# Best Management Practices

## Ontario Golf Courses

BMP Best Management Practices

GCSAA

# Best Management Practices Planning Guide & Template

*In partnership with*

PGA TOUR USGA

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GCSAA Foundation | *Funded through the GCSAA Foundation*

# Introduction


## Introduction


The Ontario Golf Course Superintendents' Association (OGSA) was established in 1924 and is comprised of dedicated golf course superintendents, assistant superintendents, golf course technicians, equipment managers, and other professionals who have a stake in the golf course industry and turfgrass maintenance. The OGSA serves its members through providing networking opportunities, professional development resources, funding for government lobbying, and funding for turf research.

Our mission is to serve our members, advancing their profession, and enrich the quality of golf and its environment. Ontario 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 Best Management Practices for Ontario Golf Courses 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.

With a special thanks to Burnside Golf Services for sharing their extensive knowledge and resources to help us develop a document that aligns with current national and provincial environmental mandates. We would also like to extend our sincerest thanks to the GCSAA for initiating this project and encouraging us to follow through with adapting their National BMP, to a Canadian version for Ontario.

This document is a collaboration of various industry experts who spent a significant amount of time conducting peer reviews for each section. We thank each of you!

It is our hope that all OGSA members will take the time to review and adapt this document to their own facility. This document will become a key reference tool when speaking with stakeholders in your community.

# Acknowledgement


## Who We Are/ Acknowledgments

## 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.

## GCSAA Foundation

The GCSAA Foundation, formerly the Environmental Institute for Golf, is focused on providing funding to strengthen advocacy, education, and research that advances the work of golf course management professionals. Founded in 1955 as the GCSAA Scholarship & Research Fund for the Golf Course Superintendents Association of America, the Foundation serves as the association's philanthropic organization. The Foundation 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 GCSAA Foundation know they are fostering programs and initiatives that will benefit the game and its environment for years to come.

## Acknowledgments

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# Additional Acknowledgements


## Who We Are/ Acknowledgments

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# Planning, Design and Construction

## *Introduction*

St. George's bunker construction. OGSA image. ONCourse, August 2019, pg. 22.

The construction phase of any industry's infrastructure poses the greatest risk of ecosystem alteration and potential negative environmental impact; and projects within the golf industry are no exception. With proper planning and design new golf course development projects and golf course renovation projects can be constructed and maintained with minimal impact to the existing environment, and also designed and constructed to maximize long term environmental sustainability and energy efficiency.

## *Regulatory Issues*

In almost all cases, Federal, Provincial and/or Conservation Authority Policies and Regulations, as well as local municipal by-laws will be in place within your jurisdiction and may impact the planning, design and scheduling of your project. Early consultation with the above agencies should be a key part of the process as it will help identify the specific approval requirements and outline the required steps (and timeframes) to obtain the necessary approvals for your construction project. It is recommended that you start with your local municipal planning department, and based on those discussions move forward to include developers, designers, local community groups, and permitting agencies as required. Navigating through the regulatory approvals process will take time and may impact the timing of your planning schedule if it not taken into account early in the process.

## *Planning*

### Principles

Proper planning will minimize time and expenses resulting from unforeseen delays and construction requirements. Good planning also provides opportunities to

maximize/integrate environmentally responsible designs/features into the property. This often requires the involvement of many key individuals/disciplines on a study team and may include golf course architects, golf course superintendents, civil engineers, soil scientists, agronomists, irrigation designers, ecologists, arborists, etc.

### Best Management Practices

- Assemble a qualified team, with all the necessary experts represented, if required:
    - Golf Course Superintendent
    - Golf Course Architect
    - Clubhouse Architect
    - Irrigation Consultant
    - Environmental Engineer
    - Energy Analyst
    - Economic Consultant
    - Civil Engineer
    - Soil scientist
    - Geologist
    - Golf course contractor
    - Lawyer
- Determine objectives and complete a feasibility study which includes consideration to financial, environmental, site servicing (including water supply) and project timing.
- Select an appropriate site that is capable of achieving the goals and objectives of the project.
- Complete an environmental constraints analysis of your site to identify any rare, protected, threatened or endangered species to determine potential impacts to your design.

## *Design*

### Principles

Proper design will meet the needs of the overall objectives of the study, while protecting the sensitive environmental features of the property.

### 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 natural features. The golf course routing plan should not only identify the course layout, but also identify the areas that provide opportunities for restoration.
- Design the course to retain as much natural vegetation as possible, and where possible, consider enhancing existing vegetation through the supplemental planting of native vegetation/materials adjacent to fairways, out-of-play areas, and along water features that support 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 specific site.
- Greens
    - Select a location that has adequate sunlight to meet future agronomic needs and provide sufficient natural drainage.
    - Choose a green size that can accommodate a sufficient number of hole locations and large enough to accommodate foot 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, or modified USGA specification (USGA Green Construction).
    - 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 project while adhering to the principle of “right plant, right place.” Utilize National Turfgrass Evaluation Program (NTEP.org) Trials and University research.
- Plant only industry certified turfgrass.
- Where possible provide adequate bunker 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 project needs.
- Define play and non-play maintenance boundaries.

## *Construction*

### Principles

Construction should be completed with qualified golf course/landscape contractors and care taken to minimize environmental impact and financial ramifications caused by poor construction techniques.

### Best Management Practices

- Conduct a pre-construction conference with stakeholders.

- Conduct weekly construction meetings (with meeting minutes) to monitor construction progress, issues, and change orders.
- Construction should be scheduled to maximize turfgrass establishment and site drainage.
- Use environmentally sound construction techniques.
- Use soil stabilization techniques to minimize soil erosion and maximize sediment containment.
- Maintain a construction progress report and communicate the report to the proper permitting agencies.
- Use only qualified contractors who are experienced in the unique requirements of golf course construction.
- Schedule construction and turf establishment to allow for the most efficient progress of the work, while optimizing environmental and resource management.
- Temporary construction compounds should be built in a way that minimizes environmental impacts.
- Develop a Health & Safety (H&S) Plan and Policies outlining the specific requirements of the site/property (Occupational Health and Safety Act (OHSA)).

## *Grow-in*

### Principles

Initial turfgrass establishment (grow-in) is a unique phase in turfgrass and golf course development which requires greater quantities of water and nutrients than managing established turfgrasses. As a result, the establishment phase should be managed carefully to minimize environmental risk.

### Best Management Practices

- The area to be established should be properly prepared and cleared of pests and debris (weeds, pathogens, sticks, stones, etc.).
- Ensure erosion and sediment control devices are properly placed and maintained.
- Sprigs should be “knifed-in” and rolled to expedite root establishment.
- Sod should be top-dressed to fill in the gaps between sod pieces. This promotes establishment and provides a smoother surface.
- Use appropriate seeding methods for your conditions. When using sod, nutrient applications should be delayed until sod has sufficiently rooted.
- When using sprigs, application rates for nitrogen, phosphorous, and potassium should correspond to percent ground cover (i.e., increasing rate as ground coverage increases).
- Slow-release nitrogen or light, frequent soluble-nitrogen sources should be used during grow-in.

- Nutrients should be applied — in either foliar or granular formulations — to the turf surface. Incorporating nutrients into the root zone does not result in more rapid establishment and increases environmental risk.
- Mow as soon as the sod has knitted-down, when sprigs have rooted at the second to third internode, and seedlings have reached a height of one-third greater than intended height-of-cut. This will hasten establishment.

## *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 construction and grow-in of a golf course.

### Best Management Practices

- Develop a working knowledge of erosion and sediment control management. Local agencies may have specifications for 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 can offer soil stabilization in some situations.

## *Wetlands*

### Principles

Wetlands are considered as a significant environmental resource and critical part of any local ecosystem. Federal, Provincial and Local approval agencies will likely have input and regulations providing for the oversight and protection of these key environmental resources, and ultimately responsible for the approval and permitting of construction projects located within or adjacent to these environmental features. 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 wetlands may need to be permitted to be an integral part of the stormwater management system.

### Best Management Practices

- Provide for early consultation with Local Conservation Authorities to determine the environmental sensitivity of the wetland.
- Ensure that wetlands have been properly delineated before working in and around any wetlands.
- Ensure that proper permitting has been obtained before working on any wetlands.

## *Drainage*

### Principles

Proper drainage is a key factor in maintaining healthy turf grass. A drainage master plan 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.
- Ideally 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 sediment and nutrients.
- Drainage should discharge through properly designed stormwater management features, including, vegetative buffers, swales, etc.
- The drainage system should be routinely inspected to ensure proper function, and any damaged infrastructure should be repaired as soon as possible.
- As-build maps of the drainage infrastructure should be created after installation.

## *Surface Water: Stormwater, Ponds, Lakes*

### Principles

Stormwater is the conveying force behind non-point 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.

### Best Management Practices

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

## *Maintenance Facilities*

## Principles

Golf course maintenance facilities are a key part of the operations of a golf facility and should incorporate BMP to minimize the potential for negative environmental impact. The management of turf equipment, pesticide mixing and storage areas, fertilizer storage, and the refueling areas are focal points that must be properly managed.

### Best Management Practices

- Pesticide storage facilities should be designed and operated to keep pesticides products secure and isolated from the surrounding environment.
- Pesticide products should be stored in a covered concrete or metal structure with a lockable door.
- Floors should be constructed of seamless metal, or sealed concrete with a chemical-resistant paint.
- Ensure that flow from floor drains does not discharge directly to the ground and that drains are not connected to the sanitary sewer line or septic system.

- Equip the floor with a continuous curb to retain spilled materials.
- Do not store pesticides near burning materials, welding and grinding areas, or in shop areas.
- Provide storage for personal protective equipment (PPE) where it is easily accessible in the event of an emergency, but not stored in the pesticide storage area.
- Provide adequate space and shelving to segregate herbicides, insecticides, and fungicides.
- Use shelving made of plastic or reinforced metal. Keep metal shelving painted.
- Provide appropriate exhaust ventilation and an emergency wash area.
- Always place dry materials above liquids, never liquids above dry materials.
- Never place liquids above eye level.
- Locate operations well away from groundwater wells and areas where runoff may carry spilled pesticides into surface waterbodies.
- Do not build new facilities on potentially contaminated sites.
- An open building must have a roof with a substantial overhang (minimum 30° from vertical, 45° recommended) on all sides.
- In constructing a concrete mixing and loading pad, it is critical that the concrete have a water-to-cement ratio no higher than 0.45:1 by weight.
- The sump should be small and easily accessible for cleaning.
- Ensure that workers always use all personal protection equipment as required by the pesticide label and are provided appropriate training.
- Assess the level of training and supervision required by staff.
- Any material that collects on the pad must be applied as a pesticide according to the label or disposed of as a (potentially hazardous) waste according to Federal/Provincial Policies and Regulations.
- Any spills should be cleaned up immediately, and reported if required.
- 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 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 used oils and 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 and provide 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 habitats specific to the site and adjacent lands.
- Identify the habitat requirements (food, water, cover, space) for identified wildlife species.
- Identify species on the site that are considered species at risk, threatened or endangered by Federal and/or Provincial Agencies.
- 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 (naturalized) buffers along waterways to protect water quality, provide food, nesting sites, and cover for wildlife.

Wildlife on golf courses. Photos submitted by OGSA members.

# Irrigation

## *Introduction*


Photo taken by Ashley Binkle, Dundee CC.

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

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

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

The monetary investment in non-structural, BMP costs little to nothing to implement in a daily course water-use plan. Other advantages to using BMP include: reduced administrative management stress, improved employee communication and direction, and effective facilities training procedures.

**Several benefits of adopting BMP are:**

- Conserving the water supply
- Protecting existing water quality
- Maintaining turf health
- Turf stress management
- Maintaining optimal ball roll and playing conditions
- Saving water and electricity

- Increasing pump and equipment life longevity
- Demonstrating responsible environmental stewardship
- Retaining knowledgeable and effective employees

## *Water Management Approaches*

### Conservation and Efficiency

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

### Resource Protection

Resource protection is an integrated approach that includes irrigation practices as part of the course design, pesticide and nutrient practices, and regulatory compliance measures and structural measures as they concern environmental stewardship and policy.

## *Regulatory Considerations*

### Principles

Golf course owners are responsible for contacting the Ministry of Environment, Conservation and Parks (MECP), and local conservation authority at the pre-and post-construction phase to determine permitting guidelines, and other requirements allowed by regulators. Superintendents have a responsibility to adhere to water-quality standard rules regarding groundwater and surface water flows resulting from the removal of water for irrigation use.

Water taking in Ontario is regulated by the Ontario Water Resources Act, Section 34, and the Ontario Regulation 387/04 Water Taking and Transfer. Any water taking in Ontario that exceeds 50,000 L/day from a lake, stream, river, pond and/or groundwater requires a Permit to Take Water (PTTW). Follow the link for more information on who requires a PTTW and how to apply.

### Best Management Practices

- Design and/or maintain a system to meet the site's peak water requirements under normal conditions and also be flexible enough to adapt to various water demands and local restrictions.
- Develop an annual water budget for the golf course.
- Look for ways to increase efficiency and reduce energy use associated with irrigation systems and practices.

- Demonstrate good stewardship practices by supplementing watering only for the establishment of new planting and new sod, hand watering of critical hot spots, and watering-in of chemicals and fertilizers (if permissible).
- Protect aquatic life and impairment of water features by adhering to provincial and local conservation authority regulations and policies.
- Obtain a valid water taking permit under Section 34 of the Ontario Water Resources Act, and comply with all of the conditions listed on the water taking permit.
- Design an irrigation system that delivers water with maximum efficiency.

## *Irrigation Water Suitability*

### Principles

Golf course designers and managers should endeavour to identify and use alternative supply sources to conserve freshwater drinking supplies, promote plant health, and protect the environment. The routine use of potable water supply is not a preferred practice; therefore, municipal drinking water should be considered only when there is no alternative. Studies of water supplies are recommended for irrigation systems, as are studies of waterbodies or flows on, near, and under the property. These may be helpful to properly design a course's stormwater systems, water features, and to protect water resources. When necessary, sodic water system treatment options should be included in the budget to address water quality and equipment maintenance.

### Best Management Practices

- Use alternative water supplies/sources that are appropriate and sufficiently available to supplement water needs.
- Use salt-tolerant varieties of turf and plants to mitigate saline conditions resulting from an alternative water supply or source, if necessary.
- Amend sodic water systems appropriately (with gypsum or an appropriate ion) to minimize sodium buildup in soil.
- Flush with freshwater or use amending materials regularly to move salts out of the root zone and/or pump brackish water to keep salts moving out of the root zone.
- Monitor sodium and bicarbonate buildup in the soil using salinity sensors.
- Routinely monitor shallow groundwater table of freshwater for saltwater intrusion or contamination of heavy metals and nutrients.
- Reclaimed, treated effluent, and other non-potable water supply mains must have a thorough cross-connection and back-flow prevention device in place and operating correctly.
- Post signage in accordance with local utility and provincial requirements when reclaimed water is in use.
- Account for the nutrients in effluent (reuse/reclaimed) water when making fertilizer calculations.

- Monitor reclaimed water tests regularly for dissolved salt content.
- Where practical, use reverse-osmosis filtration systems to reduce chlorides (salts) from saline groundwater.
- Monitor the quantity of water withdrawn to avoid aquatic life impairment.
- Identify appropriate water supply sources that meet seasonal and bulk water allocations for grow-in and routine maintenance needs.

## *Water Conservation and Efficient Use Planning*

### Principles

Document actual watering practices, especially to show savings in water use over averages. Communication should be maintained with water managers, golf course members, and the public to explain what you are doing and why.

Potable water supplies in many areas of the Province are limited and heavily regulated, and demand for potable water supplies continues to grow. Our challenge is to find solutions to maintain the quality of golf while using less water. BMP and educational programs are necessary to change the public's mind-set toward the inevitable changes in water-related issues. Some courses are being designed using a "target golf" concept that minimizes the acreage of irrigated turf. Existing golf courses can make an effort to convert out-of-play areas turf to naturally adapted native plants, grasses, or ground covers to reduce water use and augment the site's aesthetic appeal.

### Best Management Practices

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

## *Irrigation System Design*

### Principles

A well-designed irrigation system should operate at peak efficiency to reduce energy, labour, and natural resources. Irrigation systems should be properly designed and installed to improve water use efficiency. An efficient irrigation system maximizes water use, reduces operational cost, conserves supply and protects water resources.

### Best Management Practices

- Irrigation design should account for optimal distribution efficiency and effective root-zone moisture coverage. Target 80% or better sprinkler Distribution Uniformity (DU).
- Ideally irrigation design should allow for individual sprinkler control and watering of greens, tees, fairways, rough, bunkers and slopes to allow specific application rates and different watering intervals.
- The design package should include sprinkler application rates, a general irrigation schedule with recommendations and instructions on modifying the schedule for local climatic soil and growing conditions. It should include the base ET rate for the particular location.
- The design should allow the adjustment of station run times and/or multiple run times so the sprinkler application rate does not exceed the infiltration rate (the ability of the soil to absorb and retain the water applied). Conduct saturated hydraulic conductivity tests periodically.
- The design operating pressure must not be greater than the available source pressure.
- The design operating pressure must account for peak-use times and supply line pressures at final buildout for the entire system.
- The system should be flexible enough to meet a site's peak water requirements and allow for operating modifications to meet seasonal irrigation changes or local restrictions.
- Turf and landscape areas should be zoned separately. Specific use areas should be zoned separately; greens, tees, primary roughs, secondary roughs, fairways, native, trees, shrubs, etc. Full circle and part-circle valve-in-head sprinklers should never operate together on the same station. Block zones must include matched precipitation rates of all sprinklers.
- Design should account for the need to leach out salt buildup from poor-quality water sources by providing access to freshwater.
- Only qualified irrigation contractors should install the irrigation system and according to the design and specifications of the irrigation design.
- The irrigation designer should approve any design changes prior to or during construction.
- Prior to construction, all underground cables, pipes, and other obstacles must be identified, and adequately flagged.

- Permanent irrigation sprinklers and other distribution devices should be spaced according to the manufacturer's recommendations.
- Irrigation head spacing should be based on average wind conditions during irrigation.
- For variable wind directions, triangular spacing is more uniform than square spacing.
- Distribution devices and pipe sizes should be designed for optimal uniform coverage.
- The first and last distribution device should have no more than a 10% difference in flow rate. This usually corresponds to about a 20% difference in pressure.
- Distribution equipment (such as sprinklers, rotors, and micro-irrigation devices) in a given zone must have the same precipitation rate.
- Heads for turf areas should be spaced for head-to-head coverage.
- Water supply systems (for example, wells, and pipelines) should be designed for varying control devices, rain shutoff devices, and back-flow prevention.
- Water conveyance systems should be designed with thrust blocks and air-release valves.
- Flow velocity must be a maximum of 1.52 meters (5 feet) per second or less.
- Pipelines should be designed to provide the system with the appropriate pressure required for maximum irrigation uniformity.
- Pressure-regulating or pressure compensating equipment must be used where the system pressure exceeds the manufacturer's recommendations.
- Equipment with check valves must be used in low areas to prevent low head drainage.
- Isolation valves should be installed in a manner that allows critical areas to remain functional.
- Manual quick-coupler valves should be installed near greens, tees, and bunkers so these can be hand-watered during severe droughts.
- Install part-circle heads along lakes, ponds, and wetlands margins.
- Use part-circle or adjustable part circle heads to avoid overspray of impervious areas such as roadways and sidewalks.
- Update multi-row sprinklers with single head control to conserve water and to enhance efficiency.
- Incorporate multiple nozzle configurations to add flexibility and enhance efficiency/distribution.
- Ensure heads are set at level ground and not on slopes.
- Install combination air release/vacuum breaker valves at all high points to allow automatic evacuation of air.

## *Irrigation Pumping System*

### Principles

Pump stations should be sized to provide adequate flow and pressure. They should be equipped with control systems that protect distribution piping, provide for emergency

shutdown necessitated by line breaks, and allow maximum system scheduling flexibility. Variable frequency drive (VFD) pumping systems should be considered if dramatically variable flow rates are required, if electrical transients (such spikes and surges) are infrequent, and if the superintendent has access to qualified technical support. Design pumping systems for energy conservation.

### Best Management Practices

- The design operating pressure must not be greater than the available source pressure.
- The design operating pressure must account for peak-use times and supply-line pressures at final buildout for the entire system.
- Fixed speed pumping systems should include a hydraulically-operated main control valve with pressure reducing, pressure sustaining and surge anticipating pilots.
- Variable Frequency Drive (VFD) controls should be installed to save electricity and lengthen the life of older pipes and fittings until the golf course can afford a new irrigation system.
- The pumping system should include a pressure relief valve to discharge excess pressure and protect the pumps in the event of a power failure during operation.
- The pumping system should include high pressure and low pressure shutoff safeties to shut down the system in case of malfunctions, breaks or insufficient water, as well as, low water level shutoff.
- Pumps should be sized to provide required flow and pressure.
- Pumps should be equipped with control systems to protect distribution piping.
- System checks and routine maintenance on pumps, valves, programs, fittings, and sprinklers should follow the manufacturer's recommendations.
- Monitor pumping system power consumption.
- Monthly bills should be monitored over time to detect a possible increase in power usage.
- Compare the power used with the amount of water pumped. Requiring more power to pump the same amount of water may indicate a problem with the pumps, motors, valves, pressure sensors or flow sensors.
- Periodic checks of amperage by qualified pump personnel may more accurately indicate increased power usage and thus potential problems.

## *Irrigation System Program and Scheduling*

### Principles

Irrigation scheduling must take plant water requirements and soil intake capacity into account to prevent excess water use that could lead to leaching and/or runoff. Plant water needs are determined by evapotranspiration (ET) rates, recent rainfall, recent

temperature extremes and soil moisture. Irrigation should not occur on a calendar-based schedule, but should be based on ET rates and soil moisture replacement.

An irrigation system should be operated based only on the moisture needs of the turfgrass, or to water-in a fertilizer or chemical application as directed by the label. Responsible irrigation management conserves water and reduces nutrient and pesticide movement. Electromechanical (time-clock-controlled) irrigation systems preceded computer-controlled systems, and many are still in use today. Electromechanical time clocks cannot automatically adjust for changing ET rates. Frequent adjustment is necessary to compensate for the needs of individual turfgrass areas.

## Best Management Practices

- The reliability of older electromechanical (clock-control) station timing depends on the calibration of the timing devices; this should be done periodically, but at least seasonally.
- An irrigation system should have rain sensors to shut off the system after 6.35 – 12.7 mm (0.25 to 0.5 inch) of rain is received. This amount can vary based on site and soil conditions.
- Computerized systems allow a superintendent to call in and cancel the program if it is determined that the course has received adequate rainfall.
- Install control devices to allow for maximum system scheduling flexibility.
- Certain granular fertilizer applications may need to be watered in to move particles off the leaves while minimizing runoff.
- Irrigation quantities should not exceed the available moisture storage in the root zone.
- Irrigation rates should not exceed the maximum ability of the soil to absorb and hold the water applied at any one time. If not achievable, multiple run times should be used.
- Irrigation schedule should coincide with other cultural practices (for example, the application of nutrients, herbicides, or other chemicals).
- Account for nutrients in effluent supply when making fertilizer calculations.
- Irrigation should occur in the early morning hours before air temperatures rise and relative humidity drops.
- Base plant water needs should be determined by ET rates, recent rainfall, recent temperature extremes, and soil moisture.
- Use mowing, verticutting, aeration, nutrition, and other cultural practices to control water loss and to encourage conservation and efficiency.
- Visually monitor for localized dry conditions or hot spots to identify poor irrigation efficiency or a failed system device.
- Use predictive models or soil sensors to estimate soil moisture and the best time to irrigate.
- Avoid use of a global setting; make adjustments to watering times per head.
- Base water times on actual site conditions for each head and zone.
- Adjust irrigation run times based on current local meteorological data.

- Use computed daily ET rate to adjust run times to meet the turf's moisture needs.
- Manually adjust automated ET data to reflect wet and dry areas on the course
- Use soil moisture sensors to assist in scheduling or to create on- demand irrigation schedules.
- Use multiple soil moisture sensors to reflect soil moisture levels.
- Install soil moisture sensors in the root zone for each irrigation zone to enhance scheduled timer-based run times.
- Place soil moisture sensors in a representative location within the irrigation zone. Install a soil moisture sensor in the driest irrigation zone of the irrigation system.
- Wired soil moisture systems should be installed to prevent damage from aerification.
- Periodically perform operational sprinkler audits (catch-can uniformity tests).
- Reducing dry spots and soil compaction improves water infiltration, which in turn reduces water use and runoff in other areas.
- Install emergency shutdown devices to address line breaks.

## *Turf Drought Response*

### Principles

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

### Best Management Practices

- Waiting until visual symptoms appear before irrigating is a method best used for low-maintenance areas, such as golf course roughs and, possibly, fairways.
- Use soil moisture meters to determine moisture thresholds and plant needs.
- Irrigating too frequently and too shallowly encourages shallow rooting, increases soil compaction, and favours pest outbreaks.
- For golf greens and tees, the majority of roots are in the top several centimetres of soil.
- For fairways and roughs, use infrequent, deep irrigation to supply sufficient water for plants and to encourage deep rooting.
- Proper cultural practices such as mowing height, irrigation frequency, and irrigation amounts should be employed to promote healthy, deep root development and reduce irrigation requirements.
- Create a drought management plan for the facility that identifies steps to be taken to reduce irrigation/water use and protects critical areas, etc.
- Use appropriate turfgrass species adapted to the location of the golf course being managed.

## *Irrigation System Quality*

### Principles

Irrigation system maintenance on a golf course involves four major efforts: calibration or auditing, preventive maintenance (PM), corrective maintenance, and record keeping. Personnel charged with maintaining any golf course irrigation system face numerous challenges. This is particularly true for courses with older or outdated equipment.

Good system management starts with good preventive maintenance (PM) procedures and record-keeping. Maintaining a system is more than just fixing heads. Corrective maintenance is simply the act of fixing what is broken. It may be as simple as cleaning a clogged nozzle, or as complex as a complete renovation of the irrigation system. As maintenance costs increase, the question of whether to renovate arises. Renovating a golf course irrigation system can improve system efficiencies, conserve water, improve playability, and lower operating costs.

### Best Management Practices

- Respond to day-to-day failures in a timely manner, maintain the integrity of the system as designed, and keep good records.
- System checks and routine maintenance on pumps, valves, programs, fittings, and sprinklers should follow the manufacturer's recommendations.
- The system should be inspected daily for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads. A visual inspection should be carried out for leaks, misaligned or inoperable heads, and chronic wet or dry spots, so that adjustments can be made.
- Systems need to be observed in operation at least weekly. This can be done during maintenance programs such as fertilizer or chemical applications where irrigation is required, or heads can be brought on-line for a few minutes and observed for proper operation. This process detects controller or communications failures, stuck or misaligned heads, and clogged or broken nozzles.
- If a filter is utilized, check the operation frequently. An unusual increase in the amount of debris may indicate problems with the water source.
- Even under routine conditions, keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.
- Keep records of filter changes, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.
- Application/distribution efficiencies should be checked annually. Implement a maintenance program to replace worn components before they waste fertilizer, chemicals, and water.
- Conduct a periodic professional irrigation audit at least once every five years.

- Document pump and motor run-time hours. Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Gather together all of the documentation collected as part of the PM program, along with corrective maintenance records for analysis.
- Correctly identifying problems and their costs helps to determine what renovations are appropriate.
- Collecting information on the cost of maintaining the system as part of the overall system evaluation, allows for planning necessary upgrades, replacement etc. and to compare after changes are made.

## *Pond Location and Design*

### Principles

Understanding natural lake processes and accommodating them in the design and management of a pond can create significant aesthetic value and reduce operational costs. Lakes and ponds have several distinct defining characteristics. Their size, shape, and depth may all affect how they respond to various environmental inputs.

Most golf courses plan their lakes and water hazards to be a part of the stormwater control and treatment system. This usually works well for all concerned. However, natural waters may not be considered treatment systems and must be protected. Lakes and ponds may be used as a source of irrigation water. It is important to consider these functions when designing and constructing the ponds. Careful design may significantly reduce future operating expenses for lake and aquatic plant management.

### Best Management Practices

- Consult with a qualified golf course architect, working in conjunction with a stormwater engineer, to develop an effective stormwater management system that complies with the requirements of the water management district/department or other permitting agency.
- When constructing drainage systems, pay close attention to engineering details such as subsoil preparation, the placement of gravel, slopes, and backfilling.
- Where practical, internal golf course drains should discharge through pre-treatment zones and/or vegetative buffers to help remove nutrients and sediments.
- Studies of water supplies are needed for irrigation systems, and studies of waterbodies or flows on, near, and under the property are needed to properly design a course's water system, and to protect water resources.
- Peninsular projections and long, narrow fingers into ponds may prevent water mixing. Ponds that are too shallow may reach high temperatures, leading to low oxygen levels and promoting algal growth and excess sedimentation.

- In shallow or nutrient-impacted ponds, the use of aeration equipment may be required to maintain acceptable dissolved oxygen (DO) levels in the water.

## *Pond Use and Maintenance*

### Principles

Successful pond management should include a clear statement of goals and priorities to guide the development of the BMP necessary to meet those goals. Some of the challenges facing superintendents in maintaining the quality of golf course ponds are as follows: Low DO, sedimentation, changes in plant populations, nuisance vegetation, maintenance of littoral shelves, and vegetation on the lakeshore.

Each pond has regions or zones that significantly influence water quality and are crucial in maintaining the ecological balance of the system. It is important for the manager to understand their function and how good water quality can be maintained if these zones (riparian zone, littoral zone, limnetic zone, and benthic zone) are properly managed.

Surface water sources can present problems with algal and bacteria growth. Algal cells and organic residues of algae can pass through irrigation system filters and form aggregates that may plug sprinklers and drip emitters. Pond leaks should be controlled and managed properly. Use an expert in aquatic management to help develop and monitor pond management programs.

### Best Management Practices

- Use leak controls in the form of dike compaction, natural-soil liners, soil additives, commercial liners, drain tile, or other approved methods.
- Maintain a riparian buffer to filter the nutrients and sediment in runoff.
- Reduce the frequency of mowing at the lake edge and collect or direct clippings to upland areas.
- Prevent overthrowing fertilizer into ponds. Practice good fertilizer management to reduce nutrient runoff into ponds, which causes algae blooms and ultimately reduces DO levels.
- Establish a special management zone around pond edges.
- Dispose of grass clippings where runoff will not carry them back to the lake.
- Encourage clumps of native emergent vegetation at the shoreline.
- Maintain water flow through lakes, if they are interconnected.
- Establish wetlands where water enters lakes to slow water flow and trap sediments.
- Maintain appropriate silt fencing and BMP on projects upstream to reduce erosion and the resulting sedimentation.
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered DO levels.
- Aerate ponds and dredge or remove sediment before it becomes a problem.

- Develop and implement a pond water quality monitoring and sampling program before, during and after construction to track quality over time and historical trends.

## *Pond Water-Level Monitor*

### Principles

Evaporation losses are higher in some regions than others and vary from year to year and within the year. However, evaporative losses could be as high as 15 centimetres per month during the summer. Overflow spillways should be incorporated into the construction and management of ponds/reservoirs to control potential flooding.

### Best Management Practices

- A pond should hold surplus storage of at least 10 percent of full storage.
- Provide an alternative source for ponds that may require supplemental recharge from another water source such as a well during high-demand periods.
- Estimated losses from evaporation and seepage should be added to the recommended depth of the pond.

## *Metering*

### Principles

Rainfall may vary from location to location on a course; the proper use of rain gauges, rain shut-off devices, flow meters, soil moisture sensors, and/or other irrigation management devices should be incorporated into the site's irrigation schedule. It is also important to measure the amount of water that is actually delivered through the irrigation system, via a water meter or a calibrated flow-measurement device. Knowing the flow or volume will help determine how well the irrigation system and irrigation schedule are working. Monitoring of water takings is also a general compliance condition of all PTTWs in Ontario.

### Best Management Practices

- Calibrate equipment periodically to compensate for wear in pumps, nozzles, and metering systems.
- Properly calibrated flow meters, soil moisture sensors, rain shut-off devices, and/or other automated methods should be used to manage irrigation.
- Paddle-wheel flow sensors need straight pipe run requirements upstream and downstream of the sensor to prevent turbulence and inaccurate readings. There must be 10 times pipe diameter of straight pipe upstream of the sensor and 5 times pipe diameter of straight pipe downstream of the sensor. These sensors do not provide accurate low flow readings.

- Magnetic flow meters provide more accurate flow readings (even for low flow) and require less strict straight pipe requirements.
- Flow meters can be used to determine how much water is applied.

## *Irrigation Leak Detection*

### Principles

Irrigation systems are complex systems that should be closely monitored to ensure leaks are quickly detected and corrected. Golf courses with fixed speed pumps and without hydraulic pressure-sustaining valves are much more prone to irrigation pipe and fitting breaks because of surges in the system, creating more downtime for older systems. A good preventive maintenance program is very important.

### Best Management Practices

- Monitor water meters or other measuring devices for unusually high or low readings to detect possible leaks or other problems in the system. Make any needed repairs.
- An irrigation system should also have high and low-pressure sensors that shut down the system in case of breaks and malfunctions.
- The system should be monitored daily for malfunctions and breaks and the amount of water pumped each day must be documented.
- Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings). If the system requires frequent repairs, determine why these failures are occurring. Pipe failures may be caused not only by material failure, but also by problems with the pump station.
- Ensure that control systems provide for emergency shutdowns caused by line breaks, and allow maximum system scheduling flexibility.

## *Sprinkler Maintenance*

### Principles

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

rodent damage, or frequent lightning or power surges. Control tubing problems could result from poor filtration.

## Best Management Practices

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

compute current operating costs and compare possible future costs after a renovation.
- Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings).

## *System Maintenance*

### Principles

Routine system maintenance should be completed by golf course superintendents or owners to ensure water quality and responsible use of the irrigation water supply. System checks and routine maintenance should include pumps, valves, programs, fittings, and sprinklers to ensure that it is performing as intended. Further an irrigation system should be calibrated regularly by conducting periodic irrigation audits to check actual water delivery and nozzle efficiency.

### Best Management Practices

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

## Preventative Maintenance

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

## *System Renovation*

- Appropriate golf course renovations can improve system efficiencies, conserve water, improve playability, and lower operating costs.
- Correctly identify problems and their cost to determine which renovations are appropriate.
- Determine the age of the system to establish a starting point for renovation.

- Identify ways to improve system performance by maximizing the efficient use of the current system.
- Routinely document system performance to maximize the effectiveness of the renovation.
- Complete a cost-benefit analysis to determine the overall feasibility of completing a renovation project.

## *Winterization and Spring Start Up*

### Principles

Winterization of the irrigation system is important to protect the system and reduce equipment failures resulting from freezing. Spring startup involves refilling and repressurizing the irrigation for the upcoming season.

### Best Management Practices

- Conduct a visual inspection of the irrigation system: inspect for mainline breaks, low pressure at the pump, and head-to-head spacing.
- Conduct a catch-can test to audit the system.
- Flush and drain above-ground irrigation system components that could hold water.
- Remove water from all conveyances and supply and distribution devices that may freeze with compressed air or open drain plugs at the lowest point on the system.
- Clean filters, screens, and housing; remove drain plug and empty water out of the system.
- Secure systems and close and lock covers/compartment doors to protect the system from potential acts of vandalism and from animals seeking refuge.
- Remove drain plug and drain above-ground pump casings.
- Record metering data before closing the system.
- Secure or lock irrigation components and electrical boxes.
- Perform pump and motor servicing/repair before winterizing.
- Slowly recharge the piping network in the spring with water allowing evacuation of air. Inspect for corrective maintenance issues.
- Ensure proper irrigation system drainage design.

## *Sensor Technology*

### Principles

To prevent excess water use, irrigation scheduling should take into account plant water requirements, recent rainfall, recent temperature extremes, and soil characteristics. Irrigation management and control devices need to be installed correctly for proper irrigation management. Soil moisture sensors and other irrigation management tools

should be installed in representative locations and maintained to provide the information necessary for making good irrigation management decisions.

Rain gauges are necessary measurement tools to track how much rain has fallen at a specific site on the golf course. On some courses, more than one station may be necessary to get a complete measure of rainfall or evaporation loss. The use of soil moisture probes and inspections for visual symptoms such as wilting turf, computer models, and tensiometers may supplement these measurements. Computerized displays are available to help visualize the system. Predictive models based on weather station data and soil types are also available. These are relatively accurate and applicable, especially as long-term predictors of annual turf water requirements. Weather data such as rainfall, air and soil temperature, relative humidity, and wind speed are incorporated into certain model formulas, and soil moisture content is estimated. Models, however, are only as effective as the amount of data collected and the number of assumptions made. It is best to have an on-site weather station to access daily weather information and ET to determine site specific water needs.

### Best Management Practices

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

## *Maintained Turf Areas*

### Principles

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

## Best Management Practices

- The irrigation system should be designed and installed so that greens, tees, fairways, roughs, bunkers, and slopes can be watered independently.
- Account for nutrients in effluent supply when making fertilizer calculations.
- Install part-circle heads that conserve water and reduce unnecessary stress to all irrigated areas.
- Avoid use of a global setting; make adjustments to watering times per head.
- Base water times on actual site conditions for each head and zone.
- Adjust irrigation run times based on current local meteorological data.
- Use computed daily ET rate to adjust run times to meet the turf's moisture needs.
- Manually adjust automated ET data to reflect wet and dry areas on the course.
- Install rain switches to shut down the irrigation system if enough rain falls in a zone.
- Use soil moisture sensors to bypass pre-set or to create on-demand irrigation schedules.
- Permanent irrigation sprinklers and other distribution devices should be spaced according to the manufacturer's recommendations.
- Spacing should be based on average wind conditions during irrigation.
- Triangular spacing is more uniform than square spacing.
- Periodically perform catch-can uniformity tests.
- Reducing dry spots and soil compaction improves water infiltration, which in turn reduces water use and runoff in other areas.
- Irrigation should occur in the early morning hours before air temperatures rise and relative humidity drops.
- Base plant water needs on evapotranspiration rates, recent rainfall, recent temperature extremes and soil moisture.
- Use mowing, verticutting, aeriation, wetting agents, nutrition, and other cultural practices to control water loss and to encourage conservation and efficiency.
- Depending on physical soil characteristics and turf type, using solid- tine aeration equipment in place of verticutting is an option.
- Slicing and spiking help relieve surface compaction and promote better water penetration and aeration.
- Visually monitor for localized dry conditions or hot spots to identify poor irrigation efficiency or a failed system device.
- Use predictive models to estimate soil moisture and the best time to irrigate.
- Install in-ground (wireless) soil moisture sensors or use hand-held moisture meters in the root zone for each irrigation zone to enhance scheduled timer-based run times.
- An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.
- Place soil moisture sensors in a representative location of the irrigation zone.
- Install soil moisture sensors in the driest irrigation zone of the irrigation system.
- Wireless soil moisture systems should be installed to prevent damage from aeration.

## *Non-Play and Landscape Areas*

### Principles

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

### Best Management Practices

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

## *Groundwater Wellhead Protection*

### Principles

Wellhead protection is the establishment of protection zones and safe land-use practices around water supply wells in order to protect aquifers from potential contamination. It also includes protecting wellheads from physical impacts, keeping them secure, and sampling wells according to the monitoring schedule required by the regulating authority, which is often regulated at a local and/or regional government level. When groundwater takings exceed 50,000L/day a water taking permit is required from the Ministry of Environment, Conservation and Parks under Section 34 of the Ontario Water Resources Act.

When considering the construction of new irrigation wells, hiring a licensed well driller and a Hydrogeologist early in the planning process is key to the finding and securing approvals of long-term high-capacity irrigation wells. Development of a groundwater well should be incorporated into an overall water management plan for irrigation water supplies. A preliminary desktop review of the site by a hydrogeologist or engineer may help identify the potential of establishing a groundwater supply to meet irrigation needs before a well is constructed. Once a well is drilled, testing and analysis of the impacts

from the groundwater taking will be required to support an application for a water taking permit from the MECP.

## Best Management Practices

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

# Surface Water Management

## *Introduction*

Flooding. Photos provided by Owen Russell, OGSA Past President, Markland Wood GC.

Although golf courses are typically large properties ranging in size from 60 to 200 acres, they are just one link in a stormwater management chain. In general terms, a quantity of stormwater enters a golf course area and is supplemented by what actually falls within the golf course property, and then the stormwater leaves the golf course property. Therefore, golf courses are realistically capable of having only a small impact on major stormwater flow events. That potential impact should be to only add small increments of stormwater water over a given period of time, or in an ideal case retain stormwater and provide for increased “detention”.

When golf courses are designed, engineered, and constructed properly, the drainage capability of the site is guided by an average rainfall event of a given frequency. For example, typically, a golf course drainage system is designed to detain a two- or five-year rain event, so in other words, when that particular rain event happens, the golf course will be able to be reasonably drained in a matter of hours, as excess water that is not absorbed by the soil will flow through to the drainage system, temporarily held, and then leaves the property as stormwater. In some cases, golf courses and other recreational facilities may be required by local or provincial regulatory authorities to be designed to handle a 20, 50 or 100 year rain event, which means the golf course must detain, or provide storage, for more water for a longer period of time. This ability to detain large amounts of water requires engineering and extensive grading to prevent physical damage to the property.

The following Best Management Practices (BMP) are intended to prolong the detention process as long as possible, harvest as much of the stormwater into surface and/or underground storage facilities (ponds/reservoirs/storage tanks) as reasonably possible, and where possible improve the overall quality of water leaving the property.

## Storm Water Collection

### Principles

When the golf course is properly designed, rain and runoff captured in water hazards and stormwater ponds may provide some or all of the supplemental irrigation water necessary to irrigate a golf course, although additional irrigation water sources may be required during drought conditions. Stormwater collection systems should be considered part of the overall treatment of stormwater management. Stormwater collection is also desirable where the lowest quality of water is needed to conserve potable water, maintain hydrologic balance, and improve water treatment. This practice uses natural systems to cleanse and improve water treatment.

### Best Management Practices

- Install berms and swales to capture pollutants and sediments from runoff before it enters the irrigation storage pond.
- Monitor pond water level for water loss (seepage) to underground systems. If seepage is occurring, it may be necessary to line or seal the pond, or install pumps to relocate water.
- Install water-intake systems that use horizontal wells placed in the subsoil below the storage basin; use a post pump to filter particulate matter.
- A backup source of water should be incorporated into the management plan.
- Inspect irrigation pumps, filtration systems, conveyances and control devices to prevent/correct system issues.

## *Regulatory Considerations*

### Principles

Course owners and superintendents should investigate provincial and/or local regulatory requirements that apply to the golf facility 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 regulatory agencies before managing golf course lakes and wetland areas.
- Consult with local conservation authorities, 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 under the Ministry of the Environment, Conservation and Parks.
- Golf course management may be affected by Total Maximum Daily Loading (TMDL), mitigation, and watershed basin management action plans (BMAP).
- Wetlands are protected areas; and consultation with local conservation authorities should occur before altering natural aquatic areas.
- Constructed wetlands should have an impervious bottom to prevent groundwater contamination.
- Studies of water supplies are needed for irrigation systems, including studies of waterbodies or flows on, near, and under the property to properly design a course's stormwater system and water features to protect water resources.

## *Water Quality Protection*

### Principles

An aquatic plant management strategy should be developed to address the intended uses of the waterbody with the goal of maintaining, and if possible, enhancing local water quality. Proper documentation of the site's physical attributes and location, the presence of invasive or weedy species, aesthetics, watershed and groundwater assessments, and other environmental considerations should be incorporated into the strategy. Only licensed individuals or contractors should be allowed to select and apply aquatic pesticides.

### Best Management Practices

- Accommodate natural lake processes in the construction of lakes, ponds and reservoirs; include herbaceous and woody vegetation and emergent and submergent shoreline plants to reduce operational costs.
- Use integrated pest management (IPM) strategies and native or naturalized vegetation wherever practical.
- Apply appropriate herbicides to minimize damage to non-target littoral plantings.

- Maintain a narrow band of open water at the pond edge to control the expansion of plants into more desirable littoral plantings.
- Use appropriate aquatic herbicides to prevent turfgrass injury and to protect water quality and wildlife habitat.
- Irrigation should not directly strike or run off to waterbodies, and no- fertilization buffers should be maintained along water edges.
- Outline goals and priorities to guide the development of the BMP necessary to support the lake/aquatic management plan.
- Superintendents should monitor designated waters in their area for the persistence of toxic herbicides and algaecides in the environment.
- Secondary environmental effects on surface water and groundwater from the chemical control of vegetation should be monitored and recorded.
- Apply fertilizer and reclaimed (reuse) irrigation/fertigation appropriately to avoid surface water and groundwater contamination.
- Apply copper products per label instructions to reduce the risk of impairing water quality and causing negative biological impacts.
- Identify position of property in relation to its watershed.
- Identify overall goals and validate concerns of the local watershed.
- Identify surface water and flow patterns.
- Indicate stormwater flow as well as existing and potential holding capacity.
- Indicate impervious surfaces, such as buildings, parking lots, or pathways.
- Indicate major drainages and catch basins that connect to local surface water bodies.
- Identify and understand depth to water tables and soil types.
- Locate and protect wellheads in accordance with Provincial Regulations.

## *Dissolved Oxygen*

### Principles

Every golf course should have a plan to monitor water quality and the potential impacts the golf course may be having on the environment. Water quality monitoring should be used to determine whether upstream drainage areas are changing and impacting the water quality entering the golf course, or whether the golf course is having a positive, neutral, or negative effect on water quality. Water quality monitoring also provides historical reference on the golf course's potential environmental impact. A water-quality monitoring plan should be prepared to ensure the ongoing protection of groundwater and surface-water quality after construction has been completed.

The same sites should be monitored during the pre-construction 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 Total Maximum Daily Load (TMDL) Programs). Typically, samples should be analyzed for nutrients, pH and alkalinity, sediments, and suspended solids, dissolved oxygen (DO), heavy metals, and any

pesticides expected to be used on the golf course. Ongoing, routine water sampling provides meaningful trends over time. A single sample is rarely meaningful in isolation. Post-construction sampling of surface-water quality should begin with the installation and maintenance of golf course turf and related landscaping.

Samples should be collected a minimum of three times per year. If there is 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.

## QA/QC

Sampling parameters should be determined based on golf course operation and any basin-specific parameters of concern, and/or specific concerns identified by local regulatory authorities. The purpose of quality assurance/quality control (QA/QC) is to ensure that chemical, physical, biological, microbiological, and toxicological data are appropriate and reliable. Data should be collected and analyzed using scientifically sound procedures. However, even if the data are only for proprietary use and are not reported to any regulatory agency, it is strongly recommended that a certified laboratory be used and all QA/QC procedures followed. Golf course management must have good data to make good decisions. If a golf course should ever want to produce data for an agency or go to court to defend the facility from unwarranted claims, the data collected must meet QA/QC standards to be defensible as evidence.

## Best Management Practices

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

- Sod, sprig, or reseed bare or thinning turf areas.
- Mulch areas under tree canopies to cover bare soil.
- Avoid the use of trimmers along the edge of the water body.
- Mow lake and pond collars at a higher height to slow and filter overland flow to waterbodies, or maintain a wide naturalized buffer
- Remove excess sediments to reduce irrigation system failures.
- Treat dredged materials as a toxic substance. Avoid contact with turf.
- Locate littoral shelves at the pond's inlets and outlets to reduce problems with the playability and maintainability of a water hazard.
- Seek professional assistance from an environmental specialist to design an appropriate water sample collection program/strategy
- Determine which sites will be analyzed, and use reputable equipment and qualified technicians to conduct the sampling.
- Demonstrate responsible land and water use practices based on water data.
- Define data values appropriately based on the associated BMP used to protect water quality.
- Record observations of fish, wildlife, and general pond conditions.

## *Aquatic Plants*

### Principles

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

### Best Management Practices

- Properly designed ponds with a narrow fringe (naturalized) of vegetation along the edge are more resistant to problems than those with highly maintained turf.
- In ponds with littoral plantings, problem plants should be selectively controlled without damaging littoral shelves.

- Encourage clumps of native emergent vegetation at the shoreline.
- A comprehensive lake management plan should include strategies to control the growth of nuisance vegetation that can negatively affect a pond's water quality and treatment capacity.
- Frequently remove filamentous algae by hand and/or frequently apply algaecide to small areas of algae (spot treatment).
- To reduce the risk of oxygen depletion, use an algaecide containing hydrogen peroxide instead of one with copper.

## *Human Health Concerns*

### Principles

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

### Best Management Practices

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

## *Floodplain Restoration*

### Principles

The Re-establishment of natural water systems helps mitigate flooding and provide for stormwater management. Address high sediment and nutrient loads and vertical and lateral stream migration causing unstable banks, flooding, and reductions in groundwater recharge. Land use decisions and engineering standards must be based on the latest research science available.

### Best Management Practices

- Install stream buffers to restore natural water flows and flooding controls.
- Install buffers in play areas to stabilize and restore natural areas that will attract wildlife species.
- Install detention basins to store water and reduce flooding at peak flows.

## *Stormwater, Ponds, and Lakes*

### Principles

Stormwater is the conveying force behind what is called nonpoint source pollution. Nonpoint pollution, which is both natural and caused by humans, comes not from a pipe from a factory or sewage treatment plant, but from daily activity. Pollutants commonly found in stormwater include the microscopic wear products of brake linings and tires; oil; shingle particles washed off roofs; soap, dirt, and worn paint particles from car washing; leaves and grass clippings; pet and wildlife wastes; lawn, commercial, and agricultural fertilizers; and pesticides.

The control of stormwater on a golf course is more than just preventing the flooding of the clubhouse, maintenance, and play areas of the golf course. In addition to controlling the amount and rate of water leaving the course, it involves storing irrigation water, controlling erosion and sediment, enhancing wildlife habitat, removing waterborne pollutants, and addressing aesthetic and playability concerns. Most golf courses plan their pond, reservoirs and water hazards to be a part of the stormwater control and treatment system. Lakes and ponds may also be used as a source of irrigation water and it is important to consider these functions when designing and constructing the ponds and reservoirs. Peninsular projections and long, narrow fingers may prevent mixing, and ponds that are too shallow may reach high temperatures and lead to low oxygen levels, and promote algal growth and excess sedimentation. Stormwater treatment is best accomplished by a treatment train approach, in which water is conveyed from one treatment to another by conveyances that themselves contribute to the treatment. Source controls are the first car on the BMP treatment train. They help to prevent the generation of stormwater or introduction of pollutants into stormwater. The most effective method of stormwater treatment is not to generate stormwater in the first place, or to remove it as it is generated.

### Best Management Practices

- Install swales and slight berms where appropriate around the water's edge, along with buffer strips, to reduce nutrients and contamination.
- Design stormwater treatment trains to direct stormwater across vegetated filter strips (such as turfgrass), through a swale into a wet detention pond, and then out through another swale to a constructed wetland system.
- Where possible ensure that no discharges from pipes go directly to surface water features.
- Eliminate and/or minimize areas that directly connect impervious areas to surface water sources.
- Use vegetated swales to slow and infiltrate water and trap pollutants in the soil, where they can be naturally destroyed by soil organisms.
- Use depressed landscape islands in parking lots to catch, filter, and infiltrate water, instead of letting it run off. When significant rainfall events occur, an

elevated stormwater drain inlet allows the island to hold the treatment volume and settle out sediments, while allowing the overflow to drain away.

- Maximize the use of pervious pavements, such as brick or concrete pavers separated by sand and planted with grass. Special high- permeability concrete is available for cart paths or parking lots.
- Disconnect runoff from gutters and roof drains from impervious areas, so that it flows onto permeable areas that allow the water to infiltrate near the point of generation.
- Golf course stormwater management should include “natural systems engineering” or “soft engineering” approaches that maximize the use of natural systems to treat water.
- Ensure that no discharges from pipes go directly to water.
- Use a treatment train approach.
- Institute buffers and special management zones.

# Water Quality Monitoring and Management

## *Introduction*

Photo taken by Curtis Hartley, Mississaugua G&CC.

The quality of irrigation water has a direct impact on the soil and performance of turfgrass. Understanding the chemistry of irrigation water sources is key in maintaining the highest quality of turf and minimizing impacts to the environment. The source of water used for irrigation should be considered when developing an overall water quality monitoring and management program.

## *Regulatory Considerations*

### Principles

Water Quality Monitoring is generally not a regulatory requirement unless it is captured under a specific municipal Site Plan Approval or required as part of a Ministry of the Environment, Conservation and Parks (MECP) approval under the Permit to Take Water (PTTW) or Environmental Compliance Approval. Nonetheless, in an effort to protect surface and groundwater quality, the following best management practices should be considered and where possible implemented as part of the planning and/or on-going operation of the golf facility.

### Best Management Practices

- Studies of water supplies are required for both surface water and groundwater sources, in order for them to be used for irrigation water supply. If water taking exceeds 50,000L/day a Permit-to-Take Water (PTTW) for the water taking will be required under the Ministry of the Environment, Conservation and Parks (MECP). As part of the PTTW approvals process, it is likely that supporting technical studies will be required to justify the water taking and that other regulatory agencies may also be consulted for input into managing and protecting the water resource.
- The use of onsite wastewater treatment systems (i.e., septic beds) is regulated by the Local Health Unit and/or the MECP through the ECA process. Typically

onsite wastewater treatment systems require ongoing monitoring and reporting as well as meeting performance objectives or targets. Working with a licensed operator or consulting engineer may be required.

- Aquatic management of plants may be required under the planning and permitting stage of a new golf course development and/or specific golf course construction project. Consult with local conservation authority before undertaking any project within a wetland area and/or creek or river system.
- The incorporation of native riparian areas or vegetative buffers around water features should be considered in the design process as well as the use of infiltration swales and sediment forebays in pond designs. Pond Aeration should also be considered in the design process to manage vegetation and increase oxygen.
- The disposal of sediments from surface-water ponds (stormwater detention) should be prohibited, and may be subject to regulation, permitting, and approvals.
- Wetlands are environmentally protected areas; consult with your local conservation authority prior to altering natural aquatic areas.
- Constructed wetlands should have an impervious bottom to prevent groundwater contamination.

## *Site Analysis*

### Principles

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

### Best Management Practices

- Accommodate natural lake processes in the construction of lakes and ponds; include herbaceous and woody vegetation and emergent and submergent shoreline plants to reduce operational costs.
- Use Integrated Pest Management (IPM) and native or naturalized vegetation wherever practical.
- Apply appropriate herbicides to minimize damage to non-target littoral plantings.
- Maintain a narrow band of open water at the pond edge to control the expansion of plants into more desirable littoral plantings.
- Use appropriate aquatic herbicides to avoid turfgrass injury.
- Irrigation should not directly strike or runoff into waterbodies and application 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 on the property 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.
- Identify position of property in relation to its local and regional watershed.
- Identify overall goals and qualify concerns of the local watershed stakeholders.
- Indicate surface water and flow patterns, as well as existing and potential water retention areas.
- Indicate impervious surfaces, such as buildings, parking lots, or pathways.
- Indicate major drainages and catch basins that connect to local surface water bodies.
- Identify and understand depth to water tables and soil types.
- Locate and protect wellheads in accordance with the Ontario Water Resources Act Reg.903 Wells.

# *Water Quality Sampling Program*

## Principles

Every golf course should have a plan to monitor the potential environmental impacts 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 property, or whether the golf course is having a positive, neutral, or negative impact on water quality. It also provides a body of evidence on the golf course's environmental impact. Regular monitoring over time can help establish on-going trends or change to the water quality.

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 pre-construction phase, although the monitoring plan can be modified based on site-specific conditions. Sampling parameters are determined based on golf course operation and water source-specific parameters of concern. 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. A single sample is rarely meaningful in isolation, but rather regular water sampling provides meaningful trends over time. Post-construction surface-water quality sampling should begin with the installation and maintenance of golf course turf and landscaping. Samples should be collected a minimum of three times per year. When sampling surface water locations, 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 add additional samples if a significant change has been made in course operation or design that could affect nearby water quality. Golf courses should also sample for macroinvertebrates as determined useful by water quality specialists.

## Best Management Practices

- Establish dissolved oxygen (DO) thresholds to prevent fish kills (occur at levels of 2 ppm), and if required use artificial aeration (diffusers).
- Reduce stress on fish; keep DO levels above 3 ppm.
- Select algaecides containing hydrogen peroxide instead of one containing copper or endothall to treat high populations of phytoplankton.
- Use IPM principles to limit excess use of pesticides.
- Spot-treat filamentous algae or frequently remove algae by hand to prevent lowering oxygen concentrations in water.
- Use dyes and aeration to maintain appropriate light and DO levels.
- Apply algaecides to small areas to prevent fish mortality; do not treat the entire pond at once.

- Coordinate construction/renovation activities to minimize the amount of disturbed area and possible risk of contamination via runoff.
- Plan construction/renovation activities in phases to limit soil disruption and movement.
- During construction, inspect erosion and sedimentation measures routinely and after each precipitation event. Repair any damaged sections or remove any excess sediment loading as required.
- Sod, sprig, or reseed bare or thinning turf areas.
- Mulch areas under tree canopies to cover bare soil.
- Avoid the use of trimmers along the edge of the water body.
- Mow lake and pond collars at 5 cm or higher to slow and filter overland flow to water bodies. Use of a vegetative buffer or naturalized riparian area is recommended when possible.
- Remove excess sediments to reduce irrigation system failures.
- Properly test dredged pond materials and avoid contact with turf.
- Locate littoral shelves at the pond's inlets and outlets to reduce problems with the playability and maintainability of a water hazard.

## *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 (pre-construction), 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, and if a golf course should ever want to produce data for an agency or resolve a dispute from neighbouring property owners. Any collected and sampled data must meet QA/QC standards to be defensible.

#### Best Management Practices

- Seek professional assistance from an environmental specialist to design an appropriate water sample collection program.

- Determine what sites will be analyzed and use reputable equipment and qualified technicians.
- When sampling, minimize the contact of extraneous contamination with sample containers and equipment. Common extraneous contaminants include perfumes, cosmetics, bug spray, lotion, markers, spray lubricants (e.g. WD40®) and engine fumes. Sample up wind or remove extraneous contaminants before opening containers and collecting samples.
- Confirm sampling QA/QC measures and procedures with a certified laboratory and use only approved sampling containers.
- 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 general 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 BMP 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 buffer areas are above the high-water mark and should be unfertilized and left in a natural state.
- Reduce the frequency of mowing at the lake edge and collect or direct clippings to upland areas.
- Institute buffers and special management zones.
- 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 height of cut in the riparian zone to filter and buffer nutrient movement to the water.
- Use a deflector shield to prevent fertilizer and pesticide prills from contacting surface waters.

- Apply fertilizer and pesticides based on the effective swath; keep application on target and away from buffers or channel swales.
- Use a swale and berm system to allow for resident time (ponding) for water to infiltrate through the root zone to reduce lateral water movement to the surface water body.
- Maintain a riparian buffer to filter the nutrients in stormwater runoff.
- An appropriate-sized buffer (steeper slope requires great buffer width) of turf mowed at a higher height of cut and minimally fertilized with enhanced-efficiency fertilizers can provide an effective buffer.
- Use plant buffers with native species to provide pleasing aesthetics, habitat, and food sources for wildlife.
- Ideally, littoral zones should have a slope of no less than 4:1 and planting on slopes with less than 4:1 may not be as successful over the long term.
- Encourage clumps of native emergent vegetation at the shoreline.
- Establish special management zones around pond edges.
- Reverse-grade around the perimeter to control surface water runoff into ponds and reduce nutrient loads.
- 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. The use of basing logs and natural channel/pond techniques will promote aquatic and biological diversity.
- 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.
- Practice good fertilizer management to reduce the nutrient runoff into ponds that causes algae blooms and ultimately reduces DO levels.
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered DO levels.
- Aerate shallow ponds of less than 2m in depth to maintain acceptable DO levels.
- Where applicable, aerate at night to control oxygen depletion in any pond.
- Install desirable plants to naturally buffer DO loss and fluctuation.
- Dispose of grass clippings where runoff and wind will not carry them back to the lake.
- Nutrient rich runoff encourages algae blooms and other phytoplankton; apply appropriate fertilizer rates and application buffers.
- Dredge or remove sediment to protect beneficial organisms that contribute to the pond's/reservoir's food web and overall health.

## *Wetland Protection*

### Principles

Wetlands are key environmental features and will 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 compatible 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 neighbour.

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 wetlands for stormwater filtration are always encouraged and are treated as infrastructure.

### 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 30m buffer along provincially significant wetlands.
- Establish and maintain a 10m riparian buffer around local wetlands, springs, spring runs, creeks, and rivers, and then establish a maintenance buffer of 20m beyond the 10m riparian buffer.

## *Stormwater Management*

### Principles

Controlling stormwater on a golf course is more than just preventing the flooding of the clubhouse, maintenance, and play areas. In addition to controlling the amount and rate of water leaving the course, stormwater management 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 vegetated swales to slow and infiltrate water and trap pollutants in the soil, where they can be naturally destroyed by soil organisms.
- Maximize the use of pervious pavements, such as brick or concrete pavers separated by sand and planted with grass.
- Special high-permeability concrete is available for cart paths or parking lots.

- 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*

### Principles

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. For large renovation projects or a new construction, erosion and sediment controls will likely be part of any site plan approval or construction permit process and should be considered in the design stage.

### 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.
- During construction, inspect erosion and sedimentation measures routinely and after each precipitation event. Repair any damaged sections or remove any excess sediment loading as required.
- Internal golf course drains should not drain directly into an open water body, but should discharge through pre-treatment 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.

## *Sodic/Saline Conditions*

### Principles

All natural waters contain soluble salts; however, the amount and type of salts they contain vary greatly.

For example, irrigation water can degrade when groundwater wells are pumped at high rates or for prolonged periods. Sometimes “up-coning” can occur from pumping groundwater wells, whereby saline water, rather than freshwater, is drawn into the well. Saline water typically is unsuitable for irrigation because of its high content of TDS. Application of snow melt/salting throughout the winter months in areas with drainage to surface water features and storm water facilities should be reviewed and managed accordingly. Road salting can result in a significant influence on the quality of surface/groundwater, particularly in the spring and during large discharge events.

### 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 the 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.
- Use BMP for the application of road salt and ice melters around areas that drain into surface water features.
- Select alternative landscape plants that are more salt tolerant.
- Reduce salt accumulations in the soil by flushing soils as needed with a higher-quality water source.
- Design irrigation systems to account for flushing of salt accumulation from soil. Amend soil and water to remove salt ions from affected areas.
- Evaluate BMP to determine effectiveness toward managing sodic/saline conditions. A low salt management plan should be developed to counter high TDS from irrigation sources. Consult with a certified soil consultant/agronomist to combat high TDS.

# Nutrient Management

## *Introduction*

In the greenhouse. OGSA image. ONCourse, August 2017, pg. 23.

Proper nutrient management plays a key role in minimizing potential impact to the environment, while at the same time having the potential to increases course profitability. Among other benefits, applied nutrients increase the available pool of nutrients and allow turfgrass to recover from damage, increase its resistance to stress, and increase its playability and aesthetics. One of the major concerns of excess fertilization is nitrogen and phosphorous migration through surface runoff and the potential risk of negative environmental impact. Nutrients may move beyond the turfgrass via leaching or runoff, which may directly impact our environment, and the impacts of nitrogen and phosphorus management on water quality has been well documented with solutions widely discussed throughout the golf industry. The goal of a proper nutrient management plan should be to apply the minimum necessary nutrients to achieve an acceptable playing surface and apply these nutrients in a manner that maximizes plant uptake and minimizes potential environmental impact. A property designed nutrient management program should incorporate the 4R concept: Right Fertilizer, at the Right Rate, at the Right Time and in the Right Place.

Selection of BMP's will however, vary by location, local soil and climatic conditions, turfgrass species, management conditions and other site-specific factors.

Fertilizer application records should be updated immediately after application and the records should be retained for a minimum of three (3) years and the following information is recommended:

- Name of applicator
- Date of application (month, day, year)
- Location of fertilizer application and rate of application of material applied
- Analysis of fertilizer applied and application method
- Irrigation applied if applicable
- Soil conditions at time of application
- Temperature, precipitation, and other weather conditions

- Weather forecast for the day following the application

## *Regulatory Considerations*

### Principles

There are no federal or provincial regulations currently in place to manage nutrient risks on golf courses in Ontario, nonetheless, developing a nutrient management plan within your golf course property will act to minimize the potential for environmental impact to your site and surrounding area. 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.

### Best Management Practices

- Identify who must be licensed.
- Describe differing licenses, if applicable.
- Provide the minimum requirement.
- Detail the Continued Education Unit required to maintain the license.
- Understand the value of training programs.

## *Soil Testing*

### Principles

Soil testing may or may not provide the appropriate answers to your nutrient management questions. Consult with the University of Guelph – Guelph Turfgrass Institute (GTI) or the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), or a certified soil consultant/agronomist to get the most current information and to better understand which soil test values are relevant in your location. Through proper sampling, laboratory analysis, interpretation of results, recommendations and record keeping, soil testing should be used to manage nutrients more efficiently.

### Best Management Practices

- Accurate and consistent sampling is essential to providing useful soil test information over time.
- Divide the course into logical components such as greens, fairways, tees, roughs, etc., for each hole.
- Ten to 15 soil samples should be randomly taken from each location and blended to provide a representative, uniform soil sample.
- Each soil sample should be taken from the same depth.
- Use an extractant appropriate for your soils.
- The same extractant must be used for each test in order to compare soil test results over time.

- Ensure the proper extractant is used for your soil type and matches the extractant used for your source of recommendations.
- Soil testing is a tool to assess the status of soil fertility and the potential for nutrient imbalances.
- If the location has correlation data between a given nutrient applied to soil and a response to that nutrient by turfgrass, then recommendations may provide expected results.
- If your location does not have correlation data, then soil test recommendations may be of little value.
- Keeping soil tests from prior years will allow you to observe changes over time.
- This practice can provide good evidence of the impact of your nutrient management plan.

## *Plant Tissue Analysis*

### Principles

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

### Best Management Practices

- Tissue samples may be collected during regular mowing.
- Do not collect tissue after any event that may alter the nutrient analysis. 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 submitting them to a local lab. Samples should be submitted within a few hours of collection.
- Poor-quality turfgrass that is of concern should be sampled separately from higher quality turfgrass.
- When turfgrass begins to show signs of nutrient stress, a sample should be collected immediately.
- More frequent tissue sampling allows a more accurate assessment of your turfgrass nutrient status changes over time.
- The quantity of tissue analysis you choose to use is entirely up to you and your needs. However, two to four tests per year are common on greens and one to two tests per year are common on tees and fairways.
- Keeping tissue tests from prior years will allow you to observe changes over time.

- Tissue testing can provide good evidence of the short-term impact of your nutrient management plan.

## *Fertilizers Used in Golf Course Management*

### Principles

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

### Terminology

Grade or analysis is the percent by weight of Nitrogen (N), Phosphorous fertilizer ($P_2O_5$) and Potassium fertilizer ($K_2O$) that is guaranteed to be in a fertilizer. Understanding the role of each macronutrient within the plant should provide you with a greater understanding of why these nutrients play such a key role in proper turfgrass management. A complete fertilizer contains N, $P_2O_5$, and $K_2O$.

### Label

The label is intended to inform the user about the contents of the fertilizer which, if understood and followed, will result in little to no environmental risk. The fertilizer label contains:

- Brand
- Grade
- Manufacturer's name and address
- Guaranteed analysis
- "Derived from" statement
- Net weight

### Macronutrients

Macronutrients are required in the greatest quantities and include nitrogen (N), phosphorus (P), and potassium (K). Understanding the role of each macronutrient within the plant should provide you with a greater understanding of why these nutrients play such a key role in proper turfgrass management. For sufficiency ranges for all macronutrients please consult OMFARA and/or GTI, or a certified soil consultant/agronomist for ranges in your location.

## 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 processes

- Mineralization – the microbial mediated conversion of organic N into plant-available NH4
- Nitrification – the microbial-mediated conversion of NH4 to NO3
- Denitrification – the microbial mediated conversion of NO3 to N2 gas; this primarily occurs in low oxygen environments and is enhanced by high soil pH
- Volatilization – the conversion of NH4 to NH3, N2O or NO gas
- Leaching – the downward movement of an element below the rootzone
- Runoff – the lateral movement of an element beyond the intended turfgrass location

## The release mechanism and factors influencing N release from available N sources.

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

## Soluble nitrogen sources

- Urea (46-0-0)
- Ammonium nitrate (34-0-0)
- Ammonium sulfate (21-0-0)

- Diammonium phosphate (18-46-0)
- Monoammonium phosphate (11-52-0)
- Calcium nitrate (15.5-0-0)
- Potassium nitrate (13-0-44)

## Slow-release nitrogen sources

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

**These include:**

- Sulfur-coated urea
- Polymer/resin-coated
- Isobutylidene diurea
- Urea-formaldehyde reaction products
- Many natural organic

## Sources of N that increase N uptake and length of action

### Urease and nitrification inhibitors

- Urease inhibitors reduce the activity of the urease enzyme resulting in a reduction of volatilization and an increase in plant-available N.
- Nitrification inhibitors reduce the activity of Nitrosomonas bacteria, which are responsible for the conversion of $NH_4$ to $NO_2$. This reduced activity results in a reduction of N lost via denitrification and an increase in plant-available N.

## The Role of Phosphorous (P)

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

Phosphorus forms high-energy compounds that are used to transfer energy within the plant. Phosphorous is a critical component of cell membranes and DNA making it essential for cell division, elongation and growth. Phosphorus may remain in an inorganic form or may become incorporated into organic compounds. Phosphorous application rates should be based upon soil test results derived from documented correlations demonstrating a turf response to soil test phosphorous levels.

## P deficiency symptoms

### For bentgrass and ryegrass

- 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.

### For bluegrass including annual bluegrass

- Premature yellowing of the older leaves; *3rd leaf from the sheath in annual bluegrass
- General modelled yellowing

## P fertilizer sources

- Diammonium phosphate
- Concentrated superphosphate
- Monoammonium phosphate
- Potassium phosphate
- Natural organics

## The Role of Potassium (K)

Potassium is generally not of environmental concern, but has an economic cost, particularly when potassium is over-utilized. Over application of potassium can be quite common. Generally, potassium concentrations in turfgrass tissue are about 1/3 to 1/2 that of nitrogen.

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

## K deficiency symptoms

Except under severe, documented deficiencies, K may not have an observable influence on turfgrass quality. Yellowing of older leaves followed by tip dieback and scorching of leaf margins have been reported.

## K fertilizer sources

- Potassium sulfate
- Potassium chloride
- Potassium nitrate
- Potassium phosphate

## 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). For sufficiency ranges for all secondary macronutrients, please consult OMFARA and/or GTI, or a certified soil consultant/agronomist for ranges in your location.

### The Role of Calcium (Ca)

- Primarily a component of cell walls and structure
- Found in gypsum, limestone, and calcium chloride

### The Role of Magnesium (Mg)

- Central ion in the chlorophyll molecule and chlorophyll synthesis
- Found in S-Po-Mg, dolomitic limestone, and magnesium sulfate

### The Role of Sulfur (S)

- Metabolized into the amino acid, cysteine, which is used in various proteins and enzymes
- Found in ammonium sulfate, elemental sulfur, gypsum, potassium sulfate

## Micronutrients

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

Micronutrients are just as essential for proper turfgrass health as macronutrients, but they are required in very small quantities compared to macronutrients. Micronutrients include iron (Fe), manganese (Mn), boron (B), copper (Cu), zinc (Zn), molybdenum (Mo), and Chlorine (Cl). For some sandy soils these micronutrients may be needed (depending on the soil type) but are often rarely required and can result in toxicity if over applied. For sufficiency ranges for all micronutrients please consult OMFARA and/or the GTI, or a certified soils consultant for sufficiency ranges in your location, although these nutrients rarely affect yield, they often do not have recommendations that are correlated to growth or yield.

### The Role of Iron (Fe)

- Is part of the catalytic enzymes and is required for chlorophyll synthesis and can cause a very dark green color when applied at higher rates
- 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

### The Role of Boron (B)

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

### The Role of Copper (Cu)

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

### The Role of Zinc (Zn)

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

### The Role of Molybdenum (Mo)

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

### The Role of Chlorine (Cl)

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

## *Soil pH*

### Principles

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 Ca2+ and neutralizes acidity.
- To lower soil pH, products containing elemental sulfur should be applied although this effect will be very short lived-in limestone-based soils with high pH.

- In some cases, utilizing injection pumps into irrigation water to address pH can be beneficial although this can be expensive and may result in dissolution of calcium carbonate (limestone) sands.

## *Nutrient Management*

### Principles

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

### Best Management Practices

- The objective of all nutrient applications is plant uptake and the corresponding desirable response.
- Apply nutrients when turfgrass is actively growing.
- Apply slow-release N fertilizers at the appropriate time of year to maximize the products' release characteristics.
- 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.
- The reduced height of cut , removal of clippings, and excessive traffic damage on putting greens results in an increased need for growth leading to an increase in nutrition.
- Tees and landing areas often have higher fertility requirements than fairways and roughs because they suffer constant divot damage.
- Fairways and roughs often require fewer nutrient inputs than other locations because of their increased height of cut, less damage, and clipping return.
- Exercise caution when applying nutrient applications during turfgrass establishment as these applications are particularly susceptible to loss via leaching and runoff.
- Provide appropriate rates and products to minimize N loss without reducing turfgrass establishment.
- Increased water applications
- Increased nutrients to hasten establishment
- Reduced root mass
- Be aware of the different types of spreaders and understand the advantages and disadvantages of each.
- Not all fertilizers can be spread with every spreader.  For example, if sulfur-coated urea was spread through a drop spreader, the sulfur coating could be damaged, essentially leading to an application of soluble urea.
- Choose the appropriate spreader for a given fertilizer material:

    - Walk-behind rotary
    - Drop spreader
    - Bulk rotary
    - Spray
- Calibration reduces environmental risk and increases profitability.
- Proper fertilizer storage, loading, and clean-up reduce environmental risk.
- Avoid applying fertilizer to soils that are at, or near, field capacity or following rain events that leave the soils wet.
- Do not apply fertilizer when Environment Canada has issued a weather warning. Environment Canada Alert Menu

# Cultural Practices

## *Introduction*

Aeration. Photos provided by Paul Snider, OGSA Director, Blue Mountain G&CC.

Cultivation practices are an important part of golf course turf management. Certain cultural practices such as mowing, verticutting, and rolling are necessary to provide a high-quality playing surface, while other practices such as aerification and sand topdressing are required to enhance plant and rootzone health. Heavily used areas such as putting greens often deteriorate because of compacted soil, thatch accumulation, low-mowing heights, and excessive use. Soil problems resulting from active use are usually limited to the top 76mm (3”) 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 at least temporarily negatively impacting the playing surface.

## *Mowing*

### Principles

Mowing is one of the most important cultural practices to consider when developing a management plan. The mowing practices implemented at a golf 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. Lower mowing heights will decrease root and rhizome growth as a result of plant stress associated with removal of leaf tissue. Infrequent mowing results in alternating cycles of vegetative growth followed by scalping, which further depletes food reserves of the plants.

Proper mowing height is a function of the species/cultivar being managed and the intended use of the site. Other factors influencing mowing height include mowing frequency, shade, mowing equipment, time of year, root growth, and abiotic and biotic

stress. Maintaining an optimal root-to-shoot ratio is critical. Turfgrass plants that are mowed too low 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 can support with photosynthesis. As a result, the turf will slough off the roots farthest from the shoot as the roots above take the limited needed resources. Root growth is least affected when no more than 30% to 40% of leaf area is removed in a single mowing (often referred to as the 1/3 rule). Failure to mow frequently enough and properly will result in weakened turf with poor density and quality.

## Best Management Practices

- Mowing frequency should increase during periods of rapid growth and decrease during dry, stressful periods.
- If turf becomes too tall, it should not be mowed down to the desired height all at once. Such severe scalping reduces turf density and can result in a dramatic reduction in root growth. Tall grass should be mowed frequently and height gradually decreased until desired height of cut is achieved.
- Shade impacts turfgrass growth by filtering out photosynthetically active radiation, effectively reducing photosynthetic activity. 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% and/or increase mowing frequency to improve the health of turf grown in a shaded environment. Reducing shade through strategic pruning and removals while ensuring that newly planted trees are properly located can make for healthier turf.
- The use of the plant growth regulators 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 overcast conditions or drought can have a significant impact on turf health. Increase mowing heights as use tolerances will allow in order to increase photosynthetic capacity and rooting depth of plants.
- Use mowing equipment that is mechanically sound and adjusted by a trained equipment technician. Ensure mowing blades and bedknives are sharpened regularly and consistent heights of cut are being maintained. Extra care should be taken after topdressing events as sand will negatively affect reel to bedknife contact and will cause abrasion to plants while mowing.
- Reel mowers are ideally suited for maintaining turfgrass stands that require a height of cut below 38mm (1.5”). 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 25mm (1”) 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, may contain debris that would damage other mowers, and do not have a high aesthetic requirement.
- Mowing patterns influence both the aesthetic and functional characteristics of a turf surface. Mowing directions should be alternated in order to maintain a more dense and upright growth habit and better ball roll on putting surfaces.
- 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 volume 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.
- Clippings should never be disposed of in waterways.

## *Cultivation*

### Principles

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

### Best Management Practices

- Core aerification involves removal of small cores or plugs from the soil profile. Cores are usually 6mm to 20mm (0.25” to 0.75”) in diameter.
- Annual core aerification programs should be designed to remove 15%-20% of the surface area over a number of events. High-traffic areas may require a minimum of two to four core aerifications annually.

- Core aerification should be conducted only when grasses are actively growing to aid in quick recovery of surface density.
- Vary depth of aerification events by incorporating varying length tines to prevent development of compacted layers in the soil profile as a result of cultivation.
- Solid tines cause less disturbance to the turf surface and can be used to temporarily reduce compaction and soften surface hardness during months when the growth rate of grasses has been reduced. Benefits of solid-tine aerification are temporary because no soil is removed from the profile.
- Deep-drill aerification creates deep holes in the soil profile through use of drill bits. Soil is brought to the surface and distributed into the canopy or removed. Holes can be backfilled with new root-zone materials if a drill-and-fill machine is used. These machines allow replacement of heavier soils with sand or other materials in an effort to improve water infiltration into the soil profile.
- Slicing and spiking reduce surface compaction and promote water infiltration with minimal surface damage.
- Slicing is faster than core aerification but is less effective. Slicing is best accomplished on moist soils.
- A spiker can break up crusts on the soil surface, disrupt algae layers, and improve water infiltration.
- Vertical mowing (verticutting) can be incorporated into a cultural management program to achieve a number of different goals.
- In order to promote a more vertical growth habit, the knives of the unit should be set to a depth that only impacts the canopy and does not enter into the soil profile. This will stand up the leaf blades and allow for more plant material to be mowed, creating a denser and more upright canopy, and essentially reducing grain.
- Deeper penetration of knives will stimulate new growth by cutting through stolons and rhizomes, while removing accumulated thatch.
- Verticutting depth for thatch removal should reach the bottom of the thatch layer and extend into the surface of the soil beneath the thatch.
- Dethatching with a verticutter is an aggressive practice that is not recommended on golf putting greens due to the damage that may occur and the extensive recovery time required.
- Initiate vertical mowing when thatch level reaches 6mm to 12mm (0.25” to 0.5 “) in depth. Shallow vertical mowing should be completed at least monthly on putting greens to prevent excessive thatch accumulation.
- Groomers, or miniature vertical mowers attached to the front of reels, are effective at improving management of grain and increasing plant density through cutting of stolons.
- Sand topdressing of the playing surface following core aerification and heavy vertical mowing will aid in recovery of turf and improve immediate playability.
- Rates will vary from 3mm to 6mm (0.125” to 0.25”) in depth and will depend on the capacity of the turf canopy to absorb the material without burying the plants.

- Light, frequent applications of topdressing sand on putting greens can smooth out minor surface irregularities and also aids in the management of thatch accumulation by diluting the thatch with mineral material.
- 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 have a negative impact on water infiltration.
- Daily rolling of putting surfaces following mowing can increase putting speeds by approximately 10%, allowing for improved ball roll without lowering height of cut.
- To minimize potential for compaction caused by rolling, use light weight rollers and assure that there is an adequate sand layer at the surface to resist compaction.

## *Shade and Tree Management*

### Principles

In general, most turfgrasses perform best in full sun. Excessive shade reduces photosynthesis and air circulation which impacts turf density and increases the susceptibility of the turf to pest and disease problems. Selective pruning and removals are often necessary and can be beneficial to the golf course.

### 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 sunlight availability and improve turf health.
- A sun/shade audit will help identify problem areas and help you understand the variability in sun angles at different times of the year and how this affects turf health.
- Conduct a tree survey that identifies each tree’s location, species, health, life expectancy, safety concerns, value and special maintenance requirements.
- Consult with a certified arborist/reputable tree management company on tree removals, pruning, or any tree health related issues if you aren’t comfortable performing these tasks.
- Develop a tree management plan for the property.

# Integrated Pest Management

## *Introduction*

European Chafer. Photo provided by Sara Stricker, Guelph Turfgrass Institute.

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

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

## *Regulatory Considerations*

### Principles

Federal and/or provincial regulations cover practically anyone who formulates, manufactures, markets, and/or uses pesticides in Ontario. The Ministry of the Environment, Conservation and Parks (MECP) regulates the sale, storage, use, transportation and disposal of pesticides in Ontario, and specific regulation provides for the education, licensing and/or permit requirements on pesticide use under the Pesticides Act and Ontario Regulation 63/09 (O. Reg. 63/09). Further, anyone that applies pesticides in Ontario must be licensed as an Exterminator or licensed Technician (operating under a licensed exterminator) under the Pesticides Act. The pesticide user should be familiar with Ontario Ministry of Agriculture, Food & Rural

Affairs (OMFRA) Publication 845 - Integrated Pest Management for Turf, and both the pesticide user and golf facility must be registered and accredited under the Integrated Pest Management Accreditation Program (IPMAP) which is administered under the Integrated Pest Management Council of Canada (IPM Council). Record-keeping of pesticide use is required by law and IPM principles require 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 the IPM Accreditation Program 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.
- Total Area treated (m2) and location
- Total amount of pesticide used
- Application equipment
- Additional remarks, such as the severity of the infestation or life stage of the pest
- Follow-up to check the effectiveness of the application

## *IPM Overview*

### Principles

The fundamental basis of an environmentally sound pest control program is a process called integrated pest control (IPM) which focuses on the basics of identifying the pests, choosing pest-resistant varieties of grasses and other plants, enhancing the habitat for natural pest predators, scouting to determine pest populations and acceptable thresholds, and using alternatives to chemical pesticides to combat pests and pathogens, and other less toxic alternatives to chemical pesticides whenever possible. When alternative treatments options are not available, choose chemical controls that have minimal effect on beneficial organisms and the environment and minimizing the risk 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.
- Knowledge of the pest's life cycle and which life stage to target (for an insect pest, whether it is an egg, larva/nymph, pupa, or adult).
- Use cultural, mechanical, or physical methods to prevent problems from occurring (e.g., prepare the site, select resistant cultivars), reduce pest habitat (e.g., practice good sanitation, carry out pruning and dethatching), and help promote biological control (e.g., provide nectar or honeydew sources).
- Decide which pest management practice is appropriate and carry out corrective actions. Direct control where the pest lives or feeds.
- Use preventive chemical applications only when your professional judgment indicates that properly timed preventive applications are likely to control the target pest effectively while minimizing the economic and environmental costs.
- Assess 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 the use of biological controls, cultural and physical methods, pest monitoring, and other applicable practices to reduce pest populations. Chemical pesticides are considered a last measure when threshold levels are exceeded or when alternative methods are not an option. A pest management strategy should be used only when the pest is causing or is expected to cause more damage than what can be reasonably and economically tolerated. A control strategy should be implemented that reduces the pest numbers to an acceptable level while minimizing harm to non-targeted organisms. When a pesticide application is deemed necessary, its selection should be based on effectiveness, toxicity to non-target species, solubility, persistence, cost, as well as site characteristics.

## 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.
- Assess 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 information-based 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 identified threshold levels warrant treatment. Using IPM is more challenging on golf courses than in an agricultural setting. The golf industry is sensitive to aesthetic damage, and golfers are often intolerant of anything that could affect the appearance of turfgrass and ornamental plants. Increased education of golfers and maintenance personnel could raise their tolerance of minor aesthetic damage without compromising plant health, play, and aesthetics.

### Best Management Practices

- Refer to OMAFRA Publication 845 as a general guideline to pest thresholds, but these thresholds will vary from property to property based on specific tolerance levels to potential damage caused by pests.
- Use preventive chemical applications only when professional judgment indicates that properly timed preventive applications are likely to control the target pest effectively while minimizing the economic and environmental costs.
- Record and use this information when making similar decisions in the future.

## *Monitoring*

### Principles

Monitoring, or scouting, is the most important element of a successful IPM program. Monitoring 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 information-based decisions can be made regarding how damaging they are and what control strategies are necessary.

- Train personnel to learn the pest's life cycle, and know which life stage to target (for an insect pest, whether it is an egg, larva/nymph, pupa, or adult).
- Train personnel to assess whether the corrective actions reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.
- Train personnel to document, identify, and record key pest activities on key plants.
- Look for signs of the pest. These may include mushrooms, insect frass, or webbing.
- Identify the symptoms of the pest. Look for symptoms such as chlorosis, dieback, growth reduction, defoliation, mounds, animal damage 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 on-going certification in the IPM Council of Canada Certification and Accreditation Program. Document, identify, and record key pest activities on key plants and locations. Learn 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). Assess 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 information-based decisions can be made regarding how damaging they are and what control strategies are necessary.

## *Turfgrass Selection*

### Principles

Selecting plant species or cultivars that are pest-resistant and adapted to the region in which they are grown is a very important part of IPM, and it 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 to minimize irrigation requirements, fertilization needs, and pesticide use.

### Best Management Practices

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

## *Biological Controls*

### Principles

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

### Best Management Practices

- Identify areas on the golf course that can be modified to attract natural predators, provide habitat for them, and protect them from pesticide applications.
- Install flowering plants that can provide parasitoids with nectar, or sucking insects (aphids, mealybugs, or soft scales) with a honeydew source.
- Avoid applying pesticides to roughs, driving ranges, or other low-use areas to provide a refuge for beneficial organisms.
- Release insect-parasitic nematodes to naturally suppress mole crickets and white grubs.

## *Pollinators*

### Principles

It is important to minimize the negative impacts on bees and beneficial arthropods. Pesticide applicators must use appropriate tools to help manage pests while safeguarding pollinators, the environment, and humans. Pollinator-protection language

is a label requirement found on pesticide labels. Be mindful of pollinators; when applying pesticides, focus on minimizing exposure to non-target pollinators in play and non-play course areas. Pollinators may be negatively impacted when pesticide applications are made based on insufficient information and/or made without regard to the safety of pollinators.

### 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.
- Avoid applying pesticides when pollinators are active.
- Before applying a pesticide, scout/inspect the area for both harmful and beneficial insect populations, and apply only when the indicated threshold of damage has been reached.
- Mow or control flowering plants (weeds) before insecticide application.
- 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 pesticides for insect pest management.

## *Conventional Pesticides*

### Principles

IPM does not preclude the use of pesticides. However, pesticides should be viewed as just 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 behaviour of pests. When, where, and how they can be used safely and effectively is a matter of considerable public interest. Pesticides should be evaluated for effectiveness against the pest, mode of action, 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. Label directions should always be followed. 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.

### 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.

## *Disease*

### Principles

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

### Best Management Practices

- Correctly identify the disease pathogen. This often involves sending samples to qualified labs, or investing in a microscope and training to use it to recognize pathogens.
- Ensure that proper cultural practices aimed at reducing turfgrass stress are used.
- Correct conditions that produce stressful environments for the turf (e.g., reduced airflow or drainage and shade).
- Fungicide use should be integrated into an overall management strategy for a golf course rather than relied upon as the primary line of defense.
- The appropriate (most effective) preventive fungicide should be applied to susceptible turfgrasses when unacceptable levels of disease are likely to occur.
- Record and map disease outbreaks and identify trends (hotspots) that can help guide future treatments and focus on changing conditions in susceptible areas to reduce disease outbreaks.

# *Weeds*

## Principles

Weeds compete with desired plants for space, water, light, and nutrients and can harbor insect pests and diseases. Weed management is an integrated process where good cultural practices are employed to encourage desirable turfgrass ground cover, and where herbicides are intelligently selected and judiciously used. A successful weed management program consists of:

- Preventing weeds from being introduced into an area
- Using proper turfgrass management and cultural practices to promote vigorous, competitive turf
- Properly identifying weeds
- Properly selecting and using the appropriate herbicide, if necessary

Weeds are hosts for other pests such as plant pathogens, nematodes, and insects, and certain weeds can cause allergic reactions in humans. They reproduce from seed, root pieces, and special vegetative reproductive organs such as tubers, corms, rhizomes, stolons, or bulbs. People, animals, birds, wind, and water can distribute seeds. Weeds also complete their life cycles in either one growing season (annuals), two growing seasons (biennials), or three or more years (perennials). Annuals that complete their life cycles from spring to fall are referred to as summer annuals. Those that complete their life cycles from fall to spring are winter annuals.

## Best Management Practices

- Proper weed identification is essential for effective management and control.
- Select appropriate turf species or cultivars that are adapted to the prevalent environmental conditions to promote good competition and reduce weed encroachment that may lead to bare soils.
- To prevent weed encroachment, adopt or maintain cultural practices that protect turfgrass from environmental stresses such as shade, drought, and extreme temperatures.
- To reduce weed infestation, address improper turf management practices, such as the misuse of fertilizers and chemicals, improper mowing height or mowing frequency, and improper soil aeration, and physical damage and compaction from excessive traffic.
- Ensure proper fertilization for turfgrasses to sustain desirable colour growth density, and vigour and to better resist diseases, weeds, and insects.
- Avoid scalping; it reduces turf density, increasing weed establishment.
- Use weed-free materials for topdressing.
- Address damage from turfgrass pests such as diseases, insects, nematodes, and animals to prevent density/canopy loss to broadleaf weeds.

- Record and map weed infestations to help identify site specific issues for preventative actions.

## *Nematodes*

### Principles

Plant-parasitic nematodes are microscopic roundworms (unsegmented), usually between 0.25mm and 3mm in length. They can adversely affect turfgrass health and are difficult to control. Nematodes debilitate the root system of susceptible turf grasses; plant-parasitic nematodes cause turf to be less efficient at water and nutrient uptake from the soil and make it more susceptible to environmental stresses. Additionally, weakened turf is more vulnerable to 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.
- Reduce/eliminate other biotic/abiotic stresses when nematodes are compromising the root system and plant health.

# Pesticide Management

## *Introduction*

John-Deere-GPS-PrecisionSprayer-Atelier Busche. Photo from GreenKeeping magazine.

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

Ontario Pesticides Act Reg. 63/09

## *Regulatory Considerations*

### Principles

Pesticides contain active ingredients (the component that targets the pest) and inert ingredients such as solvents, surfactants, and carriers. Both active and inert ingredients are controlled and regulated by federal and provincial regulations to evaluate pesticide efficacy as well as potential environmental and health safety concerns.

### Best Management Practices

- Only apply pesticides that are legally registered for your jurisdiction.
- Only apply pesticides that are legally registered for use on the facility type (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 described on product label.

## *Human Health Risks*

### Principles

Pesticides belong to numerous chemical classes that vary greatly in their toxicity and risk to human health. Potential health risks associated with pesticide use are 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 while also providing acceptable control of the target pest.
- Each facility should have an emergency response procedure in case excessive exposure occurs.

## *Environmental Fate and Transport*

### Principles

Environmental characteristics of a pesticide can often be determined by the environmental hazards statement found on the labels of all pesticide products. 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.
- Spray after the mowing of plant blooms.
- 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*

### Principles

Storage and handling of pesticides in their concentrated form poses the highest potential risk to ground or surface waters. For this reason, it is essential that facilities for storing and handling these products be properly sited, designed, constructed, and operated.

### 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 away from other types of structure 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*

### Principles

Advanced planning and 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,” 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 is available in an accessible and well identified place.
- Designate a spokesperson who will speak on behalf of the facility should an emergency occur.
- Host a tour for local emergency response teams (for example, fire fighters, etc.) to show them the facilities and to discuss the emergency response plan.
- Seek advice on ways to improve the plan.

## *Mixing/Washing Station*

### Principles

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 disposed of as a waste.
- Sweep up solid materials and use as intended.
- Utilize the "WALES" tank mixing method which outlines the order in which products should be added to the tank mix.

## *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 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.
- Create records for each spray application for referencing important details (pesticide, application rate, spray volume, target pest, weather conditions, etc.).
- Develop and implement a pesticide drift management plan.
- Keep a backup set of records in a safe, but separate storage area.

## *Disposal*

### Principles

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*

### Principles

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.
- Request employees who apply pesticides to not wear facility uniforms home where family members may be exposed to pesticide residues.
- Provide laundering facilities or uniform service for employee uniforms.
- All workers who are required to wear respiratory protection must follow the requirements of the Ontario Occupational Health and Safety Act (OHSA) and regulations including the Canadian Standards Association (CSA) requirements outlined in CSA -Z94.4-Selection, and Use and Care of Respirators.
- As per OSHA, all employers are required to train and test fit employees who are required to wear respiratory protection.

## *Pesticide Container Management*

### Principles

The containers of some commonly used pesticides are classified as hazardous wastes if not properly rinsed, and as such, are subject to the many rules and regulations governing hazardous waste. The improper disposal of a hazardous waste can result in very high fines and/or criminal penalties. However, pesticide containers that have been properly rinsed can be handled and disposed of as nonhazardous solid waste, and taken to a pesticide container depot within the meaning of Ontario Environmental Protection Act, or returned to the place of purchase.

### 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 back into the finished spray mix.
- Rinse emptied pesticide containers by either triple rinsing or pressure rinsing.
- Puncture empty and rinsed pesticide containers and dispose of according to instructions on the label.

## *Sprayer Calibration*

### Principle

Properly calibrated application equipment is paramount to successful target pest control and 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 or mechanical issues.
- An additional calibration is recommended prior to applying any snow mould application.
- Check equipment daily when in use.
- Use recommended spray volumes for the targeted pest to maximize efficacy.
- Calibration of walk-behind applicators should be conducted for each person making the application to take into consideration their walking speed, etc.

## *Types of Sprayers*

### Principles

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 and/or areas to be treated.

### Best Management Practices

- Use an appropriately sized applicator for the size of area being treated.
- Equipment too large in size requires greater pesticide volumes to operate effectively. This can result in significant waste that must be properly handled.

## *Inventory*

### Principles

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

- Maintain an inventory of the pesticides kept in the storage building.
- Maintain an up-to-date inventory of pesticide labels for easy access in case the label on a product is damaged.
- Material Safety Data Sheets (MSDS) for chemicals in storage building should be accessible on the premises, but not kept in the pesticide storage room itself.

## *Shelf Life*

### Principles

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

### 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.
- Ensure labels remain properly affixed to their container and are on every package.
- Consult inventory when planning and before making purchases.

## *Leaching Potentials*

### Principles

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.

# Pollinator Protection

## *Introduction*


Photos 1, 3, 4: Beekeeping. OGSA images. ONCourse, November 2020, pg. 11-12.
Photo 2: Monarch & bee. OGSA image. ONCourse, November 2018, pg. 18.

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.

There are more than 800 native bee species in Canada, such as bumble bees, mason bees and carpenter bees that are vital to the pollination of native plants. Honey bees are a managed livestock that play a crucial role in Ontario's agricultural sector. Other important pollinators include butterflies, moths, wasps, flies, some beetles and hummingbirds. Protecting bees and other pollinators is important to the sustainability of agriculture. External factors such as weather, disease and pests can all contribute to the health of native bees, managed honey bees and other important pollinators. These are just some of the complex factors that need to be assessed over many years to better understand their impacts. Ontario's Ministry of Agriculture and Rural Affairs works with beekeepers to maintain the viability of Ontario's managed honey bee sector.

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, bio stimulants, etc., are used in golf course management. The non-target effect of products used in golf course management is of increasing concern; therefore, pesticide applicators, including those on golf courses, need to be mindful of the impact that pesticides have on pollinator species and their habitat.

## *Regulatory Considerations*

### Principles

Pollinator-protection language is a label requirement found on pesticide labels; follow the instructions on the label, it is the law. Pesticide applicators must be aware of honey

bee toxicity groups and able to understand precautionary statements. Record-keeping is required by law in order to use pesticide products, and IPM principles and IPM certification provide 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 Federal regulations and certification programs (IPM Accreditation Program).
- Use records to establish proof of use and follow-up investigation of standard protocols.
- 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, understand the various routes of exposure (outside the hive and inside the hive), and the potential impacts of pesticide use 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.

When applying pesticides, be mindful of pollinators and 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 spray 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.
- Choose native Ontario plants in out-of-play areas to attract native pollinators and select plants that are of different shapes and sizes and bloom at different times from spring to fall. This will ensure that pollinators have food and adequate shelter throughout the growing season.

# Maintenance Operations

## *Introduction*

Mechanic's shop. Photo provided by Taylor Cairns, London Hunt & CC.

Equipment maintenance, fuelling, 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 Provincial regulations are in place which will have an impact on Maintenance Operations in your location. Early engagement among developers, designers, and permitting agencies is essential in designing and constructing a golf maintenance and storage facility that minimizes environmental impact and meets the needs for the approval process.

## *Storage and Handling of Chemicals*

### Principles

Proper handling and storage of pesticides and petroleum-based products is important to reduce risk of serious injury or death of an operator or bystander. Fires or environmental contamination may result in large fines, cleanup costs, and/or civil lawsuits if these chemicals are not managed properly.

Check federal, provincial, and local regulations for specific requirements related to the storage of pesticides, chemical, fuels and other potentially hazardous materials.

## Best Management Practices

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

## *Equipment Storage and Maintenance*

### Principles

Storing and maintaining equipment properly will extend useful life and reduce repairs and long-term maintenance costs

### Best Management Practices

- Store and maintain equipment in a covered area complete with a sealed impervious surface to limit risk of fluid leaks contaminating the environment and to facilitate the early detection of small leaks that may require repair before causing significant damage to the turf or the environment.
- Seal floor drains unless they are connected to a holding tank or sanitary sewer with permission from the local wastewater treatment plant.
- Store pesticide and fertilizer application equipment in areas protected from rainfall. Rain can wash pesticide and fertilizer residues from the exterior of the equipment and possibly contaminate soil or water.
- Store solvents and degreasers in lockable metal cabinets away from ignition sources and 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, and schedule collection by a commercial service.
- Blow off all equipment with compressed air to reduce damage to hydraulic seals.

## *Waste Handling*

### Principles

Proper disposal of waste materials is critical for protection of water and natural resources and Provincial regulations apply to disposal of hazardous waste products and be sure to familiarize yourself with the regulations to disposal/recycling of these waste materials. Ontario Regulation 347 General Waste Management outlines the Provincial requirements. Identify and implement waste-reduction practices and refer to Resource

Productivity and Recovery Authority (RPPA) for management of recyclables. Look for ways to increase recycling efforts and programs. Purchase environmentally preferred products in bulk packaging when possible.

## Best Management Practices

- Pesticides that will no longer be applied must be disposed of as waste and may be classified as hazardous waste depending on the materials involved.
- Recycle used tires.
- Recycle or dispose of fluorescent tubes and other lights according to the waste management requirements outlined in Ontario Regulation 347 General - Waste Management.
- Check old light ballasts for the presence of PCB's prior to disposal.

## Waste Oil, Solvents and Used Battery Storage and Disposal

## Principles

The proper storage and disposal of waste oils and solvents is key for the protection of the environment and employee health and safety. Used oils and solvents are hazardous in nature and considered waste products under Ontario Regulation 347. Given the hazardous nature of these products, limited disposal options and potential for environmental impact, the proper storage and disposal of these items is important. The storage and disposal of these products is determined by their classification relative to flammability and combustibility under the Occupational Health and Safety Act as well as their waste classification under Ontario Regulation 347. Material Data Sheets (MDS) formerly Material Safety Data Sheets should be referenced to confirm safety, storage, PPE, and specific disposal requirements (refer to O. Reg. 860 Workplace Hazardous Materials Information System (WHMIS)).

## Best Management Practices

- MDS sheets should be available and accessible for all registered products
- Storage of waste solvents must be stored in drums or pre-packed containers meeting Transport Canada's Transportation of Dangerous Goods (TDG) Regulations.
- Containers should be clearly labelled, including that the container has flammable contents.
- Containers should be sealed and kept away from sources of heat, sparks and open flames, and not stored adjacent to exits, elevators or general access locations.
- All hazardous waste and special waste must be classified prior to transportation.
- Confirm the waste removal service contractor classifies, documents, labels, and placards all materials to be transported and provide appropriate documentation, and keep all documentation on file for 2 years.

- Collect used oil, oil filters, and antifreeze in separate marked containers and recycle them as directed by local and provincial authorities.
- Antifreeze is considered a hazardous waste 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 in a covered area and on impervious services where they are protected from rainfall and recycle as soon as possible.

## *Equipment Washing*

### Principles

Equipment cleaning and washing applies to all golf course equipment, including mowers, utility vehicles and golf carts. Wash water generated from the washing of such equipment includes grass clippings, oil & grease, nutrients and pesticide rinsate and can be a source of both surface-water and groundwater contamination. Steps should be taken to prevent pollution.

### Best Management Practices

- Equipment washing areas should drain to an oil/water and solids separator before draining to a sanitary sewer, holding tank, and/or discharged to a naturalized vegetated swale.
- Where possible 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 for all hoses.
- Do not allow any untreated wastewater to flow directly into surface waters or storm drains.

## *Fuelling Facilities*

### Principles

If not managed properly the storage of diesel fuel and gasoline in aboveground storage tanks (AST’s) and underground storage tanks (UST’s) represents a potential environmental concern and liability to golf course operators. Potential impacts can result from releases from leaking storage tanks as well as accidental spills during the filling

and daily pumping of fuels from the tanks. The safe storage and handling of fuels is critical to the protection of the environment and worker health and safety.

The Technical Standards Association Standards and Safety Act, 2000, S.O. 2000, c. 16 apply.

### Best Management Practices

- All fuel storage tanks must be registered to your facility with the TSSA.
- Locate fuelling facilities under covered areas and where possible on a concrete pad (not asphalt) equipped with secondary spill-containment (Double Walled Tanks or Concrete Dikes) and recovery facilities.
- The use of AST's is preferred over UST's, and either storage tanks must be certified with the Underwriters Laboratory Canada (ULC) standard to be acceptable for use.
- Only TSSA licensed and approved contractors should be permitted to perform work on fuel storage tanks.
- All storage tanks should be set back from adjacent property boundaries, buildings, propane, groundwater wells, surface water bodies and environmentally sensitive areas in order to minimize the potential for contamination.
- Where possible secondary containment should be provided for all storage tanks.
- Inventory Control should be completed through the use of daily and monthly fuel consumptions logs in order to detect leaks and product loss.
- AST's and UST's must be vented and equipped with automatic shut-off valve to prevent the overfilling of the tanks, and anti-siphon devices to prevent overfilling of vehicles.
- Periodic testing of tank systems (pressure testing or hydrostatic) should be completed on an annual basis.
- AST's should be painted as required to prevent corrosion.
- Any water collected within secondary containment dikes should be tested prior to being discharged or released to a storm sewer, swale or surface water body.
- Report any spills as outlined in Ontario Regulation 224/07, Spill Prevention and Contingency Plans.

## *Pollution Prevention*

### Principles

Proper planning should be completed to minimize the potential of an accidental discharge and need for disposal. Monitor the water to be discharged for contamination and never discharge any contaminated water into the environment. If the water is not contaminated, it can be reused or discharged into approved stormwater treatment systems.

If contained properly, pesticide leaks or spills will not percolate down through the soil into groundwater, or run off onto the surface to contaminate streams, ditches, ponds, and/or 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 sprayers and the application equipment. Material should be collected and used as a pesticide in accordance with the label instructions for that pesticide. An equipment-washing station, or 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 should be used, maintained, and stored in a way that eliminates or minimizes the potential for pollutants/environmental contamination.

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 the soil and/or groundwater over an extended period of time.

The proper handling and storage of pesticides is important. Failure to do so correctly may lead to the serious injury or death of an employee or bystander, fires, and environmental contamination. Improper handling could also lead to wasted pesticide product, unnecessary environmental cleanup costs, and the destruction of turf grass. Pesticides that have been mixed so they cannot be legally applied to a site in accordance with the label must be treated and disposed of as a waste material. Depending on the materials involved, they may be classified as hazardous waste.

Provide adequate protection from the weather. Natural precipitation can wash pesticide and fertilizer residues from equipment and contaminate the soil and/or water. Never allow solvents to drain onto the asphalt pavement or soil, or directly discharge into water bodies, wetlands, storm drains, sewers, or septic systems, even in small amounts.

Office paper, recyclable plastics, glass, and aluminum should be collected and recycled. Place containers for recycling aluminum cans, glass and plastic soft drink bottles at convenient locations throughout the golf course property.

## Best Management Practices

- Pesticide products should be stored in a lockable concrete or metal building.
- Pesticide storage areas and mixing facility floors should be impervious and sealed with a chemical resistant paint.
- Floors should have a continuous sill constructed around the area to contain spilled materials. No floor drains should be constructed with the facility, although a sump (and sump pump) may be included to collect and re-use and/or properly dispose of any spilled material.
- For valuable information about constructing chemical mixing facilities, reference should be made to Pesticides Act, R.S.O. 1990 which regulates the sale,

storage, use, transportation, and disposal of pesticides in Ontario (see the Ontario Pesticides Act Reg. 63/09).

- Use a chemical mixing centre (CMC) (a designated area which contains a concrete pad treated with a sealant and sloped to a liquid-tight sump where all of the spilled liquids can be recovered.) as an identified location for all operations where pesticides are handled and mixed, and likely to be spilled in a concentrated form, or where even dilute formulations may be repeatedly spilled in the same area over an impermeable surface.
- Flush the concrete 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.
- The sump should then be cleaned of any sediment before another type of pesticide is handled.
- Discharge to a treatment system that is permitted to received wastewater.
- Never discharge to a septic tank, or to a sanitary sewer system without written permission from the local municipality.
- Where possible consider using a closed-loop wash-water recycling system and follow appropriate BMP.
- 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 as 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 kits available when handling pesticides and their containers.
- If a spill occurs, you may need to report any accidental release if the spill quantity exceeds the “reportable quantity” of active ingredient specified in Provincial Law.
- Large spills or uncontained spills involving hazardous materials may best be remediated by a licensed hazardous waste material cleanup company.
- For emergency (only) information on hazards or actions to take in the event of a spill, call the Ministry of Environment, Conservation and Parks (MECP) Spills Action Centre at **(800) 268-6060.**
- For information on whether a spilled chemical requires reporting call the Spills Action Centre or additional details can be reviewed in Ontario Regulation 224/07 Spill Prevention and Contingency Plans.
- 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 into the turf.
- If applicable, allow runoff onto a naturalized grassed area to soak into the ground, but never into a surface water body.
- Use compressed air to blow off equipment. This is less harmful to the equipment's hydraulic seals, eliminates wastewater, and produces dry material that is easier to handle.
- 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 other surface water sources
- Do not complete equipment wash operations on a pesticide mixing and loading pad. (This keeps grass clippings and other debris from becoming contaminated with pesticide).
- Solvents and degreasers should be used over a collection basin or pad that can provide for the collection of 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 wash pads equipped with oil/water separators.
- Collect used solvents and degreasers, place them into containers marked with the date and contents, and then have them picked up by a service provider 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 and dispose of them property. Arrange for the pickup of used oil, or deliver to a municipal 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 under a covered areas and on an impervious surface. Used Lead-acid batteries are classified as hazardous wastes unless they are recycled, and must be recycled if they are to be exempt from hazardous waste regulations.
- All lead acid battery retailers in Ontario are required by law to accept returned batteries for recycling.
- Equipment used to apply pesticides and fertilizers should be stored in areas protected from rainfall.
- Pesticide application equipment can be stored in the chemical mixing center (CMC), but fertilizer application equipment should be stored separately.

- Blow or wash loose debris off equipment to prevent dirt from getting on the CMC pad, where it could become contaminated with pesticides.
- Ensure that all containers are sealed, secured, and properly labeled.
- Use only regulatory agency-approved, licensed contractors for disposal.
- Rinse pesticide containers as soon as they are empty. Pressure rinse or triple-rinse containers, and add the rinse water to the sprayer.
- Shake or tap non-rinseable containers, such as bags or boxes, so that all dust and material fall into the application equipment.
- After cleaning, 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 proper recycling or disposal.
- Store the containers in large plastic bags/tubs to protect the containers from collecting rainwater.
- Recycle rinsed containers or take them to a landfill for disposal. Check with your local landfill before taking containers for disposal, as not all landfills will accept them.

# Landscape

## *Introduction*

Photo provided by Paul Snider, OGSA Director, Blue Mountain G&CC.

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

An ecological approach to landscape design and management is advocated. Non-play areas require sun and shade diversity, optimal soil conditions and adequate air movement to sustain growth and more general ecological function. Environmentally-safe and energy-saving practices are fundamental to such an approach. Environmentally-sound landscape management is also economically important.

## *Species Selection and Size Considerations*

### Principles

The fundamental principle for the ecologically sound management of landscapes is: “right plant, right place.” The ideal plant, ecologically, is one resulting from natural evolution. Such a plant is adapted to local soil, climate, sunlight, wildlife and endemic nutrient levels.

Know the optimum sizes and growth rates of trees, shrubs, and ground covers. This reduces the need for pruning and debris removal, and lowers long-term maintenance costs.

The addition of proper soil amendments can improve non-native 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 better utilize organic amendments such as peat or compost.
A goal of species-selection is to establish and maintain as close to a natural ecosystem as practical, while meeting the specific needs of the golf club.

Landscape areas should be designed to facilitate rapid plant establishment with the goal of conserving water and lowering the need for soil amendments. Non-native plants within areas that are not in play, or not critical to the design of the course ('leave areas') may be removed and replanted with native plant material that requires little to no maintenance after establishment.

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 including adjacent to water courses to support fish and other water-dependent species. By leaving dead trees (snags) where they do not pose a hazard, a well-developed understory (brush and young trees), and native grasses, the amount of work needed to prepare a course is reduced while habitat for wildlife survival is maintained: 50%-70% of the non-play areas should remain in natural or naturalized cover.

### Best Management Practices

- Plant selection should be to recreate or be as close to a natural ecosystem as practical while meeting the needs of a golf course.
- Select a diversity of trees, plants, and grass species to establish an ecosystem attractive to wildlife such as native pollinators.
- Be aware of the ultimate sizes, growth rates and cultural requirements of trees, shrubs, and ground covers and specify plants in keeping with existing and designed contexts.
- Use plants appropriate to a site based on the Ontario Plant Hardiness Zone Map while considering the long-term implications of climate change (see Plant Hardiness of Canada).
- Select resilient species to manage environmental stress such as periodic dry/wet conditions. It would be beneficial if cultivars are discouraged, even if they are native species as cultivars can cross pollinate with the native non-cultivars and are not as beneficial to the overall environment.

## *Design and Function*

### Principles

Gardens (on and off course), window boxes, and container gardens should include a variety of plants that provide food for pollinators such as hummingbirds and butterflies: "right plant, right place" is the key to success.

When integrating turf areas into the landscape around a clubhouse, entries, and other areas, design them for ease of maintenance respecting 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 turf.

Garden plants such as shrubs, ground covers and native plants have aesthetic value and also provide useful food, cover, or other environmental benefits to wildlife; they may also require reduced maintenance compared to turf.

Trees, shrubs and other plants along streams provide temperature moderation through shade: that lowers water temperature in summer and increases it in winter for microclimatic and habitat benefit.

### Best Management Practices

- Well-designed forested buffers or ecotones should contain a mixture of diverse native trees, shrubs, and grasses to provide resilient habitat beneficial to wildlife.
- Use vegetated buffers to mitigate environmental impacts and provide habitat to encourage and protect wildlife.
- Vegetated buffers may also be used to maintain healthy riparian (associated with water) ecosystems and stable stream channels.
- Leave dead tree snags whenever possible for wildlife nesting and food sources. Ensure retained snags or dead trees pose no hazard to persons.
- Use turf as a landscape element where needed.

## *Planting Methods*

### Principles

The fundamental principle for plant installation is: “right plant, right place.” The ideal plant, ecologically, is one resulting from natural evolution. Such a plant is adapted to local soil, climate, sunlight, wildlife and endemic nutrient levels. If the ideal plant is unavailable, be sure to uphold the fundamental principle in plant selection. A BMP goal is to maintain as close to a natural ecosystem as practical, while meeting the needs of the golf course.

The use of organic mulches in gardens and aesthetic areas increases the moisture-holding capacity of plantings and prevents weed growth when applied in sufficient depth. Organic amendments are decomposed by soil microorganisms and heighten soil quality. Keep mulch 5 - 7.5 cm (2 - 3 inches) away from plants to prevent fungal growth from excess dampness. Check for and avoid compacted or excessive mulch buildup when re-mulching. Avoid excess or compacted mulch as it may detrimentally cause water to shed away from the root zone: a negative response may be overwatering. Irrigation is advisable for plant establishment. If retained, ensure irrigation is related to appropriate, monitored soil moisture levels.

### Best Management Practices

- The plant palette and irrigation system should be appropriate for site conditions: in some cases, soil improvement can enhance irrigation or water-use efficiency.

- Landscape design and associated plant choice should be related to minimizing and simplifying irrigation layout and demand.
- Non-play landscaped areas in irrigated, high-water-use areas or ‘hydrozones’ should be avoided or minimized.
- Consider that 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: however, quality soil is the most important factor in plant health and growth.
- Amend soil as required in garden areas to improve soil physical and chemical properties, increase its water-holding capacity, and reduce the leaching of nutrients.

# Energy

## *Introduction*

Northport-Creek-Golf-Courses-2015-Green-Star-Award-Winner – Photo from Golf Digest, Google images.

According to the GCSAA Golf Course Environmental Profile, Vol. IV (GCSAA 2012), six major energy sources were identified for golf course use including: 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 potential future energy reduction opportunities, superintendents 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, fitness centers, etc.
- Golf course statements – the golf course and surrounding landscapes, pump station, irrigation system and related agronomic operations (playing surfaces, equipment, turfgrass maintenance etc.)

## *Energy Conservation*

## Principles

Determine goals and establish an energy policy that is part of the facility's overall environmental plan. Establish an energy management plan for the facility based on current energy use baselines to optimize efficiency. Communicate policy to all staff regarding use patterns and management practices to impact change. Communicate the energy policy to the entire golf facility, including facilities that provides services to members and customers. Incorporate quality management elements for continual

improvement (plan, do, check, and act) to reduce environmental and economic impacts. The irrigation pumpstation is likely the largest single user of energy at the facility. A modern well-engineered pump and maintained pumpstation is critical to reducing energy consumption.

### Best Management Practices

- Conduct an energy audit of the entire facility, including lighting.
- Conduct a carbon footprint analysis.
- Add insulation where needed/required in buildings.
- Use non-peak electrical hour rates: charge golf carts and maintenance equipment, use water pumps (irrigation), and other high consumption items later in the day or early in the morning.
- Limit high-consumption activities during periods when demand is high.
- Where possible encourage the use of alternative energy sources, such as solar, geothermal and wind energy generation.
- Upgrade or install premium high-efficiency-rated pump motors. Variable frequency drive pumps are available and should be considered.
- Seek reduction in energy use by reducing pump run times including the reduction of total irrigatable acres (watering less areas).
- Install LED lighting and/or retrofit existing non efficient energy devices.
- Install motion sensors for lights where appropriate.
- Install a programmable thermostat.
- Install solar/Geo Thermal pumps for pools and spas.

## *Evaluation*

### Principles

Continually track and measure energy use at the facility based on energy assessment units (e.g., kilowatt hour (KWH)). 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, sub metering of high consumption systems
- 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 and 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 that may be available.
- Identify and categorize operations for energy efficiency opportunity and conservation analysis.
- Perform assessments of all the facility's infrastructure and operations and perform appropriate audits throughout the facility depending on operation, infrastructure, and planning stage.
- Identify efficiency and conservation elements of infrastructure/hard items and behavioural/process-oriented items.
- Consider alternative equipment, products, and practices.

## *Design and Renovation*

### Principles

Incorporate a review and analysis of any assessments, audits, and data gathered.
Incorporate first cost consideration (initial investment and long-term gain).
Evaluate future projects with a priority for energy conservation. According to system and compliance standards, communicate with utility provider and any local regulatory agency.

### Best Management Practices

- Identify buildings, amenities, and operations including existing, new construction, or renovation activities where energy efficiency enhancements may be implemented.
- 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 and develop an implementation plan. Energy use goals should be set according to efficiency and conservation of the building, infrastructure, and equipment efficiency.

### Best Management Practices

- Evaluate effectiveness of upgrades according to efficiency and 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 and consider the materials: used insulation and colour 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, train, and motivate employees, members and guests on energy efficiency practices pertaining to golf course operations. On a regular basis, identify energy efficiency programs/incentives that may be available from energy providers. Consider energy management software, services, etc. for all building operations.

### Best Management Practices

- Evaluate alternative transportation.
- Evaluate cleaning practices (dry vs. wet).
- Consider local vs. distant purchases in your purchasing program.
- Evaluate golf car equipment/operations and ensure proper selection, operation, charging, and maintenance.
- Incorporate training for employees and use of incentives to achieve increased energy efficiency.

## *Course Management Plan*

### Principles

Establish energy-use goals for energy efficiency and conservation including infrastructure, equipment, behaviour, and agronomic practices. Ensure proper selection (type, size, etc.), operation, and equipment maintenance. Also, 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 maintenance costs in addition to acquisitions.
- Schedule regular reviews to evaluate future technology, innovation and upgrades.
- Identify future energy needs and evaluate use of alternative energy/fuels, including energy consumption.
- 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 the 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, and during non-peak electrical periods.
- Evaluate technology, innovation and upgrades and implement when feasible.

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# Additional References

***The following Acts and Regulations relate to golf course maintenance, safety, and materials handling:***

### Canadian Standards Association (CSA)

- Selection, use, and care of respirators

  https://www.csagroup.org/store/product/CAN-CSA-Z94.4-18/?format=Paper

### Environment and Climate Change Canada

- Weather alerts

  https://weather.gc.ca/mainmenu/alert_menu_e.html

### Fire Protection and Prevention Act, 1997 – Provincial

https://www.ontario.ca/laws/statute/97f04

Ontario Regulation 213/07, Fire Code, Part 4 – Flammable and Combustible Liquids:

- Requirements for the storage, handling, processing, and use of flammable liquids or combustible liquids.

  https://www.ontario.ca/laws/regulation/070213

### Guelph Turfgrass Institute

- Turfgrass research and extension

  https://www.guelphturfgrass.ca/

### Hazardous Products Act – Federal

Federal Regulation SOR 2015-17, Hazardous Products Regulations:

- This regulation modified the Workplace Hazardous Materials Information System
- WHMIS is Canada's national hazard communication standard for hazardous chemicals used in the workplace and is included under the Hazardous Products Regulation (WHMIS), to incorporate the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) for workplace chemicals.

  https://laws-lois.justice.gc.ca/eng/regulations/sor-2015-17/index.html

## Integrated Pest Management Accreditation Program (IPMAP) - Ontario

- University of Guelph Ridgetown Campus

  https://www.ontarioipm.com/

## IPM Council of Canada

https://ipmcouncilcanada.org/

## National Turfgrass Evaluation Trials

- Turfgrass variety evaluation trials

  https://www.ntep.org/

## Natural Resources Canada

- Plant hardiness zone map of Canada
- Hardiness zones by municipality

  http://planthardiness.gc.ca/ph_main.pl

## Occupational Health and Safety Act – Provincial

https://www.ontario.ca/page/occupational-health-and-safety-act-ohsa

Ontario Regulation 860 Workplace Hazardous Materials Information System (WHMIS):

https://www.ontario.ca/laws/regulation/900860

## Ontario Environmental Protection Act – Provincial

https://www.ontario.ca/laws/statute/90e19

Ontario Regulation 1990, Chapter E. 19, as amended, Part X – Spills:

- Requirements to prevent, plan for, respond to, and report spill

  https://www.ontario.ca/laws/statute/90e19#BK130

Ontario Regulation 347, General - Waste Management – Section 11, 12, 29.4, 32 (1), 53, 54 (1):

- Requirements for the proper disposal of contaminated spill cleanup materials.

  https://www.ontario.ca/laws/regulation/900347

Ontario Regulation 675/98, Classification and Exemption of Spills and Reporting of Discharges:

- Criteria and requirements for spill reporting to regulatory agencies.

  https://www.ontario.ca/laws/regulation/980675

Ontario Regulation 224/07 Spill Prevention and Contingency Plans:

https://www.ontario.ca/laws/regulation/070224

Resource Productivity and Recovery Authority (RPPA):

- Management of recyclables

  https://rpra.ca/

Transport Canada – Transportation of Dangerous Goods (TDG) Regulations:

https://tc.canada.ca/en/corporate-services/acts-regulations/list-regulations/transportation-dangerous-goods-regulations

Ontario Ministry of Agriculture, Food, and Rural Affairs (OMFRA):

- Integrated Pest Management for Turf (Publication 845)
- Soil Fertility Handbook
- Soil Testing for Turf

  https://omafra.gov.on.ca/english/crops/hort/turf.html

## Ontario Water Resources Act – Provincial

Ontario Water Resources Act, R.S.O. 1990, c. O.40 Section 34 (2):

- Requirements for water takings from all water features (ponds, rivers, streams, lakes and groundwater wells)

  https://www.ontario.ca/laws/statute/90o40

Ontario Regulation 387/04

- Water taking and transfer

  https://www.ontario.ca/laws/regulation/040387

Ontario Water Resources Act Regulation 903 Wells:

https://www.ontario.ca/laws/regulation/900903

Permit To Take Water - Ontario:

https://www.ontario.ca/page/permits-take-water

## Pesticides Act, R.S.O. 1990

Ontario Regulation 63/09 (O. Reg. 63/09)

- Regulates the sale, storage, use, transportation and disposal of pesticides in Ontario.

  https://www.ontario.ca/laws/regulation/090063

### Technical Standards and Safety Act, 2000 Chapter 16 - Provincial

- Technical standards to enhance public safety in Ontario.

  https://www.ontario.ca/laws/statute/00t16

Ontario Regulation 217/01 Liquid Fuels:

- Standard for the storage and handling of gasoline and associated products from a safety perspective.

  https://www.ontario.ca/laws/regulation/010217

## Underwriters Laboratory Canada (ULC)

https://canada.ul.com/

## United States Golf Association (USGA)

- Course care – USGA putting green construction

  https://www.usga.org/course-care/specialty-articles/usga-putting-green-construction.html

## WALES Tank Mixing Method/Order

https://www.syngenta.ca/agronomy/wales-mixing-order