, infrastructure and equipment efficiency.

Best Management Practices

- Evaluate effectiveness of upgrades according to efficiency/conservation goals for energy use.
- Continue to identify future energy needs and maintain good record keeping.
- Prioritize energy consumption as part of purchase/decision-making process for HVAC, food service, laundry, swimming pools, etc.
- Consider other devices as part of the plan; do research on building, pumps, and power generation.

INFRASTRUCTURE

Principles

- Ensure efficient building/facility/amenities and related infrastructure.
- Consider the materials being used: insulation R-values, color selection, and durability to name a few.
- Ensure efficient lighting in both interior and exterior areas. Consider higher efficiency and low power consuming lighting where applicable.

Best Management Practices

- Maximize use of space.
- Inspect and repair leaks/maintenance.
- Monitor temperature/environmental settings (heat/cooling loss, water usage, water movement around facilities and other similar items specific to your course).
- Evaluate building automation systems and monitoring systems.
- Incorporate technology and up-to-date equipment (lights, controls, switches, other similar equipment).
- Implement schedules/controlled use.

ALTERNATIVE PRODUCTS, OPERATIONS, AND PRACTICES

Principles

- Educate and motivate employees, guests, and other users of the facility.
- Educate, train, and motivate employees on energy efficiency practices pertaining to golf course operations.
- Identify incentives and programs from energy providers.
- Identify state/local programs and certification.
- Consider U.S. Green Building Council's LEED program.
- Consider EPA's EnergyStar, Portfolio Manager, and other similar programs currently available.
- Consider energy management software, services, and other similar products currently available.
- Consider national and local programs and programs like the EPA's WaterSense program as it relates to buildings (see Water Conservation BMPs).

Best Management Practices

- Evaluate alternative transportation.
- Evaluate cleaning practices (dry vs. wet).
- Consider local vs. distant purchases and product selection.
- Evaluate energy acquisition and energy coming into the facility.
- Evaluate golf cart equipment/operations and ensure proper selection, operation, charging, and maintenance.
- Incorporate training for employees.
- Incorporate the use of incentives.

COURSE MANAGEMENT PLAN

Principles

- Set energy-use goals for efficiency/conservation including infrastructure, equipment, behavior and agronomic practices.
- Ensure proper selection (type and size for example), operation, and equipment maintenance.
- Ensure efficient design, selection, operation, and maintenance of irrigation pumps, irrigation controls and other irrigation components.
- Implement energy source selection, management, and efficiency/conservation practices.

Best Management Practices

- Work with energy providers and evaluate existing programs, resources, and various ways to better manage energy usage.
- Consider long-term costs in addition to acquisitions.
- Schedule reviews to evaluate future technology and fuel types.
- Evaluate upgrades to existing systems to determine if there is or could be an energy saving. When evaluating upgrades calculate energy savings over a time period such as per month versus just a single value. An example would be, if a pump can save one kilowatt-hour, what does that calculate out to be over its use in a one-month time period.
- Evaluate use of alternative energy/fuels.
- Identify future energy needs.
- Prioritize energy consumption as part of the selection.
- Optimize equipment use data including hours operated, use patterns, energy consumed and similar items specific to the component being evaluated.
- Incorporate new technology and upgrades when feasible.
- Consider alternative equipment, products, and practices.

IRRIGATION

Principles

- Ensure efficient design, selection, operation, and maintenance of irrigation pumps, irrigation controls, and other irrigation components.
- Assess irrigation pump efficiency; consider alternative equipment, products, and practices; use energy efficiently to maximize the output of the pump station.

Best Management Practices

- Audit irrigation system (see Water Conservation BMPs).
- Schedule and operate pumps and irrigation in an efficient manner.
- Identify and implement infrastructure and behavioral changes.
- Evaluate technology and upgrades; implement when feasible.
- Compare monthly energy bills to diagnose problems with the pump.

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