GOLF COURSE SUPERINTENDENTS ASSOCIATION OF NEW JERSEY

New Jersey Golf Industry Best Management Practices

GCSAA
Golf Course Superintendents Association of America

New Jersey Chapter
GCSAA
Golf Course Superintendents Association of America

BMP Best Management Practices

Best Management Practices Planning Guide & Template

GCSAA USGA

In partnership with the PGA TOUR

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EIFG | *Funded through the Environmental Institute for Golf*

Introduction

Introduction

The Golf Course Superintendents Association of New Jersey (GCSANJ) was established in 1926 and is comprised of dedicated golf maintenance professionals and agronomists who proudly maintain New Jersey's 350 golf courses. GCSANJ serves the golf course superintendent by advancing the profession, offering professional development, and fostering relationships for all members and partners.

New Jersey, proudly known as the Garden State, has earned that name for being home to various natural features, including pristine beaches, sprawling farmlands, picturesque lake and river communities, and rugged mountainous regions. With this diverse geography, it is no surprise that New Jersey would be home to so many beautifully maintained golf courses, several of which are internationally renowned.

New Jersey golf course superintendents are committed to providing our golfers and communities with the best playing conditions while being stewards of the environment. To protect the environment with such vast differences in geography and preserving natural resources for years to come, we created this guide of best management practices (BMPs). The New Jersey Golf Industry Best Management Practices covers all aspects of maintaining golf courses with environmental concerns and sustainability as the basis for its use. Golf courses following these standards would be exercising the most current means of sustainability while becoming leaders as environmental stewards.




Acknowledgement

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 one of the key contributors in elevating the game and business to its current state.

Since 1926, GCSAA has been the top professional association for the men and women 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 & 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.

United States Golf Association

The United States Golf Association (USGA) provides governance for the game of golf, conducts the U.S. Open, U.S. Women's Open and U.S. Senior Open as well as 10 national amateur championships, two state team championships and international matches, and celebrates the history of the game of golf. The USGA establishes

equipment standards, administers the Rules of Golf and Rules of Amateur Status, maintains the USGA Handicap System and Course Rating System, and is one of the world's foremost authorities on research, development and support of sustainable golf course management practices.

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- Jeremy Hreben, CGCS, BMP Committee Chairman, Superintendent, Indian Spring Golf Course
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- Brandon Perrine, Superintendent, Deerwood Country Club
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In addition, the following Rutgers NJAES and Cooperative Extension personnel assisted in the development of this document:

- Dr. Bruce Clarke, Extension Specialist in Turfgrass Pathology
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Planning, Design and Construction

Regulatory Issues

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 to existing wildlife and their habitat. Furthermore, facilities should be designed and constructed to maximize energy efficiency.

Regulatory Issues

Local and state regulations may be in place in your location. Early engagement among developers, designers, local community groups, and permitting agencies 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.

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?
    - Environmental
    - Financial
    - Water
    - Energy
    - Labor
    - Materials
    - Governmental regulatory requirements/restrictions

- Select an appropriate site that is capable of achieving the needs of stakeholders.
- Identify the strengths and weaknesses of the selected site.
- Identify any rare, protected, endangered, or threatened plant or animal species on the site.

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.
- 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 to meet plant-specific needs and provides sufficient drainage.

    - Choose a green size and a sufficient number of hole locations that are large enough to accommodate traffic and play damage, 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 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.
- Decide whether bunkers will contain drainage.
- 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.

Construction

Principles

Construction should be completed with care to minimize environmental impact and financial ramifications caused by poor construction techniques.

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. Minimize soil compaction from heavy equipment.
- 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.
- Temporary construction compounds should be built in a way that minimizes environmental impacts.

Grow-in

Erosion and Sediment Control

Principles

- Soil carried by wind and water erosion transports 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 the 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.
- 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.

Best Management Practices

- Ensure that proper permitting has been obtained before working on any wetlands.
- Ensure that wetlands have been properly delineated before working in and around any wetlands.

Drainage

Principles

- Adequate drainage is necessary for growing 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 acceptable 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 play 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 pretreatment 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.

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; some may be from adjoining lands, including residential or commercial developments.
- It may be appropriate to maintain 12" to 14" of freeboard in the irrigation pond for storm water retention.

- Each water body should have a comprehensive plan to maintain water quality and quantity. Aquatic plant management is an important component of this strategy. The strategy should address the intended uses of the waterbody, the aquatic plants that are reasonably anticipated to be present, and the management techniques that will be used to control them. This should include both desired and nuisance vegetation. Nuisance vegetation can negatively affect a pond's water quality, storage capacity and treatment capacity.

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. 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.
- Utilize vegetated buffers adjacent to water bodies to filter pollutants and slow the flow of runoff into the waterbody.
- 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 or rain gardens 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.
- The use of cisterns and sump pumps may be useful in retaining runoff for future irrigation needs. Runoff can be pumped back to irrigation and retention ponds.

Regulatory Considerations

Principle

Course owners and superintendents should investigate regulatory requirements that apply to the golf facility to protect surface and groundwater quality and quantity.

Best Management Practices

- Golf course design and construction should be in accordance with all state and local regulations. Consulting with local officials early in the planning process will ensure that all regulatory requirements are met. This may include construction

permitting, natural resource inventory and permitting, stormwater management and water allocation.

- Environmentally sensitive areas such as wetlands, floodplains or wildlife habitat are protected under federal, state and local regulations. Consult with the appropriate officials prior to any construction or management activities in those areas.
- Golf course design and management may be affected by Total Maximum Daily Loads (TMDLs), regional stormwater management plans and watershed restoration and protection plans. Consultation with state and local officials will ensure that the golf course supports implementation of those plans.
- Consult with the appropriate officials when planning the irrigation source for the golf course. Water allocation permits may be required for the selected water source.
- Application of chemicals such as pesticides and fertilizers may be regulated under state or local regulations. Ensure that all staff hold the appropriate licenses for the work they are performing and that any necessary permits for application are obtained.
- Aquatic plant management may require additional permits or licensing. This may include use of grass carp, aeration, mechanical controls, biological controls, and chemical controls. Consult with federal, state and local agencies prior to implementing management actions for ponds or wetlands.
- Management of stormwater runoff may require permitting or compliance with state and local regulations. During design, this will include ensuring that the volume of water discharged from the golf course does not adversely affect downstream properties and that water quality criteria are met. Following construction, this will include operation and maintenance of best management practices. Disposal of sediments from stormwater ponds may be subject to regulations. New Jersey has state stormwater management regulations that apply to design and operations to protect water quality and quantity. Local municipalities may have additional requirements.

Maintenance Facilities

Principles

The maintenance facilities must incorporate best management practices 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 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 has 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 protective 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.
- Use a closed-loop recycling system for wash water.

- Recycle system filters and sludge should be treated and disposed of 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 enhance 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.

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.
- 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.

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.”
- 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 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.
- Retain riparian buffers along waterways to protect water quality, provide food, nesting sites, and cover for wildlife.

Nutrient Management

Regulatory Considerations

Proper nutrient management plays a key role in the reduction of environmental risk and increases course profitability. Among other benefits, applied nutrients increase the available pool of nutrients for dense, vigorous growth 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 rootzone 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. A proper nutrient management plan should incorporate the 4R concept: Right fertilizer source at the Right rate, at the Right time, and in the Right place. Stewardship requires the implementation of best management practices (BMPs) that optimize the efficiency of fertilizer use. The goal of fertilizer BMPs is to match nutrient supply with the need to achieve an acceptable playing surface (crop requirements) and apply these nutrients in a manner that maximizes plant uptake and minimizes nutrient losses. Selection of BMPs varies by location, and those chosen for a given golf course are dependent on local soil and climatic conditions, turfgrass species, management conditions, and other site-specific factors.

Regulatory Considerations

As of January 5, 2012, all professional fertilizer applicators are required to undergo training and become certified through the New Jersey Agricultural Experiment Station (NJAES) at Rutgers University or other qualified organization. (Source: New Jersey Act, P.L. 2010, c. 112 (C.58:10A-64), https://www.njleg.state.nj.us/2010/Bills/PL10/112_.PDF)

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 certified/licensed.
    - Persons responsible for decisions regarding the management of fertilizers containing nitrogen and/or phosphorus/phosphate at the facility must be certified/licensed (certified fertilizer applicator).
- Describe differing licenses, if applicable.

    - Persons making applications of fertilizers containing nitrogen and/or phosphate at the facility must be either certified or trained (trained fertilizer applicator).
    - Trained fertilizer applicators can only apply fertilizer containing nitrogen or phosphate while under the supervision of a certified fertilizer applicator.

- Provide the minimum requirement.

    - Certified fertilizer applicator: trained and pass the certification exam
    - Trained fertilizer applicator: trained

- Detail the Continued Education Unit required to maintain the license.

    - Certified fertilizer applicators must attain 8 units of continuing education during a 5-year recertification cycle and pay an annual certification fee.
    - Trained fertilizer applicators must receive training each year and pay an annual certification fee; Certified fertilizer applicators must attest to that training being received.

- Understand the value of training programs.

    - Protect all New Jersey surface and groundwaters from impairment by minimizing nitrogen and phosphorus loading that may be derived from fertilizer

- Contact local and state organizations for regulatory restrictions.

    - The New Jersey Agricultural Experiment Station (NJAES) is responsible for the training and certification of professionals fertilizer applicators through the Professional Fertilizer Applicator Certification and Training (ProFACT) program.

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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.
    - Rutgers Soil Testing Laboratory can provide further details and is located at 57 US Highway 1, New Brunswick, NJ 08901-8554. Phone: 848-932-9295, Email: soiltest@njaes.rutgers.edu
- Through proper sampling, laboratory analysis, interpretation of results, recommendations, and record-keeping, soil testing can be used to manage nutrients more efficiently. Resources for detailed information on the interpretation of soil tests and resulting recommendations include:

    - Turfgrass soil fertility and chemical problems: assessment and management authored by R.N. Carrow, D.V. Waddington, and P.E. Rieke (2001, Sleeping Bear Press. Chelsea, MI).
    - Rutgers New Jersey Agricultural Experiment Station. Mehlich-3 Values for Relative Level Categories. Available: https://njaes.rutgers.edu/soil-testing-lab/relative-levels-of-nutrients.php

- Interpretations of results are affected by various philosophies of laboratories or individuals and typically involves two approaches:

    - Percentage saturation of basic cations as a guide to whether nutrients are balanced
    - Sufficiency level, which evaluates the amount of available nutrients

- Recommendations are typically based on two approaches:

    - Sufficiency to meet the immediate needs of the plant
    - Buildup soil levels to an optimum and maintenance to meet plant requirements

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 component and blended together to provide a representative, uniform soil sample for that component.
- Each soil sample should be taken from the same depth.
- Poor-quality turfgrass areas that are of concern should be sampled separately from higher-quality turfgrass areas.
- The purpose of a soil test is to identify deficiencies and provide the grower with a prediction of a plant's response to an applied nutrient.
- Use an extractant appropriate for your soils. Many soil testing labs use Mehlich-3 as the primary soil test extractant in this region including Rutgers NJAES.
- Different chemical extractants used by soil testing labs have different correlations to nutrient availability and calibrations for fertilizer response. In order to compare soil test results over time, the same extractant must be used for each test.
- 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.
- Building up nutrient levels is more feasible in fine-textured soils that have greater cation exchange capacity (CEC). Nutrient levels in sand and soils with a low CEC (~4 cmol kg^{-1} or lower), having less nutrient-holding capacity, cannot be built up to levels possible in fine-textured soils.
- Annual soil testing is recommended when soil fertility status is very low or large changes are desired. Soil testing every two to three years will be adequate when soil fertility status is sufficient/high.
- At a minimum, soil testing should be used to identify whether any soil nutrient is at a very low level, which indicates action is required.
- Nitrogen availability is not a routine soil analysis due to its dynamic nature and should be applied according to turf growth needs as recommended on soil test reports and accessed in real-time by experienced turf managers.

Plant Tissue Analysis

Principles

- 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.
- Through proper sampling, consistent intervals, and record-keeping, tissue sampling may be used to measure existing turf health.

- Keep in mind that factors other than soil test levels may affect the nutrient status of the plant tissue; examples include limited root growth, soil pH, soil aeration, or soil water content.

Best Management Practices

- Tissue samples may be collected during regular mowing.
- Do not collect tissue after any event that may alter the nutrient analysis. 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 for comparison.
- 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 frequency 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.
- 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), Available Phosphate (P_2O_5) and Soluble Potash (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 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 the product is applied accordingly, 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 specifying source of nutrients
    - Net weight
    - Directions for Use

Macronutrients

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

Understanding the role of each macronutrient within the plant should provide you with a greater awareness 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 leads to an increase in course profitability and a reduction in environmental risk.
    - Nitrogen exists in many forms in soil and environment and undergoes many processes in changing from one form to another. Its dynamic nature can make it especially challenging to manage.
    - Soluble forms of N are the most common cause of eutrophication in saltwater systems, and nitrate-N is a human-health hazard in drinking water.
- *Nitrogen processes*

    - *Mineralization:* the microbial-mediated conversion of organic N into plant-available NH_4 (ammonium)
    - *Nitrification:* the microbial-mediated conversion of NH_4 to plant-available NO_3 (nitrate)

    - *Denitrification:* the microbial-mediated conversion of NO_3 to N gases, which is a loss of plant-available N; this primarily occurs in wet (low-oxygen) environments and is enhanced by high soil pH and temperature.
    - *Volatilization:* the conversion of NH_4 to NH_3 (ammonia) gas, another potential loss of plant-available N
    - *Leaching:* the downward movement of an element below the rootzone (loss)
    - *Runoff:* the surface lateral movement of an element beyond the intended turfgrass location (loss) and potentially into water bodies (pollution)

- 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. Application of N sources without regard to their release characteristics 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 1 pound of N from ammonium sulfate may cause burning, while applying 1 pound of N from certain polymer-coated urea products may not provide the desired turfgrass response. Rate, application date, location, turfgrass species and age of turf 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 plant-available 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 loss of plant-available N.
- Nitrification inhibitors reduce the activity of *Nitrosomonas* bacteria, which are responsible for the conversion of NH_4 to NO_2 (nitrite). This reduces loss of plant-available N via denitrification.

The role of phosphorus (P)

Phosphate (biologically active form of phosphorus) can be a growth-limiting factor for many unintended organisms and is a major contributor to eutrophication of freshwater bodies. Thus, proper timing and rates of fertilizer application should be implemented to reduce the risk of off-site movement of phosphates.

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

- *Phosphate 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
- *Phosphate sufficiency ranges*

  - Soil test P levels <13 ppm (<26 lb/A) using the Mehlich-3 extractant are considered very low and a spoon feeding approach, where P is applied two to six times per year at low rate of 0.25 to 0.5 lb P_2O_5 per 1,000 sq. ft., will be important. The higher of these rates for several years may be needed to build up soil test levels.
  - Tissue testing can be used to help diagnose a true deficiency, but the sufficiency range may vary with species, cultivar, and growing conditions.
  - Consult your land-grant university for additional information.

- *Phosphate fertilizer sources*
  - Diammonium phosphate (18-46-0)
  - Concentrated superphosphate (0-44-0)
  - Monoammonium phosphate (11-52-0)
  - 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. Too much potassium in soil has an antagonistic effect on uptake of certain other nutrients. Furthermore, two common K sources have risk of osmotic ‘burning’ of plant tissue (high salt index). Thus, over-application of potassium is

discouraged for agronomic as well as economic considerations. Generally, potassium concentrations in turfgrass tissue are about ⅓ to ½ that of nitrogen.

Potassium is not a component of any organic compound but is a constituent of plant cell cytosol and moves readily within the plant. Potassium is 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*
    - Soil test K levels less than the range of 20-40 ppm (40-80 lb/A) using the Mehlich-3 extractant are considered very low. Research indicates that annual bluegrass is more susceptible to anthracnose when K levels in the sand-topdressed, mat layer of putting greens are <50 ppm (<100 lb/A),
    - Potassium cannot be built up in low CEC soil (sands) that are subject to leaching from high rainfall and, therefore, must be maintained by a spoon-feeding approach. Annual fertilization rates for N and K_2O that produce a N:K_2O ratio of ~1:1 are common.
    - Percent K saturation on the soil CEC is useful in monitoring whether the percent K is changing over time in response to fertilization or irrigation. A target of 2 to 7% K saturation is a reasonable range to maintain.
    - There is limited data establishing K sufficiency ranges for turfgrass tissue; however, a general recommendation of 1.0 to 2.5% K in turfgrass leaf tissue is often used. Research indicates that annual bluegrass is much more susceptible to anthracnose at leaf K concentrations below 2.0%. Other reports indicate that leaf K concentrations below 2.1, 2.2, and 1.5% were deficient for ryegrasses (annual and perennial), tall fescue, and Kentucky bluegrass, respectively.
    - Consult your land-grant university for additional information

- *K fertilizer sources*
    - Potassium sulfate (0-0-50,low salt index)
    - Potassium chloride, or Potash (0-0-60, high salt index)
    - Potassium nitrate (13-0-45, medium salt index)

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

- Calcium deficiency is rare in grasses.
- Application of limestone to increase pH in acidic soil, typical of NJ, generally provides sufficient Ca for nutritional needs.
- Soil test Ca levels less than the range of 375-503 ppm (750-1007 lb/A) using the Mehlich-3 extractant are considered low.
- Ca saturation of 65 to 80% of the soil CEC is sometimes presented as the “ideal”. General guides to cation balance in the soil are ≤8.5:1 for Ca:Mg; ≤15:1 for Ca:K.
- Tissue Ca concentration <0.5% is considered deficient.
- Found in gypsum, limestone, and calcium chloride

The role of magnesium (Mg)

- Central ion in the chlorophyll molecule and chlorophyll synthesis
- Application of dolomitic limestone to increase pH in acidic soil acts a slow-release source of Mg.
- Soil test Mg levels less than 23 ppm (46 lb/A) using the Mehlich-3 extractant are considered very low (Rutgers NJAES)..
- Carrow et al. (2001) recommends Mehlich-3 extractable Mg of 70-140 ppm (140-280 lb/A) for sandy (low CEC) soils and >140 ppm (>280 lb/A) for finer-textured soils.
- Mg saturation of 10 to 20% on the soil CEC is normal. Typical guidelines for Mg ratios based on percent cation saturation are ≤8.5:1 for Ca:Mg; ≤5:1 for Mg:K.
- Tissue Mg concentration <0.15% is considered deficient.
- Found in S-Po-Mg (langbeinite, 11% 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
- Tissue content of S in turfgrasses ranges from 0.15 to 0.50% (dry weight) with <0.20% often considered deficient
- Grasses have a lower S requirement than many other plants
- Turfgrass often receives S additions as a component of: N-fertilizers like SCU, ammonium sulfate; from K-fertilization as K_2SO_4, potassium-magnesium sulfate (Sul-Po-Mag [langbeinite], 22% S); from P-fertilization in superphosphate 0-20-0 (12% S); in $CaSO_4$ (gypsum) to amend calcium-deficient or sodic soil; from Mg fertilizer like $MgSO_4$; with micronutrients applied as sulfate forms; and in use of elemental S to reduce soil pH and/or in irrigation water that has been acidified.
- The most reliable method to confirm S deficiency is a combination of tissue testing and trial application of a SO_4-containing fertilizer
    - Since S deficiency results in chlorosis, a foliar application of 0.05 lb S per 1,000 ft^2 as K_2SO_4 or $CaSO_4$ in 3 to 5 gallons of water should provide a greening response if S is deficient.
- Consult your land-grant university for additional information

- 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 appreciation 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), Chlorine (Cl), and Nickel (Ni). Deficiencies of most are very rarely observed (Zn, Cu, Mo, B) or never reported (Cl, Ni) under field situations. Iron (Fe) deficiencies are relatively common; manganese (Mn) deficiencies are less often observed but not unusual.

- Micronutrient categories are less well defined than macronutrient categories.

Micronutrient	Units	Critical Level†	High‡
Iron	ppm soil	50	100
Zinc	ppm soil	1.0	50
Copper	ppm soil	0.5	20
Boron	ppm soil	0.5	20
Manganese	pH dependent: calculate an activity index MnAI = 101.7 + 3.75Mn - 15.2pH	25	100

Values below the "critical level" should be considered deficient

‡ Values above "high" should be considered a warning. Certain micronutrients can be toxic to plants at excessive levels.

In addition to its effect on manganese availability, soil pH also affects the availability of other micronutrients. Aeration can also be a factor.

- Iron (Fe) deficiency symptoms first occur on younger leaves, due to its immobility in the plant, as interveinal yellowing. In contrast, N deficiency appears initially on older leaves. Leaves turn pale yellow to white under prolonged deficiency and exhibit thin spindly growth with older leaves becoming chlorotic. Tissue concentrations of Fe are usually within 100 to 500 ppm. Critical deficiencies vary with bentgrass <100 ppm and bermudagrass <50 ppm. Calcareous soils generally have a pH between 7.3 to 8.5 and are prone to causing Fe deficiency because of its low solubility in alkaline soil.
- Manganese (Mn) deficiencies can be observed on turfgrasses grown on acid sandy soils and calcareous sands. Frequent use of foliar Fe contributes to Mn

deficiencies by suppressing Mn uptake. Deficiencies of Mn are most often associated with high pH soils or recently limed soils. Acidifying N-carriers may increase Mn availability on alkaline soils by enhancing Mn solubility.

Consult your land-grant university for additional information on micronutrients.

The role of iron (Fe)

- Is part of the catalytic enzymes and is required for chlorophyll synthesis
- Affects photosynthesis, nitrogen fixation, and respiration

The role of manganese (Mn)

- Involved in photosynthesis
- Required as a cofactor for ~35 enzymes
- Lignin biosynthesis depends on Mn. Reduced lignin content in roots (thinner root cell walls) may contribute to susceptibility to take-all patch and other root diseases.

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
- Required for protein synthesis
- Carbohydrate metabolism affected by Zn

The role of molybdenum (Mo)

- Primarily related to nitrogen metabolism
- Structural and catalytic 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

The role of nickel (Ni)

- Relatively recent classification as an essential nutrient for higher plants
- Nickel is a metal component of urease (enzyme) necessary for proper structure and activity of urease, which catalyzes the transformation of urea, $CO(NH_2)_2$, to NH_3

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 most effective use of applied nutrients.

Best Management Practices

- The objective of all nutrient applications is plant uptake and the corresponding desirable response, healthy and vigorous plants.
- Apply nutrients when turfgrass is actively growing and therefore able to take up and utilize the nutrients.
- Apply slow-release N fertilizers at the appropriate time of year to maximize the products' 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. See Rutgers Cooperative Extension bulletin E327, Best Management Practices

for Nutrient Management of Turf in New Jersey at https://njaes.rutgers.edu/pubs/publication.php?pid=E327

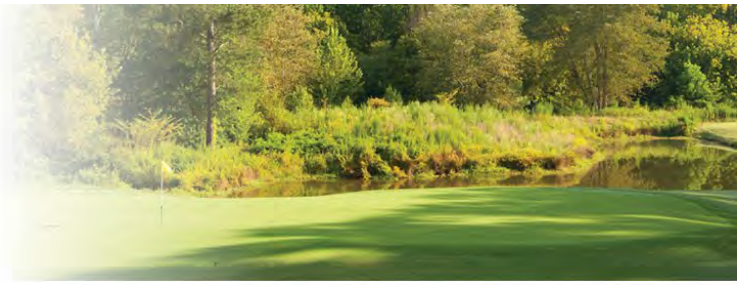
- N application rates from slow-release materials should take into consideration the release rate of the chosen material. If insufficient material is applied, the desired response may not be observed.
- Consult your local land-grant university for efficient N:K in your location. Annual fertilization rates for N and K_2O that produce a N:K_2O ratio of ~1:1 are common.
- The reduced height of cut and excessive traffic damage on putting greens result in an increased need for growth leading to an increase in nutritional requirements.
- 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, especially N and P, during turfgrass establishment as these applications are particularly susceptible to loss via leaching and runoff or erosion and can contribute to eutrophication of water bodies.
- In the seedling stage, provide appropriate rates and products to minimize N loss without reducing turfgrass establishment.
    - Increased water applications
    - Increased nutrients to hasten establishment
    - Low root density and mass compared to mature turfgrass
- 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 of spreaders and sprayer settings 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 watch or warning, or if heavy rains are likely.

Water Quality Monitoring and Management

Regulatory Considerations



Regulatory Considerations

Principle

Golf course owners and superintendents should investigate regulatory requirements that may exist in their location to protect surface and groundwater quality.

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 are needed for irrigation systems, including studies of waterbodies or flows on, near, and under the property are needed to properly design a course's stormwater system and water features to protect water resources.

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.
- Where appropriate, use mechanical means to control nuisance vegetation. For example, remove algae by hand to prevent negative effects on aquatic wildlife or desirable vegetation.
- Document maintenance of waterbodies and chemical treatment of waterbodies
- 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. Reclaimed (reuse) irrigation should be analyzed quarterly throughout the growing season.
- Apply copper products per label instructions to reduce the risk of negative biological impacts and impairing water quality.
- Identify the position of property in relation to its watershed.
- Identify overall goals and quality concerns of the local watershed.
- 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 the 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, 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 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. Some things can be monitored with handheld sensors but all can be analyzed by a certified laboratory.
- Establish thresholds for important water quality parameters such as dissolved oxygen to maintain a healthy ecosystem and reduce stress or death to aquatic wildlife such as fish.
- Ongoing, routine water sampling provides meaningful trends over time. A single sample is rarely meaningful in isolation. Select one time per year, at a minimum, and consistently use that season year after year for sampling.
- 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.
- 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.

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. Consult with a professional to properly identify the algae type.
- Use IPM principles to limit the excessive 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 that reduce debris from entering bodies of water.
- Mow lake and pond collars at 2 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. Collecting a sample of dredged material from a pond can be helpful to determine toxicity and use parameters.
- 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 baseline of water quality data.
- 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.
- QA/QC procedures should be followed. Golf course management must have good data to make good decisions. If a golf course should ever want 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 above, 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 these areas include filter and trap sediment, site-specific natural/organic fertilization, and limits on pesticide use, primarily focusing on the control of 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 buffers are zones adjacent to waterbodies that help to filter pollutants from runoff and protect the waterbody.
- Establish low-maintenance zones adjacent to waterbodies where chemicals are not applied and vegetation is not frequently mowed. This will improve the filtering

ability of these zones. The nutrients in runoff encourage aquatic plant growth and algae blooms.

- Riparian buffer areas are above the high-water mark and should be unfertilized and left in a natural state.
- Collect and dispose of grass clippings where runoff and wind will not carry them back to the water body.
- Establish chemical-free zones adjacent to waterbodies. The nutrients runoff encourages aquatic plant growth and algae blooms.
- 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.
- Use turf and native plantings to enhance buffer areas. Increase the height of cut in the riparian zone to filter and buffer nutrient movement to the water.
- Practice good fertilizer management to reduce the nutrient runoff into ponds that causes algae blooms and ultimately reduces DO levels.
- 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.
- 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.
- 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.
- Reverse-grade around the perimeter to control surface water runoff into ponds and reduce nutrient loads.
- 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 noninvasive vegetation to provide food and shelter for wildlife.
- 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.
- Dredge or remove sediment to protect beneficial organisms that contribute to the lake's food web and overall lake health.

Wetland Protection

Principles

- Several states protect wetlands as waters of the state by rule of law. Wetlands 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 is 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 and trap sediments.
- Maintain appropriate silt fencing and BMP on projects upstream to prevent erosion and sedimentation.
- Natural waters cannot be considered treatment systems and must be protected. (Natural waters do not include treatment wetlands.)
- Establish a low- to no-maintenance level within a 75-foot buffer along non-tidal and tidal wetlands.
- Establish and maintain a sustainable, protective riparian buffer.

Stormwater Management

Principle

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, 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.

Best Management Practices

- Use bioretention systems (i.e. rain gardens, bioswales, etc.) 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.
- Design stormwater control structures to hold stormwater for appropriate residence 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.

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.
- Maintain a vegetative cover on construction sites until it is actually ready for construction.
- Regularly sweep impervious surfaces during construction to remove sediment and debris.

Sodic/Saline Conditions

Principles

- All-natural waters contain soluble salts; however, the amount and type of salts they contain vary greatly.
- Irrigation water can degrade when wells are pumped at high rates or for prolonged periods. Sometimes “up-coning” can occur from pumping, whereby saline water, rather than freshwater, is drawn into the well.
- Saline water typically is unsuitable for irrigation because of its high content of total dissolved salts.
- Saltwater intrusion from groundwater pumping near coastal areas can create a problem with some irrigation wells.

Best Management Practices

- Use surface water to mix (blend) 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 plan on routine soil tests to determine sodium adsorption ration (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. In New Jersey, where rain averages 40” per year, flushing soils is typically not a concern. However, using Saturated Paste method testing and irrigation water testing can help determine if flushing is necessary to reduce sodium accumulations in the soil.
- Design irrigation systems to account for the flushing of salt accumulation from the soil.
- Amend soil and water to remove salt ions from affected areas.

Cultural Practices

Mowing

Cultural 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 3 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 the removal of leaf tissue.
- Infrequent mowing results in alternating cycles of vegetative growth followed by scalping (removing more than ⅓ of leaf tissue), 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 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 the 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 use will allow 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 1 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. Vary mowing patterns to distribute wear and compaction over as large an area as practical.
- 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.

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 conditions of the turf and soil profile and weather.
- Core aerification is effective at managing thatch, soil compaction, and aiding in the improvement of water infiltration and soil drainage.
- Accumulation of excessive thatch and organic matter will reduce root growth, encourage disease, and create undesirable playing conditions.
- Light and frequent applications of sand will smooth the playing surface, modify thatch, and potentially change the physical characteristics of the underlying soil when done in conjunction with core aerification.

Best Management Practices

- Core aerification involves the 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 are often 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 the quick recovery of plant density.
- Vary depth of aerification events by incorporating tines of varying lengths 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 the surface and is either removed or distributed into the canopy. Holes can be backfilled with new root-zone materials if a drill-and-fill machine is used. These machines allow the replacement of heavier soils with sand or other materials in an effort to improve water infiltration into the soil profile.

Drill and Fill at Deerwood Country Club

- 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 practices 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 groomer to a depth that just nicks the surface of the turf typically only cutting leaf blades. Deeper penetration of verticutting knives will stimulate new growth by cutting through stolons and rhizomes while removing accumulated thatch.
- Scarifying depth for thatch removal should reach the bottom of the thatch layer and extend into the surface of the soil or mat layer beneath the thatch.

- Dethatching with a scarifier is an aggressive practice that typically is not recommended on golf putting greens because of the damage that occurs and the extensive recovery time required.
- Initiate vertical mowing practices before the thatch level reaches 0.25 to 0.5 inch in depth. Shallow verticutting can 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 the management of grain and improving plant density.
- Topdress the playing surface with sand following core aerification and deep vertical mowing practices to aid in the recovery of turf. Rates will vary from 0.10 to 0.25 inch in depth and will depend on the aggressiveness of cultivation as well as 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 the height of the cut.
- To minimize the potential for compaction caused by rolling, use light weight rollers.

Greens Rolling- The Ridgewood Country Club

Shade and Tree Management

Principles

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

- The roots of large trees growing near playing surfaces will extend well beyond the drip line and compete with the turf for nutrients and water, leading to the decline of those playing surfaces.
- As trees age and grow larger, the impact on playing surfaces, play, and strategy of the course intensifies.

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 promote good 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.

Integrated Pest Management

Regulatory Considerations

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 include reducing pest management expenses, conserving energy, and reducing the risk of pesticide exposure to people, animals, and the environment. However, its main goal 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, understanding pest life cycles and/or conditions that favor pests, and know about all possible methods of controlling pests.

Regulatory Considerations

Principles

- Some federal or state 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.

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
- The person directing or authorizing the application
- Weather conditions at the time of application
- Target pest
- The pesticide used (trade name, the active ingredient, amount of formulation, amount of water)
- Adjuvant/surfactant and amount applied if used
- Area treated (acres or square feet) and location
- The 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

Principles

- The fundamental basis of an environmentally sound pest control program is a process called IPM.
- IPM focuses on the basics of identifying the pests, choosing pest-resistant varieties of grasses and other plants, enhancing the habitat for natural enemies of pests, 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 be used in a manner to minimize negative effects on beneficial organisms and the environment and to minimize the development of pesticide resistance.

Best Management Practices

- Chemical pesticide applications should be carefully chosen for effective and site-specific pest control with minimal environmental impact.
- Identify key pests on key plants.
- Determine the pest's life cycle and know which life stage to target (for example, for an insect pest, whether to target egg, larva/nymph, pupa, and/or adult).
- 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 to 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.

Written Plan

Principles

- IPM is an overall pest management strategy that includes pest monitoring, action thresholds, and biological controls, cultural methods, other applicable practices.
- 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-target organisms.
- When a pesticide application is deemed necessary, its selection should be based on effectiveness, minimal toxicity to non-target species, cost, and site characteristics, as well as its solubility and persistence.

Best Management Practices

- Decide which pest management practice(s) are appropriate and carry out corrective actions. Direct control where the pest lives or feeds. Use properly timed preventive chemical applications only when your professional judgment indicates they 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 golfers and maintenance personnel's education could raise their tolerance of minor, aesthetic 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 effectively control the target pest while minimizing 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 documents the presence and development of pests or the conditions that are conducive for pest outbreaks throughout the year.
- It is essential to record the results of scouting in order to develop historical information, document patterns of pest activity, and document 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 understand the pest's life cycle and know which life stage to target (for example, 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 mycelium, reproductive structures (such as acervuli, perithecia, mushrooms), animal damage, insect frass, or webbing.
- Identify the symptoms of the pest. Look for symptoms such as chlorosis, necrosis, leaf spots, 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 document 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, certain record-keeping requirements apply.

Best Management Practices

- Document, identify, and record key pest activities on key plants and locations.
- Understand 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 the use of turfgrass in heavy shade.
- Select shade-adapted grasses for areas receiving partial sun or shaded areas.
- 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 predators, parasites and pathogens, and other beneficial organisms (pollinators).
- Natural enemies (including ladybird beetles, green lacewings, parasitic wasps) may be purchased and released near pest infestations.
- Areas on the golf course can also be modified to better support pests' natural enemies and beneficial organisms.
- Biological control products that suppress turfgrass diseases must be applied on a preventive basis, have a short shelf life (3 to 6 months), need to be reapplied to maintain efficacious populations of the biocontrol agent, and typically do not provide adequate disease control when disease pressure is high.

Best Management Practices

- Identify areas on the golf course that can be modified to attract natural enemies, provide habitat for them, and protect them from pesticide applications.
- Install flowering plants that can provide parasitoids with nectar or honeydew from sucking insects (aphids, mealybugs, or soft scales).
- Minimize pesticide applications to roughs, driving ranges, or other low-use areas to provide a refuge for beneficial organisms.
- Release insect-parasitic nematodes to naturally suppress insect pests such as white grubs, billbugs, annual bluegrass weevil, and cut-, sod web-, and armyworms.

Pollinators

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 labeling requirement found on pesticide labels.
- When applying pesticides, be mindful of pollinators, focusing on minimizing exposure to 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 pollinators' safety.

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 insecticides when pollinators are active.
- If possible, spray in the evening after bees have returned to hives, which allows for spray residues to dry overnight.
- Before applying a pesticide, scout/inspect the area for both harmful and beneficial insect populations. Apply only when the indicated threshold of damage has been reached.
- Mow flowering plants before insecticide application.
- If flowering weeds are prevalent, mow them to remove blooms or 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 what 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

- Most turfgrass diseases on golf courses in the State are caused by fungal pathogens.
- The most common foliar diseases on golf courses in New Jersey include; anthracnose (*Colletotrichum cereale*), dollar spot (*Clarireedia jacksonii*), brown patch (*Rhizoctonia solani*), brown ring patch (*Waitea circinata*), etiolated tiller syndrome (*Acidovorax avenae and Xanthomonas translucens*), fairy ring (a complex of basidiomycete fungi), gray leaf spot (*Pyricularia grisea*), gray snow mold (*Typhula incarnata*), leaf spots (*Bipolaris* and *Drechslera* spp.), pink snow

mold (*Monographella nivalis*), Pythium blight (*Pythium* spp.), red thread (*Laetisaria fuciformis*), rust (*Puccinia* spp.), yellow patch (*Ceratobasidium cereale*), and yellow turf (*Sclerophthora macrospora*).

- Pythium root dysfunction (principally *Pythium volutum*), Necrotic ring patch (*Ophiosphaerella korrae*), summer patch (*Magnaporthiopsis poae* and *M. meyeri-festucae*), and take-all patch (*Gaeumannomyces graminis*) are the major root diseases on golf courses in the state.
- In the presence of a susceptible host and a conducive environment, plant pathogens can disrupt play by infecting and damaging intensely managed turf.
- No measure can completely eliminate the threat of turfgrass disease on a golf course. However, turfgrass managers can reduce the likelihood of disease by following best management practices.
- Cultural factors that can influence turfgrass stress and the likelihood of disease include fertilizer programs, mowing and rolling practices, irrigation management, topdressing and cultivation practices.
- Healthy, well-managed turfgrass is less likely to develop disease problems.
- Moreover, 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

- Select turfgrass cultivars with good tolerance to major diseases on the golf course to reduce the severity of disease outbreaks and lower fungicide inputs (http://ntep.org/ and https://turf.rutgers.edu/research/reports/).
- Optimize cultural practices to reduce disease pressure:
    - Fertilize to maintain vigor without overfertilizing turf.
    - Maintain adequate nitrogen (N) fertility to reduce the severity of low N diseases (anthracnose, dollar spot, red thread, brown ring patch, and rust), and avoid excessive applications (> 0.5 lb/1,000 sq ft) of water-soluble N to limit outbreaks of high N diseases (brown patch, Pythium blight, pink snow mold, and leaf spot).
    - Annually test the turfgrass root zone to ensure that soil pH does not become too acidic.
    - Apply acidifying fertilizers to lower soil pH and reduce the severity of summer patch, take-all, and pink snow mold using a target pH of 6.0, when possible.
    - Apply potassium and manganese to reduce the severity of anthracnose and certain root diseases (summer patch and take-all), respectively, when soil or tissue concentrations are sub-optimal.
    - Use sufficient rates of topdressing to reduce the severity of stress-related diseases such as anthracnose and dollar spot.
    - Avoid extremes in soil water since wilt-stress and excessively wet conditions can predispose turf to stress-related diseases such as anthracnose and dollar spot.

    - Mow at or above 0.125 inches (3.2 mm) on putting greens to reduce the severity of stress-related diseases such as anthracnose.
    - Use rolling or increased mowing frequency to maintain ball roll distance (green speed) at higher mowing heights.
    - Utilize cultivation practices to reduce compaction, layering, and improve plant vigor while avoiding excessive turf injury.
- Identify the causal agent (turf pathogen) when disease develops. This often involves sending samples to a diagnostic laboratory.
- Record and map turf areas that have a history of disease, identify trends that can help guide treatments, and focus on modifying conditions in disease-prone areas to reduce the incidence and severity of future outbreaks.
- Determine when major diseases typically occur on the course and make sure appropriate cultural and chemical control measures are in place before disease outbreaks develop.
- Correct conditions that produce stressful environments and encourage disease (for example, improve airflow and drainage, decrease shade, and reduce the leaf wetness period).
- Integrate fungicides into an overall management strategy for the golf course.
- Employ sound resistance management strategies to reduce the risk of fungicide resistance:

    - Limit the total number of applications during the growing season (typically 3 to 4 per year) for fungicides with a high potential for resistance (for example, benzimidazole, phenylamide, demethylation inhibitor, QoI/strobilurin, and succinate dehydrogenase inhibiting fungicides).
    - Avoid sequential applications of fungicides with a high risk of resistance.
    - Alternate fungicides with different modes of action (for example, use fungicides with different FRAC numbers).
    - It is important while tank mixing fungicides, or using premixed products, with different modes of action to assure that all active ingredients are effective against the target pathogen.
    - Use preventative fungicide applications for high-risk diseases.
    - Avoid late-curative and reduced rate fungicide applications which can allow pathogen populations to increase.
    - Reduce the interval between fungicide applications and/or increase rates during periods of high disease pressure.

- Select and apply the most efficacious fungicides at the optimum rate, timing, and water carrier volume (1 - 2 gal. water/1,000 sq ft for foliar diseases, and 2 - 5 gal. water/1,000 sq ft for root diseases). See PPA-1 fungicide recommendation booklet entitled, *Chemical Control of Turfgrass Diseases* for fungicide ratings (http://www2.ca.uky.edu/agcomm/pubs/PPA/PPA1/PPA1.pdf)
- Schedule (time) fungicide applications properly to maximize efficacy:

    - Apply fungicides preventively when conditions are conducive to infection to avoid severe outbreaks.

    - Use disease predictive models for diseases such as dollar spot, Pythium blight, brown patch, summer patch, take-all patch, and fairy ring to time fungicide applications when conditions are most conducive to infection and before symptoms appear.
    - Routinely scout areas on the course with a previous history of disease (hot spots) to identify initial outbreaks and breakthroughs in the fungicide program.
    - When best management practices are being followed, early-curative /threshold sprays can effectively control "foliar" diseases such as dollar spot and anthracnose particularly on more tolerant cultivars.

- However, for "ectotrophic root-infecting diseases" such as summer patch, necrotic ring patch, take-all patch and fairy ring disease, fungicides must be applied on a preventive basis when conditions are conducive to infection (typically when soil temperatures exceed a specific temperature).
- Select fungicides that do not adversely affect animals, fish, birds, or pollinators, by utilizing methods such as the "The Environmental Impact Quotient" (https://nysipm.cornell.edu/eiq/) to assess potential environmental and health impacts and make informed decisions regarding pesticide selection.

Weeds

Principles

- Weeds compete with desired plants for space, water, light, and nutrients and can harbor insect pests and diseases. Weeds also reduce the quality and functionality of the playing surface. Weeds are hosts for other pests such as plant pathogens, nematodes, and insects, and certain weeds can cause allergic reactions in humans. Whether a plant is considered a weed or a desirable plant is at the golf course superintendent's discretion.
- Many weeds can be found on a golf course. The most problematic weeds of fine turf in New Jersey include annual bluegrass (Poa annua), crabgrass (Digitaria spp.), sedges (Cyperus spp.), and kyllingas (Kyllinga spp.), goosegrass (Eleusine indica), and paspalum species (Paspalum spp.). Other common weeds include dandelion (Taraxacum officinale), clovers (Trifolium spp.), violets (Viola spp.).
- Weeds found in low maintenance "naturalized" areas are different than those found in fine turf areas due to infrequent (typically once or twice annually) mowing. Quackgrass (Elymus repens), deertounge grass (Dichanthelium clandestinum), Japanese stiltgrass (Microstegium vimenium) sedges, and thistles are some of the weeds common to naturalized areas in New Jersey.
- Weed management is an integrated process by which several strategies are employed. Encourage desirable turfgrass ground cover to help prevent infestations. If a weed infestation occurs, various strategies can be used to selectively remove the weed from the turfgrass. The most common methods of weed removal include physical removal (e.g., hand weeding) or chemical removal (e.g., herbicide application). When herbicides are used, it is important

that they be intelligently selected and judiciously used. Strategies for successful weed management often include:
    - preventing weed seed or other reproductive structures (e.g., stolons, rhizomes) from being introduced to a weed-free area.
    - using proper turfgrass management and cultural practices to promote vigorous, competitive turf
    - properly identifying the target weeds, and then selecting and using the appropriate control strategy.
- Weeds reproduce from seed, root pieces, and special vegetative reproductive organs such as tubers, corms, rhizomes, stolons, or bulbs. People, maintenance equipment, 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. Many winter annuals such as annual bluegrass can survive the summer in New Jersey and behave as perennials.

Best Management Practices

- Properly identify problematic weeds and understand their life cycles. “Weeds of the Northeast” authored in 1997 by Uva et al. and the “Turfgrass Weed Control for Professionals” guide authored by Patton et al. and updated annually are excellent guides to aid in turfgrass weed identification. The Uva et al. guide can be purchased through various booksellers. The Patton et al. guide is available online through the Purdue University bookstore.
- Understand the abiotic factors (e.g., soil properties, environmental conditions, mowing practices) that may contribute to weed infestations.
- Understand biotic factors (e.g., improper turfgrass species and/or cultivar, disease incidence, insect damage) that may contribute to weed infestations.
- Understand the source of the weed infestation. For example, weed infestations of crabgrass on putting greens are often the result of seed movement into the putting green from surrounds, as crabgrass will not usually produce seed when mowed at putting green height. Control the weed in these source areas.
- Implement cultural practices that protect turfgrass from environmental stresses such as disease, shade, drought, and extreme temperatures.
- Address turf management practices, such as fertilizer sources, rates, and application timing, mowing height or mowing frequency, soil aeration, and physical damage and compaction from excessive traffic that may contribute to weed incidence. Not all changes in turf management practices that discourage weeds are practical. Additionally, a change in management practices to discourage one weed may cause another weed or biotic or abiotic stressor to become problematic.
- Proper fertilization is essential for turfgrasses to sustain desirable color, growth density, and vigor and to better resist weeds. This is especially true for annual weeds such as crabgrass.

- Avoid scalping; it reduces turf density, increasing weed establishment.
- If renovation is an option, select appropriate turf species or cultivars that are adapted to the prevalent environmental conditions to reduce weed encroachment that may lead to bare soils. Utilize University Extension resources, local seed retailers, as well as results of the National Turfgrass Evaluation Program (NTEP) to select the appropriate species and cultivars.
- Weed-free materials should be used for topdressing, sodding, and construction.
- Record and map weed infestations to help identify site-specific issues for future preventative actions.
- Control weeds, ideally before they begin to reproduce via seed or vegetative structures (e.g., tubers, rhizomes). Physical (e.g., hand weeding, sod cutting) or chemical weed control methods (e.g., herbicides) can be used depending on the target weed and resources available. Target the weed at vulnerable periods in the life cycle. For example, annual grassy weeds can be controlled before they emerge from seed using pre-emergent herbicides. Post-emergence herbicides are most effective when weeds are small and actively growing. Controlling mature weeds is more difficult.
- The “Turfgrass Weed Control for Professionals” guide authored by Dr. Aaron Patton and available online through the Purdue University bookstore is a comprehensive resource available to help superintendents select the proper herbicide(s) depending on the target weed and desirable turfgrass species.

Insects

Principles

- A plethora of insect species can be found in golf course turf areas, the majority of which are harmless or even beneficial to the turfgrass.
- White grubs, the larvae of a complex of several species of scarab beetles (e.g., oriental beetle, Japanese beetle, northern masked chafer, etc.), are the most common and potentially the most destructive insect pest group in New Jersey. They feed on the grass roots near the soil surface, which at high larval densities and under warm and dry conditions can lead to wilting of plants, gradual thinning of the turf, and death of large turf areas. In addition, vertebrate predators (skunks, raccoons, crows, etc.) can tear up the turf to feed on the grubs, even at larval densities that by themselves would not cause damage.
- The annual bluegrass weevil is the most difficult to control insect pests in New Jersey, particularly due to its ability to develop resistance to many synthetic insecticides. Its larvae initially tunnel grass stems but cause the most severe damage as larger larvae by feeding on the crown and at the base of stems, killing tillers or entire plants.
- The larvae of several moth species initially skeletonize foliage; but as they get larger, they create burrows in the soil from which they emerge at night to feed on the grass shoots (sod webworms, cutworms), or they live on the surface feeding on grass foliage and stems (armyworms). Black cutworm larvae are perennial

problems on golf course greens and tees because their feeding and burrowing create dead patches, sunken areas, or pockmarks.

- Other common, potentially damaging insects include chinch bugs, billbugs, ants, and crane flies.
- Healthy, well-managed turf is generally more tolerant of insect feeding and better able to recover from limited damage.
- Synthetic insecticides can become less effective over time due to the development of insecticide resistance in some insect populations and/or increased microbial degradation of the active ingredient by soil bacteria that adapt to use repeatedly applied material as an energy source.

Best Management Practices

- Proper identification of insects and their life stages is essential for effective management.
- Record and map insect infestations and identify trends that can help guide future treatments and focus on changing conditions in susceptible areas to reduce infestations.
- Increase turf tolerance to insect feeding by reducing turf stress by selecting appropriate turf species or cultivars adapted to the prevalent environmental conditions and using stress-reducing cultural practices.
- Use endophyte-infected cultivars of tall fescue, perennial ryegrass, or fine fescues where appropriate as they are relatively resistant to many surface feeding insects (chinch bugs, billbugs, sod webworms).
- Correct conditions that favor insect infestation and damage. For example, keep areas with a high percentage of Poa annua drier to reduce Poa annua and with that annual bluegrass weevil problems; drain wet areas to reduce issues with crane flies.
- Design your regular pest management activities around the key pest(s) in any given area, those pests that are most likely to occur and cause problems.
- Use spot treatments as needed for occasional infestations of easy-to-control insects (for example, army-, cut-, sod webworms).
- Base preventive applications against perennial and difficult to control pests on records of previous infestations and risk for damage. Treat only areas at risk, including an adequate buffer around them.
- Minimize the use of synthetic insecticides and rotate modes-of-action and insecticide classes between insect generations to delay the development of insecticide resistance and increased microbial degradation.
- Consider using the multi-target approach to reduce insecticide applications. The right material applied at the right rate and the right time can suppress more than one insect problem. But always use this approach around your key pest(s).

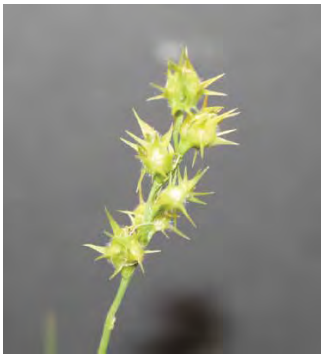
Nematodes

Principles

- Plant-parasitic nematodes adversely affect turfgrass health.
- Plant-parasitic nematodes are microscopic roundworms (unsegmented), usually between 0.0156 and 0.125 inches (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.
- Spoon-feed the turf with repeated applications of a small amount of fertilizer rather than larger amounts applied more often. This prevents excessive fast root growth which can increase populations of plant-parasitic nematodes.
- Reduce/eliminate other biotic/abiotic stresses when nematodes are compromising the root system and plant health.



Pesticide Management

Regulatory Considerations

Pesticide use 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 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

The manufacturing, labeling, registration, and classification of pesticides, the registration of pesticide dealers and pesticide dealer businesses, the registration of applicators of pesticides, the use of Integrated Pest Management (IPM) in schools, and the distribution, use, application, storage, handling, transportation, and disposal of pesticides in the State of New Jersey is governed by the New Jersey Department of Environmental Protection (NJ DEP) Pesticide Control Program (Source: New Jersey Administrative Code Title 7, Chapter 30, Subchapter 1,1 https://www.nj.gov/dep/enforcement/pcp/regulations/Subchapter%201.pdf)

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

- Persons who use or supervises the use of any pesticide for any purpose or on any property other than as provided by the definition of “private pesticide applicator” should achieve and maintain the status of a “Commercial pesticide applicator” (Source: New Jersey Administrative Code Title 7, Chapter 30, Subchapter 1,2 https://www.nj.gov/dep/enforcement/pcp/regulations/Subchapter%201.pdf)

- Commercial pesticide applicators who satisfactorily complete the requirements for Core certification and training pursuant to N.J.A.C. 7:30-6.2 should successfully pass a Category 3B - Turf examination; this subcategory includes commercial pesticide applicators using or supervising the use of pesticides to control pests in the maintenance and production of turf. This subcategory also includes vegetation control on commercial and residential sites only; flea and tick control in turf areas only; and soil fumigation for turf only. (Source: New Jersey Administrative Code Title 7, Chapter 30, Subchapter 6.3 https://www.nj.gov/dep/enforcement/pcp/regulations/Subchapter%206.pdf) .
- In order to maintain his or her certification, the commercial pesticide applicator shall meet the requirements for recertification as specified by the Department. If the requirements for recertification are not met, the commercial pesticide applicator shall again become certified in accordance with the provisions of the NJ DEP Pesticide Control Program. (Source: New Jersey Administrative Code Title 7, Chapter 30, Subchapter 6.6, https://www.nj.gov/dep/enforcement/pcp/regulations/Subchapter%206.pdf)

- Once certification is achieved, certification is good for a minimum of 5 years. Recertification can be accomplished in two ways:
  - Retake exams during the 5th year.
  - Accumulate recertification credit units over the 5 year period by attending Pesticide Control Program approved courses, seminars, and meetings. A commercial pesticide applicator must accumulate 8 units of Core credits and 16 units of Category 3B – Turf credits over the 5 years. (Source: https://www.nj.gov/dep/enforcement/pcp/bpo-appcom.htm)

- Persons who apply pesticides under the direct supervision of a responsible commercial pesticide are “Commercial pesticide operators” (Source: New Jersey Administrative Code Title 7, Chapter 30, Subchapter 1,2 https://www.nj.gov/dep/enforcement/pcp/regulations/Subchapter%201.pdf)

  - Commercial pesticide operators do not require passing Core and Category 3B examinations. Commercial pesticide operators must complete an NJ DEP Pesticide Control Program approved Basic Pesticide Training Course and complete forty hours of on-the-job training in each category of work. (Source: https://www.nj.gov/dep/enforcement/pcp/bpo-operator.htm).

- Contact information for the NJ DEP Pesticide Control Program:

  Bureau of Pesticide Compliance & Enforcement
  Mail Code 401-04A
  401 East State Street
  PO Box 420
  Trenton, NJ 08625-0420

- 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 recommendations as seen on the label.

Human Health Risks

Principle

Pesticides belong to numerous chemical classes that vary greatly in their toxicity. The human health risk associated with pesticide use is related to both pesticide toxicity and the level of exposure. The risk of a very highly toxic pesticide may be very low if the exposure is sufficiently small.

Best Management Practices

- Select the least toxic pesticide with the lowest exposure potential.
- Know the emergency response procedure in case excessive exposure occurs.

Environmental Fate and Transport

Principle

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.

Best Management Practices

- Select pesticides that have a low runoff and leaching potential.
- 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.

Pesticide Transportation, Storage, and Handling

Principle

Storage and handling of pesticides in their concentrated form pose 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.

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 structures to allow fire department access.
- Storage 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.
- 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.
- 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, firefighters, etc.) to show them the facilities and to discuss the emergency response plan. Seek advice on ways to improve the plan.

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 concerns.

Best Management Practices

- Personally ensure spray technician is 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 spray volumes, as directed by pesticide labeling, 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.

Best Management Practices

- Use appropriately sized application equipment for the size of the 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.

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.

Shelf Life

Principle

- 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 greater 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, and unusable pesticides that are being stored.
- Ensure labels are on every package and container.
- Consult inventory when planning and before making purchases.
- Ensure that labels remain properly affixed to their containers.

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).

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 surface 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 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

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 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 non-hazardous 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.

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 them according to the label.

Pollinator Protection

Regulatory Considerations

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 are 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 pesticides have on pollinator species and their habitat.

Regulatory Considerations

Principles

- Pollinator-protection language is a labeling 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.
- Recordkeeping may be required by law to use some products. 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.

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. Pesticide 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 pollinators in play and non-play course areas.
- Pollinators require a diversity of flowering species to complete their life cycle. Pollinator habitat contains a diversity of wildflower species of different colors and heights, with blossoms throughout the entire growing season

Best Management Practices

- Follow label information directing the application of pesticide when the plant may be in bloom. 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.
- 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 forecast.
- 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.
- Develop new pollinator habitat and/or enhance existing habitat.

Maintenance Operations

Regulatory Considerations

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.

Regulatory Considerations

Local and state regulations may be in place in your location. 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 are important to reduce the risk of serious injury or death of an operator or bystander. Fires or environmental contamination may result in large fines, cleanup costs, and civil lawsuits if these chemicals are not managed properly.
- Check federal, state, and local regulations for specific requirements related to the 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 cleanups should be properly trained under the requirements of the 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.
- Floor should be recessed, or a berm added 4” to 6” to retain a major spill.
- Mixing and Fill area or station should also have a containment sump or pad to retain and reuse any spilled chemicals or rinsate.
- Mixing personnel should also be wearing PPE while mixing and loading tanks.
- 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.
- 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 the building before entrance of staff.
- Maintain detailed records of current pesticide inventory in the storage facility.
- Inventory should be shared or submitted to the local fire department on a yearly basis.
- Safety Data Sheets (SDS) for the chemicals stored on-site should be stored separately 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 nonflammable.
- Store liquid materials below dry materials to prevent leaks from contaminating dry products.
- Ensure that oil containers and small fuel containers (service containers) are properly labeled and stored within the facility.
- Periodically evaluate products and chemicals in use for opportunities to replace with alternative products that are more human health- or environment-friendly.

Equipment Storage and Maintenance

Principle

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

Best Management Practices

- Store and maintain equipment in a covered area complete with a sealed impervious surface to limit the 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.
- Keep storage areas clean and free of debris to prevent fires and allow personnel to swiftly exit the building in the event of an emergency.

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.

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.
- 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 minimal 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 on 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.

Pollution Prevention

Principles

- Plan appropriately to minimize the possibility of a discharge and the 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. The 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 are 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 cleanup 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.
- Pesticides that have been mixed so they cannot be legally applied to a site in accordance with the label must be disposed of as 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.

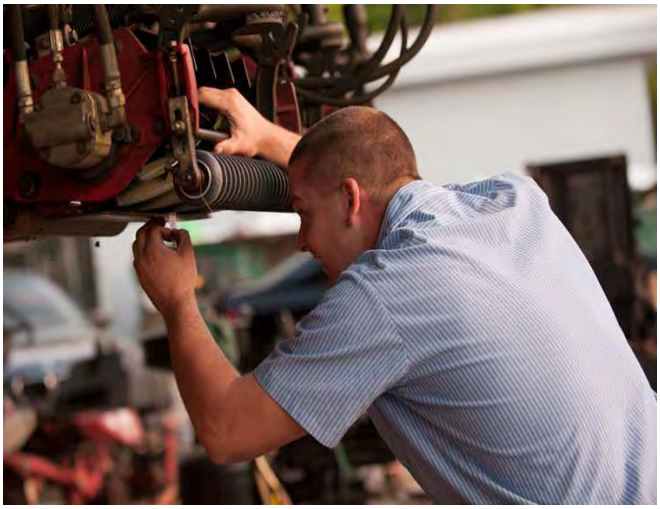
Best Management Practices

- Pesticides should be stored in a lockable concrete or metal building.
- Pesticide storage and mixing facility floors should be impervious and sealed with 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 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 then be cleaned of any sediment before another type of pesticide is handled.
- Discharge to a treatment system that is permitted under industrial wastewater rules.
- Never discharge to a sanitary sewer system without written permission from the utility.
- Never discharge to a septic tank.
- Use a closed-loop wash-water recycling system and follow appropriate BMP.
- 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.
- Grass-covered equipment should be brushed or blown with compressed air before being washed. Dry material is much easier to handle and store or dispose of than wet clippings.
- 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 cleanup 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 cleanup 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 helpline 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 or asphalt 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.

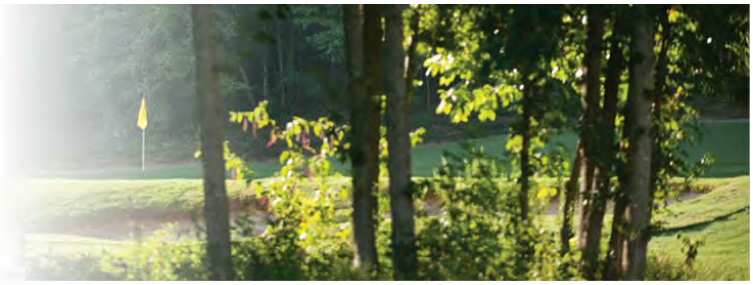
- Handle clippings and dust separately. After the residue dries on the pad, it can be collected and composted or spread in the field.
- Minimize the use of detergents. Use only biodegradable non-phosphate detergents.
- Minimize the amount of water used to clean equipment. This can be done by using spray 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 pesticides).
- 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 undercover. Remember, spent lead-acid batteries must be recycled if they are to be exempt from strict hazardous waste regulations.
- Lead acid batteries are required to be recycled by law. At a minimum, retail establishments are required to accept old batteries in exchange for the purchase of a new battery. The system for recycling lead acid batteries is well established and economical. In addition, local and county hazardous waste collection facilities generally accept used lead acid batteries.
- 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 them, puncture the pesticide containers 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.
- Storing the containers in large plastic bags/tubs to protect the containers from collecting rainwater.



Landscape

Species Selection and Size Considerations



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, light patterns, insects, 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 microorganisms rapidly decompose organic amendments such as peat or compost.
- The goal of species-selection BMP is to maintain as close to a natural ecosystem as practical while meeting a golf course's needs.
- 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 course

design 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, along with 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. At the same time, habitat for wildlife survival is maintained.

Best Management Practices

- Base plant selection as close to a natural ecosystem as practical, while meeting the needs of the golf course. It 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) cold-hardiness map.
- Select stress-tolerant species or cultivars to manage periodic dry/wet conditions.
- Choose the most stress-tolerant species or cultivar for a particular area.

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 should they get blown over.
- Use turf as a landscape element where needed.

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, 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 BMP goal is to maintain as close to a natural ecosystem as practical while meeting the golf course's needs.
- 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 2 to 3 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 buildup 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.
- Plants should be grouped 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.

Energy

Energy Conservation

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 the 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 the National Electrical Manufacturers Association's (NEMA) premium efficiency-rated pump motors.
- Seek output reduction by watering less area, apply target golf goals.
- Install LED lighting and/or retrofit devices.
- Install motion sensors for lights where appropriate.
- Install a programmable thermostat.
- Install solar/Geo-Thermal 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.
- 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 the 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.

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: used insulation and color selection.
- Ensure efficient lighting in both interior and exterior areas.

Best Management Practices

- Maximize use of space.
- Inspect and repair leaks/maintenance.
- Monitor temperature/environmental settings (heat loss, etc.).
- Evaluate building automation systems, monitoring systems, etc.
- Incorporate technology and up-to-date equipment (lights, controls, switches, etc.).
- Implement schedules/controlled use.
- Evaluate off-grid pole lighting and similar technology.

Alternative products, operations, and practices

Principles

- Educate and motivate employees, guests, etc.
- 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, etc.
- Consider energy management software, services, etc.
- Consider national and local programs and programs like the EPA's WaterSense program as it relates to buildings (see Water Conservation BMP).

Best Management Practices

- Evaluate alternative transportation.
- Evaluate cleaning practices (dry vs. wet).
- Consider local vs. distant purchases, product selection, etc.
- Evaluate energy acquisition and energy coming into the facility.
- Evaluate golf car 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, size, etc.), 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, etc.
- Consider long-term costs in addition to acquisitions.
- Schedule reviews to evaluate future technology and fuel types.
- Evaluate upgrades.
- Evaluate use of alternative energy/fuels.
- Identify future energy needs.
- Prioritize energy consumption as part of selection.
- Optimize equipment use data including hours operated, use patterns, etc.
- 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 BMP).
- Schedule and operate pumps and irrigation in an efficient manner.
- Identify and implement infrastructure and behavioral changes.
- Evaluate technology and upgrades; implement when feasible.

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