Connecticut Association of Golf Course Superintendents

CONNECTICUT GOLF INDUSTRY BEST MANAGEMENT PRACTICES

Connecticut Chapter GCSAA

GCSAA
Golf Course Superintendents Association of America

CONNECTICUT ASSOCIATION OF GOLF COURSE SUPERINTENDENTS

RICH IN HISTORY, CULTURE, DIVERSITY, *and varied landscapes*

Connecticut's terrain spans across coastal towns, mountains, plains, river valleys, urban centers, and forested areas. Golf plays a special role within the State, as Connecticut is home to some of the oldest golf clubs in the country. There are more than 185 golf facilities ranging from municipal golf courses like Richter Park and Shinnecossett to top-ranked New England courses, including The Stanwich Club, the Country Club of Fairfield, and Yale Golf Course.

The industry generates $1.1 billion in total economic output, produces 11,570 jobs, and contributes $336 million in wage income, based on a study from the Connecticut Golf Alliance in 2010. Connecticut golf also serves as a significant driver of tourism, with an estimated $89.7 million spent on golf-related activities and entertainment, including the Travelers Championship on the PGA Tour played at TPC River Highlands in Cromwell, Connecticut.

The Connecticut Association of Golf Course Superintendents (CAGCS), founded in 1929, is comprised of hard-working agronomists and golf maintenance professionals who are responsible for maintaining golf courses throughout the state.

One way the CAGCS is working to demonstrate its dedication to communities, the public, golfers, and the environment is through developing this guide of best management practices (BMPs). This guide serves as operating standards for superintendents to strive toward and an educational resource for all stakeholders.

The BMP guide details 12 sections to address sustainable golf course operations ranging from irrigation to integrated pest management to water quality and wildlife protection, to name a few. Each section contains principles, BMPs and regulatory considerations, as well as local resources for additional information.

A steering committee of superintendents worked together to create the document, in collaboration with Radius Sports Group, a sustainability consulting firm. This guide has been reviewed by leaders in golf course management, architecture, construction, regulatory, academic, and sustainability fields.

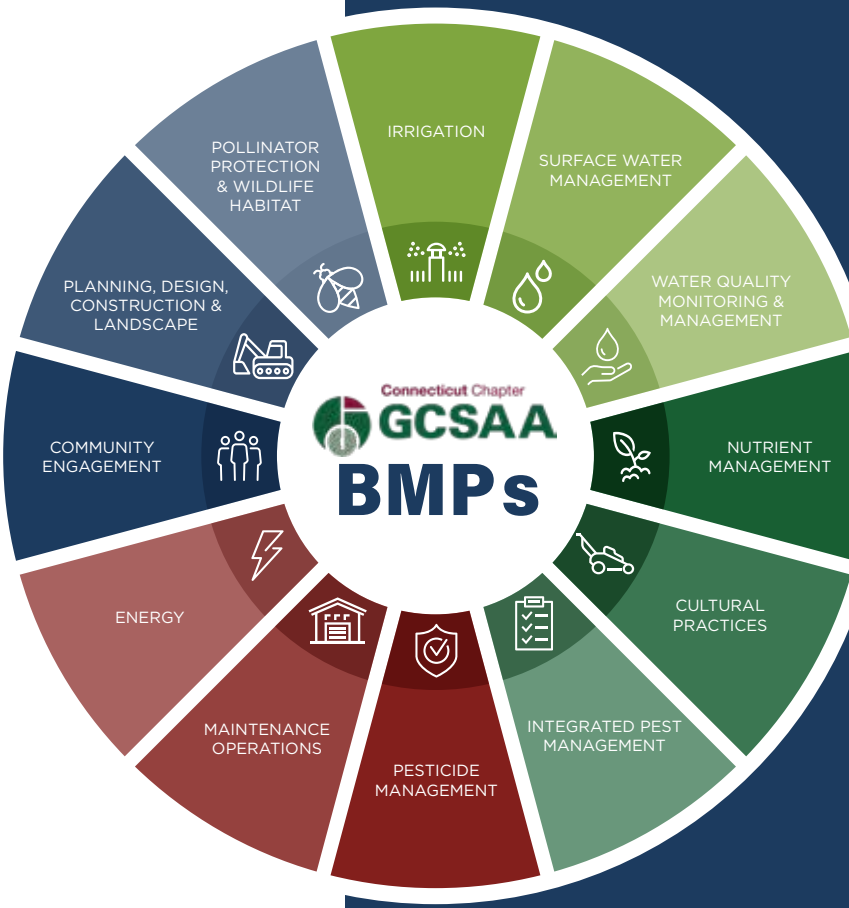
The CAGCS cares about the communities in which it operates. Its commitment is demonstrated throughout this guide with a goal of providing sustainable golf course operations now and for many years to come.

Connecticut Chapter GCSAA

Connecticut®

Connecticut Sustainability Planning

Sustainability is integrated throughout our BMPs in order to help guide golf courses in balancing performance and economic impact with environmental stewardship and community. Our golf courses have adopted recommendations and BMPs encouraged by the Connecticut Department of Energy and Environmental Planning (DEEP) for greening businesses statewide. Cities, regions, and communities have varying levels of sustainability planning; courses are encouraged to collaborate within their communities to make a positive impact today and in the future.



Connecticut golf course superintendents hold strong family values and are deeply rooted within their communities. They are committed to providing high quality recreational facilities, while protecting the natural environment and preserving open spaces through using science-based practices.

FOREWORD

Connecticut is a state with hard-working people who share strong community values. Golf course superintendents here take pride in the quality of their work and being a part of the community. This Connecticut Golf Industry Best Management Practices Guide developed by the Connecticut Association of Golf Course Superintendents shows how much the industry cares for the game and quality of golf courses in our state.

The state is home to some of the oldest clubs in the country – Farmington, Waterbury, Brooklawn, and Greenwich, to name a few. My fellow tour caddies love playing golf in Connecticut when they come to town and all give high praise to the conditions of the courses they play in the area.

What superintendents are doing is ensuring courses like these, plus our municipal and public courses sustain for years to come. The BMPs address cultural practices, water quality and surface water management, design, and construction so that golfers can continue to enjoy the game, with optimal conditions, and respect for the environment.

I applaud the efforts of Connecticut superintendents statewide. Thank you for your dedication to the game, the community, and our great state of Connecticut.

JOE LACAVA
Caddie, of Tiger Woods
Caddie Hall of Fame Inductee

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I am pleased to support the initiative of the Connecticut Association of Golf Course Superintendents to publish a Connecticut Golf Industry Best Management Practices Guide. This guide promotes environmental stewardship, incorporating science-based practices and advancements in turfgrass.

Superintendents throughout the state, University of Connecticut educators, stakeholders from the Connecticut Department of Energy and Environmental Protection, plus leaders within golf, sustainability, and conservation disciplines have reviewed and contributed to this collaborative effort. I applaud the development of such a comprehensive document, specific to our great state.

The guide covers twelve operational areas including design and construction of golf courses, water quality, pollinator protection, and energy.

These voluntary guidelines will help provide sustainable operations for recreation, conservation of natural resources, healthy greenspaces, and wildlife habitats for years to come.

Sincerely,

DAVID ARCONTI
Connecticut State Representative
Chair, Energy and Technology Committee
Member, Environment and General Law Committees

SERVING DANBURY

ACKNOWLEDGEMENTS

The CAGCS would like to thank the following individuals for volunteering their time and organizations for their support to complete the Connecticut Golf Industry BMP Guide. The efforts of these individuals will guide future generations of superintendents and help educate all stakeholders within the state. Thank you to superintendents and industry associates who provided photo contributions.

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Connecticut State Golf Association

A special thank you to the Connecticut State Golf Association (CSGA) for its support of this initiative. The CSGA functions as an extension of the USGA and provides stewardship for amateur golf in Connecticut. Founded in 1899, it is the country's oldest state golf association and conducts over 60 Championships, Qualifiers and One-Day Tournaments throughout the year, in addition to administering handicaps for over 40,000 members and 181 member clubs.

This initiative would also not have been possible without the support of the Golf Course Superintendents Association of America (GCSAA), the Environmental Institute for Golf (EIFG), the PGA Tour and the United States Golf Association (USGA).

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. 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 golf course maintenance in the United States and worldwide. From its headquarters in Lawrence, Kansas, the association provides education, information and representation to more than 17,000 members in more than 72 countries. GCSAA's mission is to serve its members, advance their profession and enhance the enjoyment, growth, and vitality of the game of golf.

Environmental Institute for Golf

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

United States Golf Association

The United States Golf Association (USGA) provides governance for the game of golf, conducts the U.S. Open, U.S. Women's Open and U.S. Senior Open as well as 10 national amateur championships, two state team championships and international matches, and celebrates the history of the game of golf. The USGA establishes equipment standards, administers the Rules of Golf and Rules of Amateur Status, maintains the USGA Handicap System and Course Rating System, and is one of the world's foremost authorities on research, development and support of sustainable golf course management practices.

SPECIAL ACKNOWLEDGMENTS

The GCSAA and EIFG wish to thank the University of Florida, Institute of Food and Agricultural Sciences, faculty, Dr. J. Bryan Unruh, Dr. Travis Shaddox, Dr. Jason Kruse, and Mr. Don Rainey, who worked on this project, providing their knowledge and expertise to help the golf course industry; the USGA for their grant to fund this important project; the volunteers who served on the task group to review BMP and provide technical assistance; and the Florida Department of Environmental Protection for permission to copy its publication, "Best Management Practices for the Enhancement of Environmental Quality on Florida Golf Courses".

TABLE OF CONTENTS


12
Community Engagement


44
Pollinator Protection &
Wildlife Habitat


82
Surface & Stormwater
Management


106
Nutrient Management


120
Cultural Practices


164
Maintenance Operations

ACTIVE CONTRIBUTOR TO COMMUNITIES *for more than 90 years*

For more than 90 years the CAGCS has been an active contributor to communities throughout the state. Real community engagement goes beyond one-way communication or a public relations campaign. Community engagement is more than providing updates to members, guests, neighbors, city or state officials from owners or course officials. Effective community engagement creates rich relationships with neighbors and local stakeholders, identifies concerns and values, optimizes resources, increases participation, improves decision-making, resolves conflicts, and creates trust.

Philanthropy and charitable giving are at the core of the golf industry. Golf clubs and courses provide exceptional venues for fundraising events and charity golf tournaments. Since 2012, golf as a fundraising vehicle has raised nearly $20 billion in charitable giving. The We Are Golf coalition estimates $3.9 billion in total annual charitable impact from golf. The Connecticut golf industry generates $32 million in charitable giving. (Connecticut Golf Alliance, 2010) Organizations include those focused on arts and heritage, education, environment and animals, health, and human services.

Connecticut golf course maintenance departments provide full-time and seasonal work for a diverse workforce. The association also supports scholarships for local students. Superintendents frequently hire students from local schools and universities for golf maintenance positions and internships.

Connecticut superintendents are focused on positively impacting their communities. Together with the GCSAA and partner advocates, the CAGCS meets annually with state legislators on environmental, economic, and health-related legislation including participation in National Golf Day, a day of golf industry advocacy in Washington D.C. Superintendents throughout the state are also actively involved with meeting with local representatives.

Developing rapport with neighboring community members, customers, legislators, regulators, and civic leaders helps all stakeholders better understand the actions golf courses are taking to protect human and environmental health.

Superintendents and their teams host field trips with local schools to explore golf courses from a science, math, biology, and learning perspective. This includes hosting First Green programs, an initiative of the EIFG.


earth
CAPE COD

Best Management Practices

- Conduct stakeholder mapping to understand who to best engage in outreach efforts
- Identify what is important to each stakeholder
- Identify community values and principles
- Establish engagement targets, goals, and desired outcomes
- Understand the importance of building trust
- Plan engagement efforts, strategies, and methods of communication
- Engage community prior to design & construction; in addition to ongoing efforts

More information on community engagement: https://extension.psu.edu/understanding-community-engagement

COMMUNITY SAFETY AND CORONAVIRUS

Pandemics and others crisis often involve circumstances where golf course play must be modified to keep the public safe while also allowing recreational opportunities. BMPs have been developed to limit touch points in order to reduce risk and help provide safe playing conditions.

Adhere to local, state, and federal guidelines from the Center for Disease Control and Prevention (CDC):

https://portal.ct.gov/coronavirus

https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html

Best Management Practices

- Removal of ball washers, Bunker rakes and most trash cans
- Use of pool noodles or PVC or EZ Lift devices to limit ball going in cup
- Single rider golf carts
- Sanitation programs to kill virus
- Manual clocking in of staff
- Staggering start times to limit exposure
- Maintain minimum of six feet of social distancing
- Wash hands frequently with soap for a minimum of 20 seconds
- Wear masks as required

For additional resources related to golf club operations, visit https://www.csgalinks.org/content/csga/csga-covid-19-resources

DEVELOPMENTS REQUIRE CONSIDERATION *of environmental and economic factors*

New golf course developments or renovations must consider site suitability factors. All factors must be carefully considered during planning and design to insure development of a viable and sustainable project.

This document is not meant as a blanket standardization of golf development and maintenance. All courses are different in their location and maintenance level; the approach outlined in this guidance is general and may not be applicable to all situations. Connecticut is an ecologically diverse area with courses in mountains, adjacent to rivers, in farmland, in urban settings and on the coastlines. Utilization of BMP guidelines provide a framework for good decision-making through each phase of a project.

The construction phase for a new course or renovation project poses the greatest risk for ecosystem alteration. Facilities should be designed and constructed to maximize sustainability and energy efficiencies. By utilizing BMPs for planning, design, scheduling, and construction, golf facilities may be constructed and maintained with minimal impact to sensitive resources and associated buffers.

REGULATORY CONSIDERATIONS

Federal, state, and local permitting may be required prior to initiating construction. It is important to seek the advice of consultants familiar with permitting during the planning phase to determine what regulations may be impacted. This may involve a review of the project site to determine if survey and mapping of any jurisdictional areas is required.

During planning, the project scope and or limits of work may be adjusted to eliminate or shorten the permitting process. The permits necessary for construction will vary considerably based on the location and scope of the proposed improvements. For new course projects, the first determination should be if the property is locally zoned for a golf course development, as the lack of appropriate zoning can stop a project or severally lengthen the permitting timeline. A new course project will then be subject to all environmental regulation permits for the locality, such as a general environmental review, water withdrawal and wetland impacts, to name but a few. For renovation projects, an early on-site meeting with an environmental consultant or the local conservation agent can help to identify the extent of permitting, if any are required.

Permits from local, state and federal agencies typically include a significant number of general and project specific conditions that must be followed to insure acceptance of the work upon completion. Orders of Conditions imposed by permit authorities are to be followed during construction, therefore potential contractors should be provided copies of the approved permit plans and Order of Conditions during bidding of the work. Compliance monitoring should be instituted and enforced by the course owner. Compliance monitoring is generally done by the course Superintendent or the consultants who assisted with permitting.

Reference for information about obtaining a construction stormwater permit; registration is required a minimum of 60 days prior to commencement of planned construction:

https://portal.ct.gov/DEEP/Water-Regulating-and-Discharges/Stormwater/Construction-Stormwater-GP

Wetlands

Prior to commencement of planning, the boundaries and buffer zones of any wetlands, vernal pools, coastal zones, water bodies, intermittent streams and rivers should be identified, flagged and mapped in accordance with local, Connecticut, and federal regulations because activities taking place within these boundaries (and buffer zones) may require permits. Connecticut has rules which protect such water bodies from loss and degradation. This protection is achieved through regulation of draining, dredging, clearing and filling within or in proximity to the wetlands.

The regulations include an authorization process implemented in close coordination with the federal government through the Army Corps of Engineers, state-specific information:

https://www.nae.usace.army.mil/Missions/Regulatory/State-General-Permits/Connecticut-General-Permit/

BMPs dictate that a professional consultant be utilized to determine if permitting may be needed and to assist with design of the project to reduce impacts. In some cases, the scope of a project can be changed to eliminate work in a regulated area. If not, the design may be altered to reduce impacts or generate other environmental improvements.

Floodplains

Most activities associated with construction or renovation, including grading and filling, within the 100-year floodplain zone will likely require a permit issued by the local and/or Connecticut DEEP. Regulations have been enacted to reduce the potential for downstream or coastal flooding. For floodplains adjacent to rivers and streams, filling an area that floods will likely not be approved unless a compensatory amount of ground level lowering is made at the same elevation in a nearby area. A goal of no net loss of floodplain area is desired.

Erosion & Sediment Control

A goal of any project should be the elimination of sediment in runoff prior to it leaving the project site and entering a waterway or wetland area. Connecticut and the federal government have implemented erosion and sediment control programs to control sediment-laden runoff from the exposed ground of construction sites. Regulations establish criteria and procedures for erosion and sediment control in Connecticut, and it could be even more regulated by municipality. Such regulations enhance erosion and sediment control practices, improve water quality of construction runoff and reduce negative impacts of sediment on drainage pipes, wetlands and adjacent waterways. Reducing sediment from runoff assists in water quality restoration efforts of streams, rivers, and water impoundments.

Information on Connecticut's Erosion and Sediment Program:
https://www.ct.gov/deep/cwp/view.asp?a=2720&q=325660&deepNav_GID=1654
https://www.ct.gov/deep/cwp/view.asp?a=2720&q=325658&deepNav_GID=1654

Water Management

Golf courses are perceived as using a lot of water. Many states, including Connecticut, regulate the amount of water a course can use for irrigation, and the source of that water. Water Diversion Permits are required for most golf courses in Connecticut.

Connecticut water diversion permit information:
https://www.ct.gov/deep/cwp/view.asp?a=2709&q=324178&deepNav_GID=1654

Withdrawals of surface water or groundwater exceeding 50,000 gallons per day which were not registered as of 1983 are required to have diversion permits. Registrations or permits are not required for water supplied by a public water utility; these registrations or permits are held by the utility.

Regulators may require that the course utilize degraded water, or limit the amount of water taken from wells, streams or lakes. For some courses that lack their own supply, the only option is to purchase costly municipal water. These requirements can severely impact the economic feasibility of a golf project.

Rare and Endangered Species and Habits

In addition to identifying wetlands and floodplains before intensive planning, the course should check with the state to determine if there are any state listed species or habitats of special concern in potential proximity to the project site. Their presence may severely limit goals and objectives for the project.

The Natural Diversity Data Base maps represent approximate locations of endangered, threatened, and special concern species and significant natural communities in Connecticut, referenced at: https://portal.ct.gov/DEEP/Endangered-Species/Natural-Diversity-Data-Base-Maps

A full list of rare and endangered species for the State of Connecticut can be found at:
https://www.fws.gov/endangered/map/ct-info.html
https://portal.ct.gov/DEEP/Endangered-Species/Endangered-Species-Listings/Endangered-Threatened--Special-Concern-Species

Watershed or Aquifer Area Project Notification Form

Connecticut General Statutes Public Act No. 06-53

If the golf course is in a watershed or aquifer, the course must file a "Watershed or Aquifer Area Project Notification Form". Within seven days of filing, all applicants before a municipal Zoning Commission, Planning and Zoning Commission, Zoning Board of Appeals or Inland Wetlands Commission for any project located within a public water supply aquifer or watershed area are required by Public Act No. 06-53 of the Connecticut General Statutes to notify The Commissioner of Public Health and the project area Water Company of the proposed project. To determine if your project falls within a public water supply aquifer or watershed area visit the appropriate town hall and look at their Public Drinking Water Source Protection Areas map. If your project falls completely within or contains any part of a public water supply aquifer or watershed you are required to complete the form found at:

https://portal.ct.gov/-/media/Departments-and-Agencies/DPH/dph/drinking_water/pdf/iferAreaProjectNotificationFormpdf.pdf

Stakeholders integral to golf course design:

- *Golf course superintendent*
- *Clubhouse architect*
- *Golf course architect*
- *Landscape architect*
- *Irrigation engineer and pump station designer*
- *Environmental engineer*
- *Economic consultant*
- *Soil scientist*
- *Geologist*
- *Archaeologist*
- *Turfgrass consultant*
- *Golf course builder*
- *Legal team*

PLANNING

Proper planning will minimize expenses resulting from unforeseen construction requirements. Thorough planning provides opportunities to maximize/integrate environmentally favorable characteristics into the property.

The implementation of a golf course project will typically benefit from the use of professional consultants familiar with similar requirements. The consultants needed will depend on the scope and complexity of the proposed work and the constraints present at the project site. Most projects commence with the hiring of a qualified golf course architect, a civil engineer and an environmental consultant. For most renovation projects, this may be the extent of consultants required for planning.

The first step in planning is development of an accurate existing conditions plan identifying property boundaries, topography, vegetation limits, roads, wetlands and other jurisdictional areas. A detailed base plan is a critical tool in planning a project to avoid negative environmental impacts and to determine the feasibility of achieving project goals. The development of a constraints plan, along with identification of a suitable water source (for new courses) may determine that a site is unsuitable for the intended golf project before expensive planning and permitting is begun. Determine if the site is within a public water supply watershed or aquifer protection area.

Once the suitability is confirmed through generation of preliminary concept plans and cost estimates, a team is generally assembled to guide the project. The golf course architect and civil engineer may be helpful in assembling the permitting team. Professional, experienced judgement is crucial when applying BMPs in the planning, design and construction phases of the project.

An experienced golf course superintendent is integral to the planning process for any golf project. For course renovation projects, with their extensive knowledge of the site, they can assist in determining the most suitable design and can inform the design team of issues that may impact maintenance of the course or player enjoyment of the facility.

The superintendent's knowledge of the BMPs and their direct participation in planning and construction greatly affect the success of the project.

Early engagement among developers, designers, local community groups, and permitting agencies is essential to designing and constructing a golf facility that minimizes environmental impact and meets the approval process.

Best Management Practices

- Assemble a qualified team with expertise in golf development and environmental permitting.
- Determine objectives and complete a feasibility study of the project; evaluate whether the needs are feasible given existing resources.
- Consideration should be given to the cost of the work and the ability to pay for it, the environmental impacts, availability of water for irrigation, energy demands and access to a suitable power supply, cost and availability of golf materials (such as root zone mix or bunker sand), and governmental regulatory requirements and restrictions.
- Prior to commencement of planning, boundaries and buffer zones of wetlands, vernal pools, coastal zones, water bodies, intermittent streams and rivers should be identified, flagged and mapped in accordance with local, Connecticut, and federal regulations because activities taking place within these boundaries (and buffer zones) may require permits.
- Contact the water supplier seeking suggestions to comply with water quality standards and BMPs so watersheds and/or aquifers are protected.
- Select an appropriate site that can achieve the needs of stakeholders; identify strengths and weakness of the selected site.
- Identify rare, protected, endangered, or threatened plant or animal species on the site. For an updated list, reference: *https://www.fws.gov/endangered/map/ct-info.html*

Wetlands

Wetlands act as filters for both pollutant removal and as nurseries and habitat for many species of birds, insects, fish, reptiles, amphibians 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. Wetland areas are generally described as primarily saturated soils with a plant community that is specific to this soil condition.

Connecticut considers wetlands as "waters of the state," a designation that carries significant legal ramifications. Furthermore, permitting requirements for wetlands can have multiple overlapping jurisdictions of federal, state, and local agencies. At the federal level alone, the U.S. Army Corps of Engineers (USACOE), EPA, U.S Fish and Wildlife Service (FWS), National Oceanic and Atmospheric Administration (NOAA), and maritime agencies may all be involved. Connecticut inlands wetlands permitting generally takes place at the municipal level (delegated statutory authority from the State). Wetlands boundaries are field located by qualified specialists who take soil borings and review the plants to make the determination.

Prior to commencement of planning, the boundaries and buffer zones of any wetlands, vernal pools, coastal zones, water bodies, intermittent streams and rivers should be identified, flagged and mapped in accordance with local, state and federal regulations because activities taking place within these boundaries (and buffer zones) may require permits. Connecticut has rules which protect such water bodies from loss and degradation. This protection is achieved through the regulation of draining, dredging, clearing and filling within or in proximity to the wetlands.

https://portal.ct.gov/DEEP/Water/Watershed-Management/CTs-Watershed-Management-Program

https://portal.ct.gov/DEEP/Water/Wetlands/Connecticut-Wetlands

BMPs dictate that a professional consultant be utilized to determine if permitting may be needed and to assist with design of the project to reduce impacts. In some cases, the scope of a project can be changed to eliminate work in a regulated area. If not, the design may be altered to reduce impacts or generate other environmental improvements.

Wetlands in Connecticut

The state of Connecticut defines inland wetlands based on soils. The Connecticut Inland Wetlands and Watercourses Act defines wetland soils to include any of the soil types designated as poorly drained, very poorly drained, alluvial, and floodplain by the National Cooperative Soil Survey, as may be amended from time to time, of the Natural Resources Conservation Service of the United States Department of Agriculture.

Connecticut's definitions of wetlands may be found at: https://www.ct.gov/deep/cwp/view.asp?a=2720&q=325684&depNav_GID=1654

Best Management Practices

- Ensure that proper permitting has been obtained before disturbing any tidal or non-tidal wetland or the regulated buffer zone.
- For any type of work that would involve wetlands, reference state and municipal information, including the Inland Wetlands and Watercourses Act (IWWA) at: https://portal.ct.gov/DEEP/Water/Inland-Wetlands/Inland-Wetlands-and-Watercourses and https://portal.ct.gov/DEEP/Permits-and-Licenses/Land-and-Water-Resource-Division-LWRD-Applications
- Ensure that wetlands have been properly delineated by a professional consultant and approved by the regulatory agency before working in and around any wetlands.

Drainage

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

Best Management Practices

- When constructing drainage systems, pay close attention to engineering details such as subsoil preparation, slopes, backfilling and placement of drainage gravel.
- Surface water runoff from tees, greens and intensively managed fairways and internal golf course drains should not drain directly into an open body of water or protected wetland but should discharge through pretreatment zones (such as grass swales or retention basins) and/or vegetative buffers to help remove nutrients and sediments.
- The drainage system should be routinely inspected to ensure proper function.
- Post development flow rates should be equal to or less than predevelopment conditions. Where extensive clearing occurs or impervious surface is added, this will require the installation of water retention components that slow the release of water from the site.

DESIGN

It is important to establish clear and achievable goals and objectives at the commencement of any proposed project. The professional team can assist the course owner or developer in refining the goals and objectives by providing concept plans and cost estimates for work in the preliminary phase of design. This information will help to determine what changes are appropriate for the site, the financial feasibility of paying for the work and the anticipated schedule for implementation. Although the process of developing goals and objectives varies depending on the complexity of the proposed work, projects are most successful when a clear scope of work is defined and thoughtfully implemented. If necessary, the design should address the following site issues:

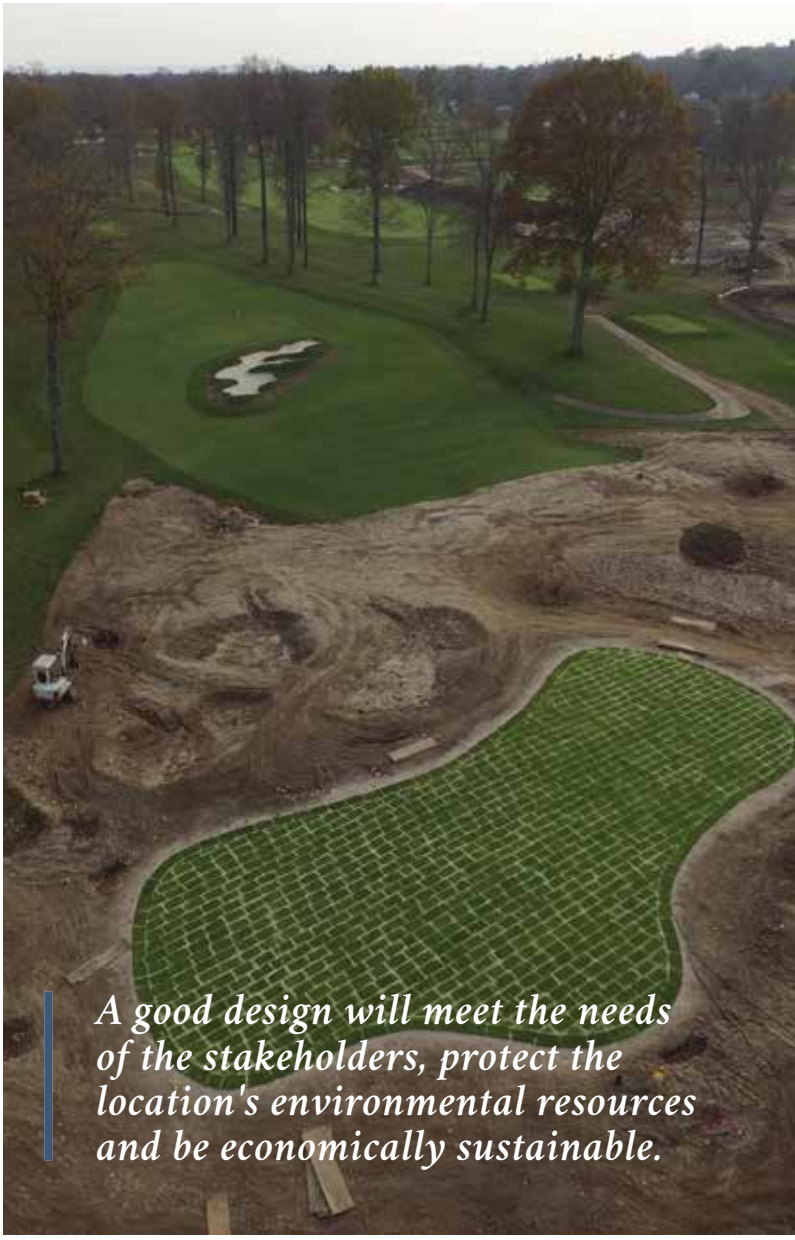
Environmental Impacts

The design should avoid or minimize impacts to sensitive environmental issues that may have been identified during the site review and preliminary planning phase. When impacts are unavoidable, the design should identify the level of impact and address how future course use and maintenance will be undertaken to lessen negative impacts.

Wetlands and Streams

When incorporated into a golf course design, wetlands should be maintained as preserves and separated from highly managed turf areas with native vegetation or structural buffers. Constructed or disturbed wetlands may need to be permitted to be an integral part of the stormwater management system. Boundaries for wetlands are field located by qualified specialists who take soil borings and review the plants to make the determination. Proposed work adjacent to streams and rivers is also highly regulated.

The State of Connecticut regulates any activity within or in proximity to the wetland boundary. This regulated buffer zone will vary depending on the wetland, but any work (clearing, filling or dredging) within 100-feet of a suspected wetland or stream should be reviewed with an environmental consultant to determine if permits will be required.



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

More information on Connecticut wetlands:

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/soils/?cid=nrcs142p2_011148

https://portal.ct.gov/DEEP/Water/Wetlands/Connecticut-Wetlands

https://portal.ct.gov/DEEP/Water/Inland-Wetlands/How-Are-Inland--Wetlands-and-Watercourses--Defined

Floodplains

A golf course can be a compatible use of a floodplain zone, depending on the frequency and severity of flooding. When persistent floods result in course closures, turf loss and significant sediment removal and bunker repair then use of the floodplain for golf may not be sustainable without improvements. Where raising of features is proposed to make them less susceptible to floods, the volume of fill installed must be balanced by lowering an equal volume of nearby ground at the same elevation to compensate for the loss in flood zone volume. Regulators will seek to insure there is no net loss in floodplain area on the site.

Stormwater Management

Stormwater management planning is necessary to ensure sediment controls are in place during construction and to make sure that runoff from the course doesn't impact adjacent properties and waters. Projects are required to maintain or even reduce the volume of stormwater leaving a site. Good drainage is the primary tenet of good golf design. Techniques that manage and conserve water should be adopted into the design. Methods of stormwater management include infiltration chambers that allow water to better enter the ground and recharge aquifers, retention basins that slow the flow of water off the property during heavy rain events while also trapping sediments, installation of swales with check dams to slow runoff, installation of erosion control barriers and use of mulch on seeded areas to assist with germination without soil erosion, and planting native aquatic species within the stormwater treatment system will aid in nutrient uptake. Also, locating the constructed stormwater systems in areas prone to sunlight will allow for UV degradation of chemicals such as pesticides/herbicides and fertilizers that may be applied to the course. The Connecticut Stormwater Quality Manual provides guidance on measures to protect Connecticut water bodies from adverse impacts of post-construction stormwater runoff: https://portal.ct.gov/DEEP/Water-Regulating-and-Discharges/Stormwater/Stormwater-Manual

Surface Drainage

Good surface drainage is the most reliable method for removal of water from course play areas. Where the ground is very flat, subsurface drainage may be needed to assist in expedient removal. Where the ground is steep, reduction in watersheds through installation of berms and interceptor swales, along with sub-surface piping and drain inlets, are advantageous to slow surface runoff and lessen soil erosion. Use of natural water conveyance systems, such as streams or ditches should be considered as they improve water quality, provide habitat, and can be a strategic element. In general, for turf areas to achieve sufficient surface drainage, putting surfaces should be tilted at no less than one percent (1%) slope and fairways and roughs no less than two percent (2%). Turf relies on adequate drainage to remain healthy and disease free.

Sub-surface Drainage

Underground gravity pipe systems are typically used in conjunction with surface drainage to remove water from the turf. Underground piping can move water more quickly than surface drainage and is utilized in a variety of ways. When perforated pipe is installed in a trench with gravel or sand, the objective is generally, to remove water in saturated soil conditions.

Best Management Practices

- Involve a qualified golf course superintendent/ project manager at the beginning of the design process to integrate sustainable maintenance practices in the development, maintenance, and operation of the course.
- Design the proposed changes to minimize or eliminate alteration of sensitive existing native landscapes and retain natural site characteristics. The plans should review alternate designs to determine the concept plan that best meets the objectives with the least disturbance.
- Consider implementing increased plant diversity into the site to improve habitats.
- Design out-of-play areas to retain or restore existing native vegetation where possible. Nuisance and invasive plants should be removed and replaced with native species that are adapted to that particular site. Managing invasive plants will require ongoing maintenance.
- Consider potential wear patterns in turf areas and create adequate space for ingress/egress at greens, tees, fairways and bunkers.
- Define play and non-play maintenance boundaries.

Connecticut Native Plant Species

Design to retain as many natural site characteristics as possible. Where appropriate, consider enhancing existing vegetation through the supplemental planting of native vegetation and materials

Reference for native plants:

https://portal.ct.gov/DEEP/Plants/Plants

www.hort.uconn.edu/plants

https://portal.ct.gov/-/media/DEEP/wildlife/pdf_files/outreach/NativeLandscapingpdf.pdf

Common Cool Season Turfgrass Species in Connecticut Connecticut Native Plant Species

Bluegrass (Poa)

- Kentucky (P. pratensis)
- Roughstalk (P. trivialis)
- Supina (P. supina)
- Canada (P. compressa)
- Annual (P. annua)

Fescue (Festuca)

- Tall (F. arundinacea)
- Fine Leaf Species:
- Creeping red (F. rubra)
- Chewings (F. rubra commutata)
- Sheep (F. ovina)
- Hard (F. longifolia)

Ryegrass (Lolium)

- Perennial (L. perenne)
- Annual (L. multiflorum)

Bentgrass (Agrostis)

- Creeping (A. palustris)
- Colonial (A. capillaris)
- Velvet (A. canina)
- Redtop (A. alba)

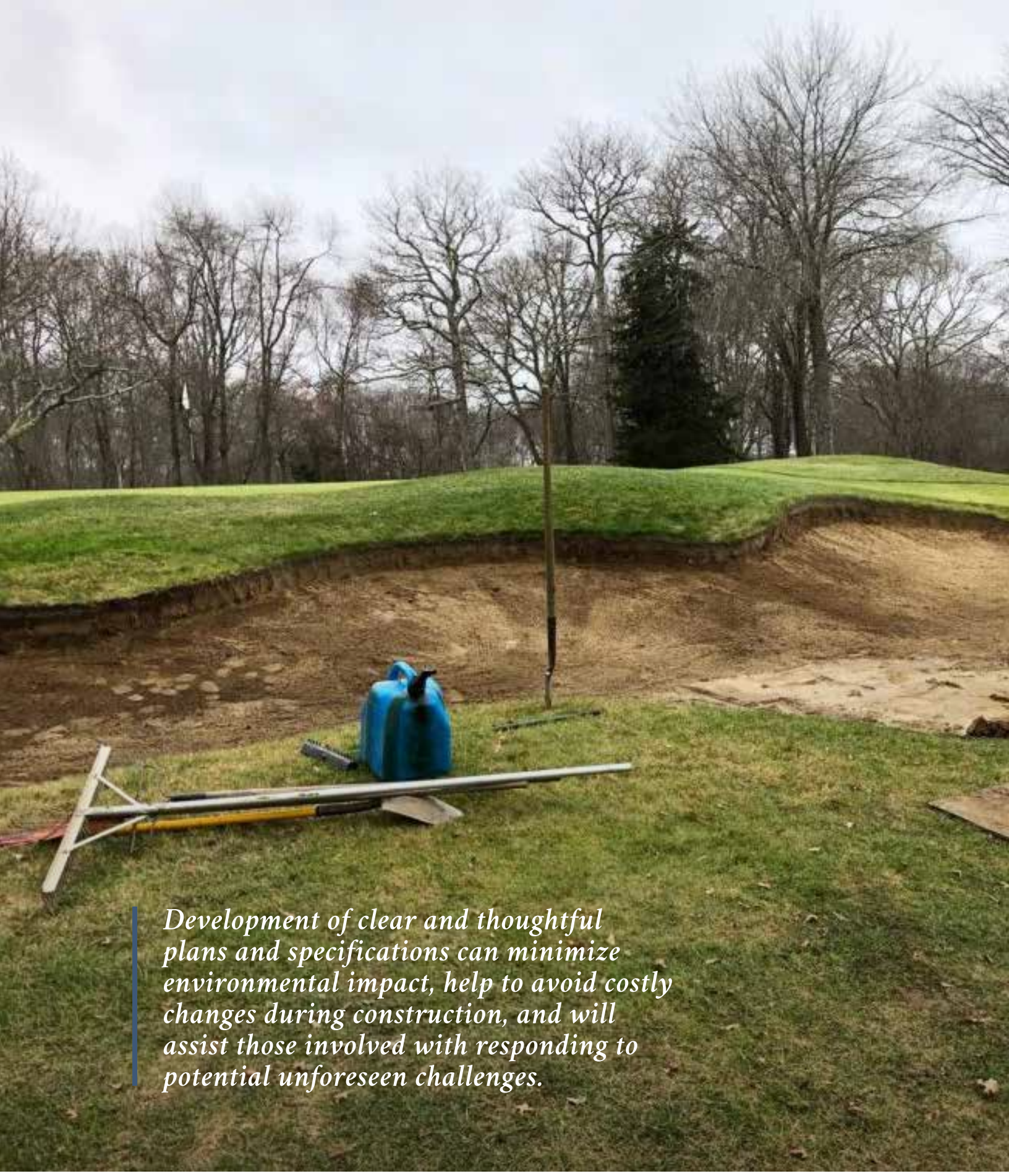
Reference for Connecticut turfgrass species: http://cag.uconn.edu/documents/Turfgrass-IPM-manual-s.pdf

Greens, Fairways, and Tees

- Select a location that has adequate sunlight to meet plant specific needs and provides sufficient drainage, or design site improvements to reduce shade and improve drainage characteristics.
- Choose a green size and enough hole locations that is large enough to accommodate traffic and play damage, but not so large that it is not sustainable with the available resources.
- For tees, select a size large enough to accommodate traffic and divot recovery. Par-three tees typically need more square footage than par-four and par-five tees.
- For fairways consider using well drained soil or even manufactured soils to promote soil drainage, health turf and firm playing conditions.
- Select an appropriate and local root-zone material that meets USGA established material protocols. More information from the USGA may be found here:
  - *https://www.usga.org/content/usga/home-page/articles/2018/02/decades-of-research-fuel-new-specs-for-putting-greens.html*
  - *https://www.usga.org/course-care/digitalcollections/creating-usga-putting-green.html*
- Greens should be irrigated separately from surrounding turf.
- Select certified turf cultivars based on an evaluation of the site and climate conditions.

Bunkers

- Consider placement of bunkers in relation to circulation patterns at greens so as not to concentrate turf wear, while keeping with golf course design considerations.
- Consider the number, size, construction components, and style of sand bunkers as they relate to resources available for daily maintenance.
- Be aware of bunker design as it relates to cost of construction and future maintenance. Make sure bunkers have suitable machine entry and exit points.
- Select the proper color, size, and shape of bunker sand that meets the site requirements, course maintenance level, and sustainability goals.
- Reference additional bunker BMPs in Cultural Practices section



Development of clear and thoughtful plans and specifications can minimize environmental impact, help to avoid costly changes during construction, and will assist those involved with responding to potential unforeseen challenges.

CONSTRUCTION

Construction Documents

Prior to starting construction, it is important to develop construction plans that clearly communicate scope of work to ensure that all parties understand the project. Construction Plans are typically created by the Golf Architect, Engineer and Irrigation Designer. All critical data from the environmental resource inventory as well as key notes regarding construction processes should be included in the construction documents, as well as any conditions imposed in the permitting process. Documents should include any sediment and erosion control or stormwater management plans that

were established in design. Challenges often arise in construction that were not foreseen in planning and design. Proper planning can reduce the number of issues, but it is best if the responsible contractor has significant experience with golf course renovation or new construction. A well-qualified contractor will be familiar with environmentally sound construction methods and be a team member who can assist in the successful completion of the project.

Construction

Construction should begin with the project team (superintendent, consultants, and owner's representatives) conducting a pre-construction meeting with the contractor(s) to review construction protocols. This meeting is important to define lines of communication, review the scope of work, review schedule, review methods for reducing environmental impacts and for the contractor(s) to become familiar with any permit requirements. Any resource areas impacted by the project should be clearly marked out prior to the meeting, and the meeting should include a field review of these areas and discussion of permit conditions impacting construction in, or adjacent to, those areas.

The golf course architect, engineer, irrigation designer and other key consultants should remain involved through the construction phase to ensure plans and specifications are being followed and permit conditions being met. The consultant's role in construction should be defined at the start of work.

During construction the site should be kept as stable as possible to reduce erosion. For large renovation and new course projects, the contractor should attempt to limit the amount of disturbed area at one time, which may require completing and stabilizing a portion of the site prior to starting on a new area. On smaller projects, rather than phasing, the best method to prevent environmental impacts may be a narrow construction window. The construction schedule and work limitations should be tailored to each site and project. The emphasis during construction must be on performing the work with quality and care to minimize the potential for future problems.

Construction Techniques

Sound construction techniques include those processes and practices that control soil erosion and stormwater runoff. Such techniques include installation of erosion control barriers prior to any land disturbance; locating of construction staging and fueling operations at least two-hundred feet (200') from any water body, wetland or sensitive area; checking barriers prior to a predicted rainfall and removing excess siltation and repairing barriers immediately following a storm; and protection of drain inlets with gravel and silt fabric. These are just a few of the procedures used.

Construction Monitoring

The contractor, owner's representative or a hired consultant should be responsible for monitoring the construction process and providing any reports required by project permits. The level of diligence invested in monitoring can significantly influence the environmental and financial sustainability and viability of the project.

Best Management Practices

- Conduct a pre-construction conference with stakeholders.
- Use a qualified golf course contractor, such as a member of the Golf Course Builders Association of America, or one with significant local golf course construction experience. Both certified and non-certified members and companies can be found in the links below:
  - *https://www.gcbaa.org/Resources/Find-a-Member/Individual-Directory/pagesize/10?p=CertifiedBuilder&Name=A*
  - *https://www.gcbaa.org/Resources/Find-a-Member/Individual-Directory/pagesize/10?p=CertifiedBuilder&Name=A*
- The article link below has some helpful information on levels of insurance policies that the contractor should have, based on the size of the project, and/or bonds that could be required during the bidding process. Bonds are more common with municipal bids, but any course could require them.
  - *https://constructioncoverage.com/construction-insurance*
- 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.
- Provide monitoring of the work. Maintain a construction progress report and communicate the report to the proper permitting agencies.
- Schedule construction and turf establishment to allow for the most efficient progress of the work, while optimizing environmental conservation and resource management.
- Temporary construction components and siltation barriers should be built in a way that minimizes environmental impacts. They should be reviewed before and after any rain event and repairs made where damage has occurred.

Construction with a Watershed or Aquifer Protection Area: Local Water Utility Inspection

Section 19-13-B102(b) of the Regulations of Connecticut State Agencies (RCSA) requires water utilities to perform an annual sanitary survey of their watershed areas and to submit an annual sanitary survey report to the Department of Public Health (DPH). Section 25-51 of the Connecticut General Statutes (CGS) authorizes water utility inspectors to enter and inspect premises located within public drinking water supply reservoir watershed areas. During the construction phase, the local water utility may inspect the project and offer suggestions to protect the public water supply if the course is within a watershed or aquifer protection area.

The State of Connecticut has erosion and sediment control regulations in place that require project proponents to consider and design appropriate runoff control measures from the start of any land disturbance project.

More information on Connecticut's Erosion and Sediment Program:

https://www.ct.gov/deep/cwp/view.asp?a=2720&q=325660&deepNav_GID=1654

https://www.ct.gov/deep/cwp/view.asp?a=2720&q=325658&deepNav_GID=1654

Erosion and Sediment Control

Sediment is defined as loose particles of sand, silt and clay carried and deposited by wind or water. Sediment most often occurs when heavy rain or irrigation flows over an area of exposed soil causing particles to be picked up by the moving water and deposited off site. Sediment dispersal can also be caused by the wind when the exposed soil is dry and can be blown. Sediment and eroded soils that reach surface waters can degrade water quality by increasing turbidity. The turbid waters can harm aquatic plants and impair the habitat for fish, shellfish and reptiles. The sediment may settle out, thereby reducing the volume of the water body and further impacting aquatic life. In addition, soil contaminants such as pesticides and excess nutrients may be picked up and transported with the eroding soil. These issues are of special concern to any course located adjacent to open water, such as ponds, lakes, streams and rivers. Protection of these areas is critical to a successful project. Good erosion and sediment control are among the most important components of the design, construction and grow-in of a project.

A stormwater pollution prevention plan may be required for projects that expose the soil. Sediment control requirements may include the mapping of slopes greater than fifteen percent (15%) or the determination of locations of highly erodible soils. Methods used to reduce sediment runoff may include the establishment of vegetative buffer strips, construction of interceptor swales that empty into detention basins, use of riprap to slow runoff and settle out sediment and the installation of erosion control barriers. Reference the 2004 Connecticut Stormwater Quality Manual: *https://portal.ct.gov/DEEP/Water-Regulating-and-Discharges/Stormwater/Stormwater-Manual for specific BMPs related to stormwater quality.*

The extent of the protections will depend on the area of work and the potential for soil movement. Project regulators will often require submittal of a narrative describing how erosion and sediment control measures will be integrated into the stormwater management strategy and a sequence of construction that describes how the work will occur to minimize potential sediment issues. Adhering to the planning principles should result in development that better fits existing site conditions and reduces both the extent and duration of soil disturbance during construction

Best Management Practices

- Develop a working knowledge of erosion and sediment control management. Connecticut has specifications including types of acceptable structures, materials, and design features.
- Develop and implement strategies to effectively control sediment, minimize the loss of topsoil, protect water resources, and reduce disruption to wildlife, plant species, and designed environmental resource areas.
- Integrate hydro-mulching, erosion blankets or straw mulch into the seeding process to enhance soil stabilization. Avoid using hay as mulch which may introduce unwanted weed seeds that may become a future problem.
- Check and repair erosion control barriers after every rain event.
- Consider limiting the area of disturbance at one time. Finish and stabilize one area before starting another area.

Surface Water: Stormwater, Ponds, Lakes

Stormwater is the conveying force behind nonpoint source pollution. Care must be taken to ensure that the golf course doesn't contribute to pollution of water bodies, especially during construction.

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, yet the course must address control and cleansing of this water as it does water that originates on site.

Best Management Practices

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

Grow-In

The soil preparation, grassing and turf establishment phase is a critical element in the development process. The process to be undertaken to prepare the ground, install the turf, seed and establish the turf to a playable condition must be carefully planned to minimize environmental risk. Timing of grassing can be critical, with late summer and early fall being the best time to quickly establish turf in Connecticut with minimal input.

During the establishment phase, greater quantities of water and nutrients may be required than on a fully established course. Most projects use a combination of seed and newly imported sod. The selection of the most appropriate grass and starter fertilizer is a critical aspect of this process. Reference the National Turfgrass Evaluation Program for help with cultivar selection: *http://www.ntep.org/*

It is wise to seek advice from a regional USGA agronomist or a knowledgeable turfgrass consultant regarding the best varieties of grass to use based on an evaluation of soil conditions, watering capabilities and the expected level of maintenance. USGA research should be utilized to select the most drought and disease resistant cultivars. Adequate nitrogen and phosphorous are critical for rapid turf establishment and prevention of soil erosion. Soil testing should be conducted prior to planting to best determine the amount and types of nutrients required. Long-term potential issues such as weed encroachment, disease and drought susceptibility can be reduced with proper seedbed fertility. Where feasible, delivery of nutrients is best done through the irrigation system (fertigation) in small quantities at regular intervals to reduce the potential for runoff. Erosion barriers should remain in place through the soil preparation and grassing phase until full establishment of the turf.

Best Management Practices

- The area to be established should be properly prepared with a suitable depth of growing medium for the turf. Soil in seeded areas should be loose enough to allow for good penetration of seed. Compacted areas should be loosened prior to planting.
- Ensure erosion and sediment control devices are in place and properly maintained. Additional erosion devices or spreading of mulch may be necessary to slow runoff over the finely graded and smoothed ground surface. Sod should be top-dressed to fill in the gaps between sod pieces and rolled. This hastens establishment and provides a smoother surface.
- Use appropriate seeding methods for the golf course's conditions. If applying pre-plant fertilization to bare soil, it should only be done immediately prior to seeding to reduce the chance of nutrient movement should a rain event occur. When using sod, nutrient applications should be delayed until sod has sufficiently rooted.
- 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.
- Apply phosphorus based on soil tests. Reduce phosphorus applications when possible.
- Maintain unfertilized buffer strips between fertilized turf and water bodies.
- Utilize vegetated containment areas for drain discharges.
- Mow as soon as the sod has rooted, or when seedlings have reached a height of one-third greater than intended height-of-cut.
- On newly seeded areas, irrigation should be applied lightly and frequently with the goal of keeping the soil damp but without runoff. Irrigation will become less frequent and heavier as the grass grows and thickens.
- Remove erosion barriers only after the turf is fully established in the area being protected

Additional reference:

https://www.gcsaa.org/uploadedfiles/Environment/Get-Started/BMPs/Best-management-practices-for-golf-course-water-use-(CT).pdf

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

LANDSCAPE

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

Species Selection and Size Considerations

The fundamental principle for the environmentally sound management of landscapes is "right plant, right place." The ideal plant from an environmental standpoint is the one that nature and evolution placed there. It has adapted specifically, to the soil, microclimate, rainfall, and light patterns, insects, and other pests, and endemic nutrient levels over thousands of years. Using native plantings will also improve diversity on the course (vegetation and animals), causing a more desirable experience and aesthetics. Utilize native perennial plantings whenever possible.

Over the years, a variety of non-native species (plants, animals, and other organisms) have been introduced to Connecticut. Non-native species are those that are alien to the ecosystem that they have been introduced into and whose introduction causes or is likely to cause harm to the environment or human health. Some non-native species exhibit an aggressive growth habit and can out-compete and displace native species. These are referred to as invasive species and they are a serious problem in Connecticut and elsewhere.

List of designated invasive plant species in Connecticut: https://cipwg.uconn.edu/invasive_plant_list/

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

The addition of proper soil amendments can improve soil's physical and chemical properties, increase its water-holding capacity, and reduce the leaching of fertilizers. Amendments may be organic or inorganic; however, soil microorganisms rapidly decompose organic amendments such as peat or compost. Soil testing should be done prior to planting to ensure that the selected plants will be planted in soil that is naturally compatible to the desired plants (i.e. proper pH, nutrient levels, wet versus dry tolerant, shaded versus full sun, etc.).

The goal of species-selection BMP is to maintain as close to a natural ecosystem as practical, while meeting the needs of a golf course.

Landscape areas should be fundamentally designed to facilitate rapid plant establishment to conserve water and lower nutritional input requirements once mature. Plants within areas that are not in play or are not critical to the design of the course may be removed and replanted with native plant material that requires little to no maintenance after establishment. Additionally, 50 percent to 70 percent of the out-of-play areas should remain in natural cover. As much natural vegetation as possible should be retained and enhanced through the supplemental planting of native trees, shrubs, and herbaceous vegetation to provide wildlife habitat in non-play areas, along water sources to support fish and other water-dependent species. By leaving dead trees (snags) where they do not pose a hazard, a well-developed understory (brush and young trees), and native grasses, the amount of work needed to prepare a course is reduced while habitat for wildlife survival is maintained.

Best Management Practices

- Base plant selection as close to a natural ecosystem as practical, while meeting the needs of the golf course. It has adapted specifically to the soil, microclimate, rainfall, light patterns, insects and other pests, and endemic nutrient levels over many years.
- Select trees, plants, and grass species to attract birds seeking wild fruits, herbs, seeds, and insects.
- Know the ultimate sizes and growth rates of trees, shrubs, and ground covers.
- Use plants that are adapted for the site based on the United States Department of Agriculture (USDA) cold-hardiness map: https://planthardiness.ars.usda.gov/PHZMWeb/
- Select stress-tolerant species or cultivars to manage periodic dry/wet conditions. Choose the most stress-tolerant species or cultivar for a particular area.

DESIGN AND FUNCTION

- Aesthetic gardens, window boxes, and container gardens should include a variety of plants of different heights that provide nectar for hummingbirds, butterflies, and other pollinators. Again, "right plant, right place" is the key to success.
- Consider construction of pollinator gardens to increase native diversity and pollinator species on the course.
- When integrating turf areas into the landscape around the clubhouse, entries, and other areas, design for ease of maintenance and keep in mind that turfgrasses grow best in sunny areas.
- Garden plants, shrubbery, ground covers, or native plants may provide a pleasing a view and provide useful food, cover, or other environmental benefits to wildlife; they may also require reduced maintenance.
- Well-designed forested buffers should contain a mixture of fast- and slow growing native trees, shrubs, and grasses to provide a diverse habitat for wildlife.
- Trap and remove upland sources of sediments, nutrients, and chemicals through placement of forested buffers.
- Use forested buffers to maintain a healthy riparian ecosystem and stable stream channel to protect fish and wildlife by supplying food, cover, and shade.

The ideal plant from an environmental standpoint is the one that nature and evolution placed there. It has adapted specifically to the soil, microclimate, rainfall, light patterns, insects, and other pests, and endemic nutrient levels over hundreds or thousands of generations.

PLANTING METHODS

A BMP goal is to maintain as close to a natural ecosystem as practical, while meeting the needs of the golf course. Where factors have changed, the challenge is finding other suitable plants.

The use of organic mulches in gardens and aesthetic areas increases the moisture-holding capacity of plantings and prevents weed growth when applied in enough depth. Organic amendments are decomposed by soil microorganisms and add to soil tilth. Establishment of a healthy ground cover layer will reduce or even eliminate the need for repeated mulch applications. Keep mulch 2 to 3 inches away from plants, to prevent fungal growth from excess dampness. Excess mulch or compacted mulch may be detrimental, causing water to shed away from the root zone and encourage overwatering. Compaction or excessive mulch buildup should be avoided, especially when annual re-mulching is performed.

Best Management Practices

- The plant palette and irrigation system should be appropriate for site conditions, considering that, in some cases, soil improvement can enhance water use efficiency.
- Plants should be grouped together based on irrigation demand.
- The percentage of landscaped area in irrigated high-water-use hydrozones should be minimized. Local government ordinances should address the percentage of irrigated landscaped area that may be included in high-water-use hydrozones. These high water-use limits should not apply to landscaped areas requiring large amounts of turf for their primary functions (for example, ball fields and playgrounds).
- In most instances, established, drought-tolerant, native or naturalized landscape plants have a root system substantial enough to keep them alive with little or no supplemental irrigation.

- Pruning and fertilizing will also benefit landscape plants while they are becoming established.
- Add proper soil amendments in garden areas to improve the soil's physical and chemical properties, increase its water-holding capacity, and reduce the leaching of fertilizers.
- For information about developing a best management program for pollinators or establishing pollinator friendly gardens, please see the Pollinator section in this BMP manual.

TREES

Trees are an important and significant component of most American golf courses. They offer beauty to the landscape and strategy for golf holes by indicating the line of play, either through, around or over existing trees.

The correct placement and selection of species are paramount to having a successful tree program where golf strategy is complemented, and the trees grow healthy and thrive for decades with few pest problems. These end results are usually the outcome of using an educated, experienced professional to develop the planting plan.

Best Management Practices

- Hire an arborist or tree specialist to aid in developing a planting plan.
- Establish a tree care program using a licensed arborist.
- For safety purposes use staff or an arborist for small scale pruning, pest management, and some tree removal. Use an outside professional tree service to handle large scale spray applications and removals that require climbing and bucket work.
- Create a tree inventory. Include information regarding tree species; map of location; age; condition; life expectancy; monetary value.
- Annually evaluate the condition of trees and make decisions regarding removals, pruning, thinning, fertility, pest control requirements.
- Regular inspection for pruning requirements is important for safety purposes, and the health of the tree by removing dead, poorly attached, or overcrowded branches.
- Most trees should be pruned during cool seasons of the year.
- Use paint to improve the appearance of a wound when in a highly visible location.
- To avoid excessive shade on turf surfaces, trees should be removed entirely or thinned through selective pruning to increase light penetration, especially around putting greens.
- Tree canopy can be raised from the ground to improve air movement and light for better turf growth.
- Trees and shrubs along streams provide temperature moderation through shade, which lowers water temperature in summer and increases it in winter.
- Trees with very dense canopy can be crown thinned to increase light penetration and wind resistance.
- Leave dead tree snags whenever possible for nesting and food source to wildlife. However, make sure that these snags are a safe distance away from playing surfaces should they get blown over.
- Root pruning can be done with a trencher, vibratory plow, backhoe, or cutting saw to reduce competition for water between the turf versus trees.
- Root pruning to a depth of 12-20” will sever the roots of most trees. Stay 1 foot in distance away from the tree for each inch in diameter at chest height. If the tree is moderately sized and healthy, a distance of 3 feet from the trunk can be used without seriously affecting the health of the tree.

Maintenance Facilities
Refer to the section “Maintenance Operations” for more detail regarding the maintenance facility design, construction, and operations.

Wildlife Considerations
Refer to the section “Pollinator Protection and Wildlife Habitats” for more detail regarding wildlife considerations.

Irrigation
For information about planning, installing, and maintaining an irrigation system, please refer to the “Irrigation” section.

Surface Water Management and Water Quality Monitoring and Management
For information about surface water management and protecting water quality, please refer to the “Surface and Stormwater Management” section.

27,000 ACRES OF GREENSPACE PROVIDES *valuable wildlife and pollinator habitats*

Connecticut golf courses provide greenspace and bluespace for habitats — including turfgrass, flowers, trees, native plants, streams, lakes, and ponds.

Golf courses enrich communities through providing valuable habitats for pollinators and wildlife, especially in urban areas. In areas with sprawling urban developments and few trees, grassland, or wetland areas, this service is of critical importance.

REGULATORY CONSIDERATIONS

- Pollinator protection language is a label requirement found on pesticide labels and must be followed; it is the law! (insert picture of "The New EPA Bee Advisory Box)
- Pesticide applicators must be aware of honeybee toxicity groups and be able to understand precautionary statements
- Recordkeeping, as required by Connecticut law, should be maintained in order to refer to in the future and follow the best course of action with future applications if necessary, reference IPM BMPs section for additional information
- Applicators of pesticides should be mindful of applications and their effects on the target and any others that may be compromised
- Connecticut State law prohibits use of neonicotinoid pesticides on plants when plants are in bloom
- Reference Connecticut Endangered, Threatened, and Special Concern Species by County: *https://portal.ct.gov/DEEP/Endangered-Species/Endangered-Species-Listings/Endangered-Threatened-and-Special-Concern-Species-listed-by-County*

Protecting bees and other pollinators is important for sustainable agriculture, including pollination of Connecticut fruits and vegetables like blueberries, strawberries, raspberries, apple trees, and alfalfa.

POLLINATOR PROTECTION

Most flowering plants need pollination to reproduce and grow fruit. While some plants are pollinated by wind, many require assistance from insects and other animals. In the absence of pollinators, many plants species, including the fruits and vegetables, would fail to survive.

The western honeybee (Apis mellifera), is an important pollinator in the United States and is maintained in commercial and residential beehives around the country. Other pollinators include butterflies, beetles, and flies. These guidelines provide ways to encourage pollinator habitats and help take precautionary steps to reduce potential impact, if any, on bee populations caused by pesticide usage.

Pollinator Habitat Protection and Enhancement

Pollinators face many numerous challenges related to loss of natural habitat as suburban areas encroach into more rural settings. Minimizing these reductions can be mitigated by golf courses by providing or enhancing pollinator habitat in non-play areas of their property and being mindful when applying pesticides near non-play areas. Pollinators require a diverse variety of flowering species to complete their life cycle. It's helpful to understand colors, odors, and variety of plants that encourage pollinators.

Best Management Practices

- Follow label instructions when applying pesticides to avoid application when plants are in bloom.
- Follow IPM BMPs.
- Consider lures, baits, and pheromones as an alternative to pesticides for pest management.
- Mow flowering plants before pesticide applications to remove blooms.
- Consider manual removal of weeds or spot treatment in pollinator habitat areas.
- Use the latest spray technologies such as drift-reduction nozzles to prevent off target application.
- Apply during times of little or no wind in order for more accurate placement of pesticide.
- Avoid applications during low temperatures and when dew is forecasted.
- Plant flowers with varying characteristics like color, shapes, sizes, flowering times, and growth habits.
- Mow natural areas 1x per year late in season when plants are going dormant in order to control growth of woody ornamentals and other undesirable plants to minimize effects on pollinators.
- Apply pesticides at times when pollinators are least active during the early morning or late evening hours.
- Limit use of granular pesticides that can be mistaken for pollen.

Connecticut Native Wildflowers for Bee Habitats

Source: https://portal.ct.gov/-/media/CAES/DOCUMENTS/Publications/pollinators/Sample-List-of-Native-Wildflowers-for-Bees-through-the-Season.pdf

Additional buzz pollinator habitats: http://nenativeplants.uconn.edu/pollinators_20_3483074612.pdf

CAES

Sample List of Native Wildflowers for Bees Through the Season
Kimberly Stoner, Connecticut Agricultural Experiment Station

Wildflower	May		June		July		Aug		Sept		Oct	
Golden Alexanders, *Zizia aurea*	■	■	■									
Ohio Spiderwort, *Tradescantia ohiensis*		■	■	■	■							
Culver's root, *Veronicastrum virginicum*				■	■	■	■					
Butterfly milkweed, *Asclepias tuberosa*				■	■	■	■					
Wild bergamot, *Monarda fistulosa*				■	■	■	■	■				
Mountain mint, *Pycnanthemum tenuifolium*				■	■	■	■	■				
Partridge pea, *Chamaecrista fasciculata*				■	■	■	■	■				
Spotted Joe Pye weed, *Eutrochium maculatum*					■	■	■	■				
New York ironweed, *Vernonia noveboracensis*							■	■	■	■		
Fall sneezeweed, *Helenium autumnale*							■	■	■	■		
Gray goldenrod, *Solidago nemoralis*								■	■	■		
New England aster, *Symphyotrichum novae-angliae*									■	■	■	

POLLINATOR RELATED OUTREACH

In addition to procedures used on the property, several steps may be taken to protect pollinators by increasing communication with the community:

- Join a local beekeeper association to become connected with local education events and mentoring opportunities.
- Consider setting up hives within a natural area of the golf course that can be maintained by an interested staff member or person within the community.
- Check with local state or agricultural and natural resource agencies to obtain a list of beekeepers within a 3-mile radius of the golf course. Contact these beekeepers about pending applications in order to allow them to take any precautions they feel necessary to protect the hives.
- Attend workshops and online seminars to learn more about pollinators and steps to protect them.
- Use social media and local news outlets to educate golfers and the general public on steps taken to minimize effects on pollinators.
- Invite local schools, garden clubs, master gardeners, etc. to visit the facility to demonstrate the steps taken to protect pollinators.

WILDLIFE HABITATS

In Connecticut, about 600 species of plants and animals are listed as endangered, threatened, or special concern. Loss of habitat is the primary reason for a species becoming endangered. More than 50 birds on the overall state list have declined due to loss of habitat. According to the U.S. Fish & Wildlife Service, Connecticut is home to endangered or threatened communities that include the bog turtle, Piping Plover, red knot, Indiana bat, and New England cottontail.

References for additional information:

https://portal.ct.gov/DEEP/Wildlife/Learn-About-Wildlife/Wildlife-Slideshows

https://portal.ct.gov/DEEP/Wildlife/Learn-About-Wildlife/Connecticut-Endangered-and-Threatened-Species-Fact-Sheets

https://www.fws.gov/endangered/map/ct-info.html

Best Management Practices

- Develop relations with the DEEP wildlife division and local fish and wildlife service organizations
- Understand whether the property is an existing or potential habitat for endangered species
- Develop a management plan and objectives
- Retain existing vegetation when possible and plant native vegetation
- Use "xeriscape" landscaping and native drought tolerant plants where feasible
- Educate staff, members/guests, and community
- Use social media and local news outlets to educate golfers and the general public on steps taken to promote wildlife habitats
- Invite local schools, garden clubs, master gardeners, etc. to visit the facility to demonstrate the steps taken to promote habitats
- Participate in bird counts or bird-watching tours for guests

Examples of Connecticut Wildlife

Mammals
Bats
Beaver
Black Bear
Bobcat
Chipmunk
Cottontail Rabbits
Coyote
Fisher
Flying Squirrels
Gray Fox
Gray Squirrel
Least Shrew
Moose
Muskrat
Opossum
Raccoon
Red Fox
Red Squirrel
River Otter
Striped Skunk
White-tailed Deer
Woodchuck

Birds
American Bittern
American Crow
American Kestrel
American Woodcock
Bald Eagle
Barn Owl
Bobwhite
Brown-headed Cowbird
Canada Goose
Common Moorhen
Eastern Bluebird
Grasshopper Sparrow
Great Egret
King Rail
Least Bittern
Least Tern
Long-eared Owl
Mallard
Mute Swan
Northern Harrier
Osprey
Peregrine Falcon
Pied-billed Grebe
Piping Plover
Purple Martin
Ring-necked Pheasant
Rock Pigeon
Roseate Tern
Ruffed Grouse
Sedge Wren
Sharp-shinned Hawk
Short-eared Owl
Snowy Egret
Upland Sandpiper
Vesper Sparrow
Wild Turkey
Wood Duck
Woodpeckers
Yellow-breasted Chat

Connecticut golf courses host an abundance of wildlife species. It's not uncommon in Connecticut to see deer, coyotes, bobcats, foxes, owls, or hawks enjoying the golf course surroundings. Ponds, lakes, and streams are also home to many species of fish, frogs, and turtles; in addition to providing habitat for waterfowl. Forested buffers along golf course streams and wetland areas provide sanctuaries for birds and other wildlife, while protecting water quality. When riparian buffers connect isolated blocks of habitat, they also serve as important travel corridors for species that may not cross large open areas. Natural vegetation should be retained and enhanced through supplemental planting of native trees, shrubs, and grasses in non-play areas. Avoid exotic species, particularly invasive plants, or plants that are not well adapted to the local environment. Natural cover around a course also serves as a buffer to reduce urban traffic noise.

Reference additional Connecticut wildlife habitat information:

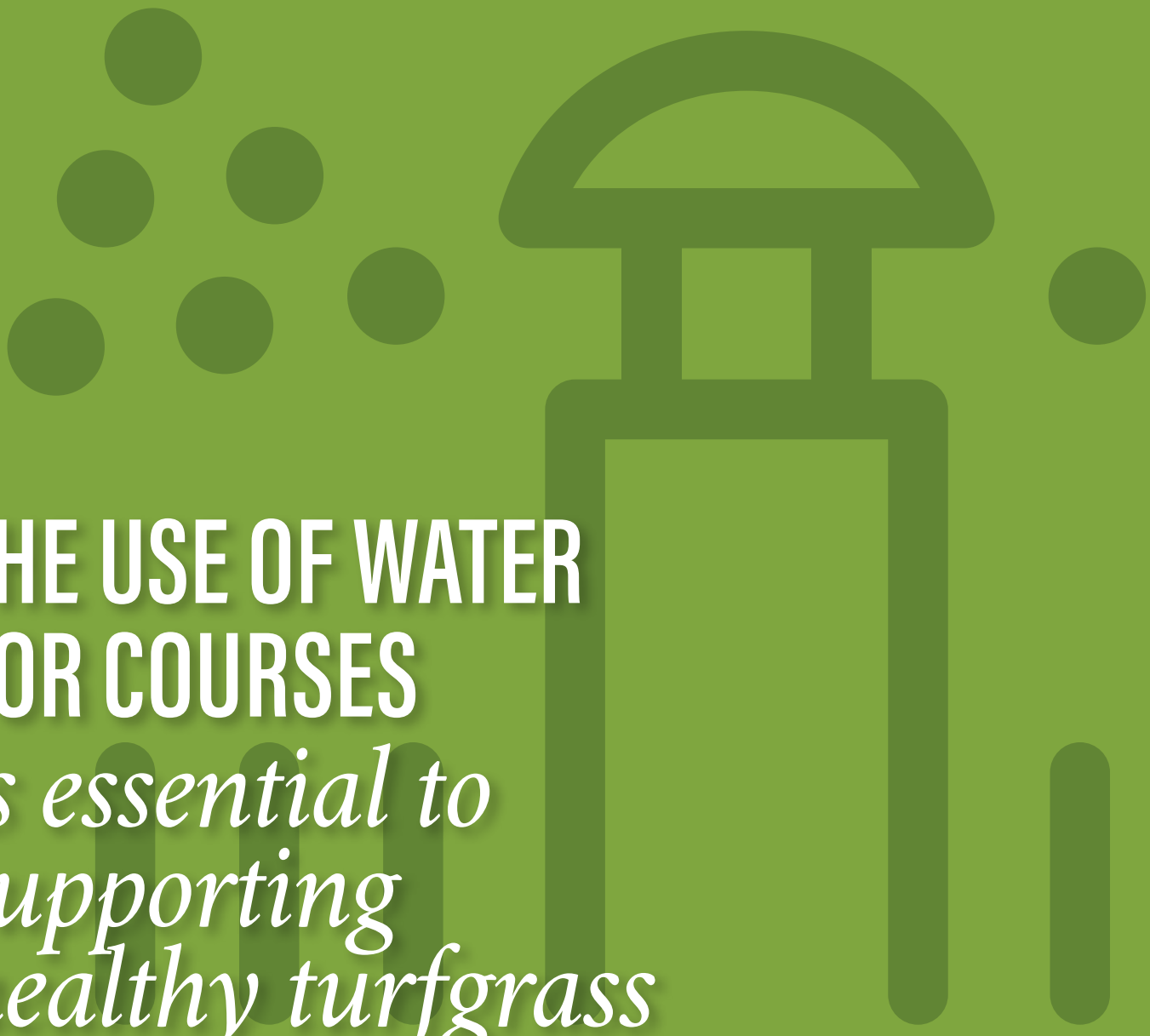
https://portal.ct.gov/DEEP/Wildlife/Learn-About-Wildlife/Wildlife-Fact-Sheets#mammals

Reference Audubon International wildlife habitat and conservation BMPs:

https://auduboninternational.org/wp-content/uploads/2019/02/G_E-Environmental-Management-Guidelines-for-Golf.pdf

Reference Surface Water Management and Water Quality Monitoring and Management for additional information about protecting water quality for wildlife and aquatic habitats.

Golf courses provide habitats for birds including designated wetlands, lakes, streams, ponds, plus grasslands, trees, and native areas, in addition to protection of migratory corridors.



THE USE OF WATER FOR COURSES *is essential to supporting healthy turfgrass and landscape*

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

The purpose of this section is to identify BMPs related to water use that conserve and protect water resources. Additionally, irrigation BMPs may provide an economic, regulatory compliance, and environmental stewardship advantage to those who consider them part of their irrigation management plan. If applied appropriately, they can help stabilize labor cost, extend equipment life, limit repair and minimize risks.

The monetary investment in non-structural BMPs costs little to nothing to implement in a daily course water-use plan. Other advantages include reduced administrative requirements, improved employee communication, and effective training procedures.

There are several water-management approaches which may be utilized:

Embracing Irrigation BMPs

There are several environmental, performance, and employee benefits from adopting BMPs for Irrigation:

- Conserve and protect the water supply
- Protect existing water quality
- Maintain optimal ball roll and playing conditions
- Save electricity, which helps reduce a facility's carbon footprint
- Increase pump and equipment life longevity
- Demonstrate responsible environmental stewardship
- Retain knowledgeable and effective employees

CONSERVATION AND EFFICIENCY

Conservation and efficiency consider 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.

Understanding Distribution Uniformity vs. Efficiency

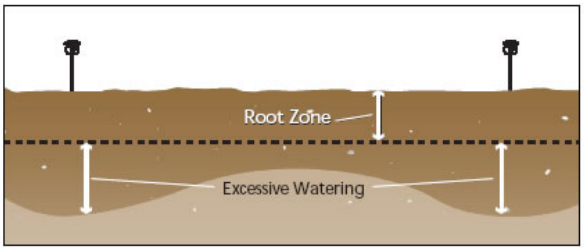


FIGURE 1: Depiction of irrigation resulting in poor DU and excessive watering

Poor distribution uniformity combined with poor application efficiency wastes water applied beyond the root zone and perhaps wet playing conditions depending soil drainage

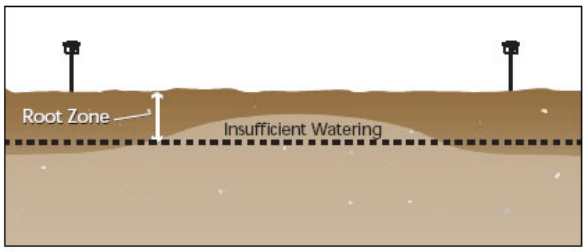


FIGURE 2: Depiction of irrigation resulting in poor DU and insufficient irrigation in parts of the field

Poor distribution uniformity and good application efficiency does not waste water but in a turf application would leave noticeable dry spots in turf

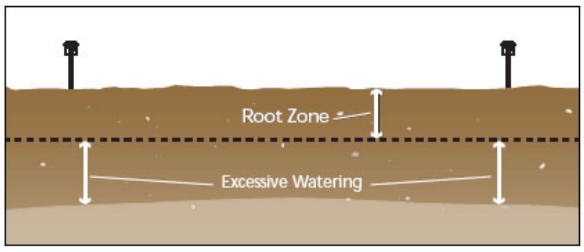


FIGURE 3: Depiction of irrigation resulting in good DU but poor irrigation efficiency

Good distribution uniformity and poor application efficiency results in wasted water applied beyond the root zone and perhaps wet playing conditions depending soil drainage

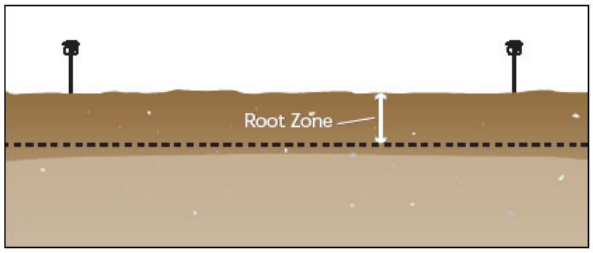


FIGURE 4: Depiction of irrigation sufficiently watering the entire field with good DU and irrigation efficiency

Good distribution uniformity and good application efficiency does not waste water and optimizes playing conditions

REGULATORY CONSIDERATIONS

- Golf course owners are responsible for contacting federal, state, and local water use authorities at the pre-and post-construction phase to determine annual or specific water consumption (water rights), permitting guidelines, and other requirements allowed by regulators.
- See Connecticut's water diversion program: https://portal.ct.gov/DEEP/Water/Diversions/Water-Diversion-Program
- See Connecticut BMPs for Golf Courses for state guidelines: https://portal.ct.gov/DEEP/Water/Diversions/Water-Diversion---Related-Guidance
- 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.
- Connecticut golf courses may be subject to obtaining a water withdrawal permit. More information: https://www.ct.gov/deep/cwp/view.asp?a=2709&q=324178&deepNav_GID=1643

Best Management Practices

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

Some golf courses are being designed using a "target golf" concept that minimizes the acreage of irrigated turf. Existing golf courses can try to convert turf in out-of-play areas to naturally adapted native plants, grasses, or ground covers when feasible to reduce water use and enhance aesthetics.

IRRIGATION WATER SUITABILITY

Golf course designers and managers should endeavor 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; 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 maybe helpful to properly design a course's stormwater systems, water features, and to protect water resources.

When necessary, treatment options should be included in the budget to address water quality and equipment maintenance. Maintaining good internal soil drainage to manage saline and/or sodic water quality may require additional soil cultivation to relieve compaction and/or chemical amendments to exchange with sodium in severe circumstances.

Additional information on irrigation water suitability:

http://gsr.lib.msu.edu/2000s/2000/000914.pdf

http://plantscience.psu.edu/research/centers/turf/extension/factsheets/water-quality

https://anrcatalog.ucanr.edu/pdf/8009.pdf

http://www.fao.org/3/t0234e/t0234e00.htm

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 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, effluent, and other non-potable water supply mains must be protected by an approved backflow protection device as specified by state and/or local regulations.
- Potable supply lines to buildings (for domestic uses) at recycled (reclaimed, effluent, non-potable) water use sites typically must be protected with backflow prevention device(s) in place, that are operating correctly and tested regularly.
- Irrigation pipeline systems directly connected to municipal water distribution mains must have an approved backflow device at the point of connection.
- Backup/emergency supplies of potable water used to replenish recycled water storage reservoirs must be protected by an approved backflow protection device such as a reduced pressure principle device or an air gap structure as specified by state and/or local regulations.
- Post signage in accordance with local utility and state 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.
- Regularly perform soil testing to monitor the accumulation of salts and sodium delivered in the recycled (reclaimed, effluent, or non–potable) water supplies.
- Where practical, use reverse-osmosis (RO) filtration systems to reduce chlorides (salts) from saline groundwater; if using RO to improve water quality, be certain the reject concentrate (brine) is disposed of in a legal, proper, and environmentally responsible manner.
- 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.
- Meter the water supply and maintain accurate records to document irrigation water used monthly and annually. Avoid relying on estimated flow data provided by the central irrigation control computers, instead install a totalizing flow meter for accurate record keeping.

WATER CONSERVATION AND EFFICIENT USE PLANNING

Document the watering practices at the golf course to show savings in water use over averages and set goals for reductions when practicable. Communication regarding actions taken and purpose for those actions should be maintained with water managers, golf course members, and the public. Potable water supplies in many areas of Connecticut are limited and demand continues to grow. The best and most effective method to reduce water use on any golf course is to reduce the irrigated acreage where possible. The challenge is to find solutions to maintain the quality of golf while using less water. BMP usage and communications are important to educate the community and public around water use.

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, noninvasive 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 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.
- Always closely monitor soil moisture levels, particularly during a drought. Whenever practicable, irrigate at times when the least amount of evaporative loss will occur.
- Control invasive plants or plants that use excessive water.
- During a drought, closely monitor soil moisture levels. Whenever practicable, irrigate at times when the least amount of evaporative loss will occur.

General information on water conservation on golf courses:

United States Golf Association (USGA) Research on Turfgrass Water Use
http://www.usga.org/course-care/water-resource-center/research-on-turfgrass-water-use.html

"Water Conservation" Golf Course Superintendents Association of America (GCSAA)
http://www.gcsaa.org/course/communication/golfcoursefacts/water-conservation

IRRIGATION SYSTEM DESIGN

A well-designed irrigation system should operate at peak efficiency to reduce energy, labor, and natural resources. Irrigation systems should be properly designed and installed to improve water application efficiency through high distribution uniformity. Irrigation managers should be properly trained to understand soil-water relationships, principles of crop coefficients and evapotranspiration for efficient scheduling, to prevent applying excess water that will percolate beyond the root zone (except when purposely leaching salts). An efficient system, combined with a well-educated irrigation manager, maximizes water use, reduces operational cost, conserves supply, and protects water resources. When in the design phase, pipe sizing and pump capacity should be budgeted for to have the shortest and most efficient water-time-window. Sprinkler selection, spacing, configuration (as triangular or rectangular arrangements) and nozzle selections should all be made to maximize distribution uniformity.

Best Management Practices

- Design should account for optimal distribution efficiency and effective root-zone moisture coverage. Target 80% or better Distribution Uniformity (DU).
- Design should allow the putting surface and slopes and surrounds to be watered independently.
- Design should offer individual sprinkler control instead of "block systems", particularly with fine turf areas.
- The design package should include a general irrigation schedule with recommendations and instructions on modifying the schedule for local climatic, soil and growing conditions. It should include the base evapotranspiration (ET) rate for the location.
- The application rate must not exceed the infiltration rate, ability of the soil to absorb and retain the water applied during any one application. Conduct saturated hydraulic conductivity tests periodically. (Note: Since golf rotors and many other sprinkler's precipitation rates may exceed soil infiltration rates, avoiding surface runoff is often accomplished by operating sprinklers in short durations with a "soak in time" programmed to occur between each application cycle.)
- The design operating pressure must not be greater than the available source pressure or a booster pump will become necessary.
- The design operating pressure must account for peak-use times, maximum flow rates and supply line size and operating 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. (Typically, a system should be designed with at least 15 percent additional capacity (i.e; flow rate at the specified operating pressure) to accommodate "catching up" over 7 days if an irrigation event is missed due to a power failure, etc.)

- Turf and landscape areas should be zoned separately. Specific use areas zoned separately: greens, tees, primary roughs, secondary roughs, fairways, native, trees, shrubs, etc.
- Design should account for the need to leach out salt buildup from poor-quality water sources by providing access to freshwater.
- Only qualified specialists should install the irrigation system.
- Construction must be consistent with the design.
- The designer should be a qualified irrigation designer/consultant.
- The designer must approve any design changes before construction.
- Construction and materials must meet existing standards and criteria.
- Prior to construction, all underground cables, pipes, and other obstacles must be identified, and their locations flagged.
- Permanent irrigation sprinklers and other distribution devices should be spaced according to the manufacturer's recommendations.
- Sprinkler spacing distance 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 each zone must have the same precipitation rate.
- Sprinklers in 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 backflow prevention.
- Water conveyance systems should be designed with thrust blocks (or joint restraints) and air-release valves and/or vacuum release valves as necessary.
- Sites with significant elevation change may require a design incorporating pressure regulating valve (PRV) station(s) and/or multiple points of connection (POCs), pump stations and/or mainline systems separately pressurized to minimize zones of excess and/or insufficient pressure due to elevation-related pressure loss and/or gain.
- Flow velocity must be 5 feet per second or less.
- Pipelines should be designed to provide the system with the appropriate pressure required for maximum irrigation uniformity.
- Pressure-regulating or compensating equipment must be used where the system pressure exceeds the manufacturer's recommendations.
- Equipment with check valves must be used in low areas to prevent low head drainage.
- Isolation valves should be installed in a manner that allows critical areas to remain functional while making repairs to the system.
- Manual quick-coupler valves should be installed near greens, tees, and bunkers so these can be hand-watered during severe droughts.
- In areas that are known to be drier than others, consider adding manual quick-coupler valves to these areas, as well.
- Update multi-row sprinklers with single head control to conserve water and to enhance efficiency.
- Ensure heads are set at level ground and not on slopes.

Benefits & Placement of Part-Circle or Adjustable Heads

- Install along lakes, ponds, and wetlands margins.
- Use to avoid overspray of impervious areas such as roadways and sidewalks.
- Use to avoid overspray into natural water features and/or other environmentally sensitive areas particularly when using recycled/reclaimed/effluent water.
- Place along areas that will be considered non-irrigated, such as forest borders, native meadows, perennial rock gardens, etc.

IRRIGATION PUMPING SYSTEM

Properly maintained and running pump stations are critical for water and energy conservation. 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. VFDs can help reduce energy usage to improve conservation and cost reductions.

Best Management Practices

- The design operating pressure must not be greater than the available pump's capabilities or source pressure.
- The design operating pressure must account for peak-use times, peak flow rates, and supply-line diameter and operating pressures at final buildout for the entire system.
- Maintain the air-relief and vacuum-breaker valves by using hydraulic-pressure-sustaining values.
- Install VFD systems to lengthen the life of older pipes and fittings until the golf course can afford a new irrigation system.
- An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.
- Pumps should be sized to provide adequate flow and pressure.
- 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 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.
- Pump efficiency tests performed every 3 to 5 years will document wells and/or irrigation pumps are in good working order, operating efficiently, and not wasting energy.

IRRIGATION SYSTEM PROGRAM AND SCHEDULING

Responsible irrigation management conserves water plus reduces nutrient and pesticide movement. Irrigation scheduling must take plant water requirements and soil intake capacity into account to prevent excess water use that could lead to leaching and runoff. Plant water needs are determined by ET rates, recent rainfall, recent temperature extremes, and soil moisture.

Irrigation should not occur on a calendar-based schedule; it 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.

Time-clock-controlled irrigation systems preceded computer-controlled systems, and many are still in use today. Electric/mechanical time clocks cannot automatically adjust for changing ET rates. Frequent adjustment is necessary to compensate for the needs of individual turfgrass areas.

An onsite weather station will offer the best ET information. When unavailable, follow several local weather stations that can be found on Weather Underground: www.weatherunderground.com or the Northeast Regional Climate Center: http://www.nrcc.cornell.edu/wxstation/pet/pet.html. It is important to note when using a local weather station's data, that the E.T. may not be calibrated for turf and the weather station location may not be on turf, so the numbers may not be exactly what is desired. It is possible to still draw conclusions over time in relation to what the turf requirements are.

Best Management Practices

- The reliability of older 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 0.25 to 0.5 inch of rain is received. Computerized systems allow a superintendent to access the control system 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.
- Generally, granular fertilizer applications should receive 0.25 inch of irrigation to move the particles off the leaves while minimizing runoff.
- Irrigation quantities should not exceed the available water holding capacity of the soil based on texture and root zone depth.
- Irrigation schedule should coincide with other cultural practices (for example, the application of nutrients, herbicides, or other chemicals).
- 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. All of this is driven by site surveying and scouting.
- Use mowing, verticutting, aeration, nutrition, and other cultural practices to control water loss, reduce compaction to maintain infiltration rates and minimize runoff, 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 to estimate soil moisture and the best time to irrigate.
- Avoid use of a global setting; adjust 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.

Accounting for Nutrients in Effluent Water Supply When Making Fertilizer Calculations

Water reports from wastewater treatment plant's internal laboratories do not always report nitrate (NO3) and ammonium (NH4) as nitrogen (N). NO3-N means nitrogen in the form of nitrate (NO3) and NH4-N means nitrogen in the form of ammonium (NH4) in mg/l.

To convert nitrate (NO3) or ammonium (NH4) to nitrogen, 10 mg/l N = 45 mg/l NO3 = 13 mg/l NH4, each should be reported as 10 mg/l NO3-N or 10 mg/l NH4-N. Water reports from wastewater treatment plant's internal laboratories do not always report nitrate (NO3) and ammonium (NH4) as nitrogen (N). NO3-N means nitrogen in the form of nitrate (NO3) and NH4-N means nitrogen in the form of ammonium (NH4) in mg/l.

To convert nitrate (NO3) or ammonium (NH4) to nitrogen, 10 mg/l N = 45 mg/l NO3 = 13 mg/l NH4, each should be reported as 10 mg/l NO3-N or 10 mg/l NH4-N.

For further discussion visit Water Quality for Agriculture: Section 5.1 at: http://www.fao.org/3/t0234e/T0234E06.htm#ch5.1

To calculate the nitrogen contribution provided from a recycled water supply, multiply the mg/l (or ppm) of NO3-N and NH4-N combined by 2.72 to determine the pounds of actual nitrogen contained in an acre-foot (326,000 gallons) of water. One acre-foot (AF) is the equivalent of 12" of water applied over one acre.

Example:

10 mg/l of NO3-N and 20 mg/l NH4-N for a total of 30 mg/l total N are reported by laboratory analysis to be contained in a recycled water sample.

30 mg/l X 2.72 = 81.6 lbs. of N per AF

If 32,600,000 gallons per year are used to irrigate 50 irrigated acres of turf. 32,600,000 gal / 50 Acres = 652,000 gal/Acre

652,000 gallons per acre / 326,000 gallons per AF = 2 AF per Acre

2 AF per Acre X 81.6 lbs of N per AF = 163.2 lbs. of actual N per Acre or 3.74 lbs of N per 1000 sq ft.

- ET rates should be adjusted by the appropriate crop coefficient (Kc). Average Kc values are 0.80 for cool season turfgrasses and 0.60.for warm season turfgrasses. Kc values may require minor adjustment through the growing season. Average Kc values can be used when creating annual water budgets and/or as a starting point when scheduling for ET replacement.
- Manually adjust individual control stations' automated ET data with a Kc to reflect wet and dry microenvironments on the course.
- Use soil moisture sensors, or if unavailable a soil sampling tube, to assist in scheduling or to create on-demand irrigation schedules.
- Use multiple soil moisture sensors to reflect soil moisture levels. Evaluate variations in soil types across the property using the USDA Web Soil Survey when selecting locations for multiple sensors placement. https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
- Install soil moisture sensors in the root zone for each irrigation zone as feasible to enhance scheduled timer-based run times.
- Place soil moisture sensors in a representative location within the irrigation zone. Installing a soil moisture sensor in the driest or wettest irrigation zone of the irrigation system may lead to over or under watering on a larger scale.
- Wired soil moisture systems should be installed to prevent damage from aerification.
- 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.
- Install emergency shutdown devices to address line breaks.
- Check to ensure system is operating properly after power outages.

SENSOR TECHNOLOGY

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 depths 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.

To prevent excess water use, irrigation scheduling should consider plant water requirements, recent rainfall, recent temperature extremes, and soil water holding characteristics.

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 and accuracy of data collected and the number of assumptions made.

Best Management Practices

- Irrigation controllers/timers should be reset as often as practically possible to account for plant growth requirements and local climatic conditions.
- Properly calibrated flow meters, soil moisture sensors, rain shut-off devices, and/or other automated methods should be used to manage irrigation.
- Irrigation rates should not exceed the maximum ability of the soil to absorb and hold the water applied in any one application.
- Irrigation should not occur on a calendar-based schedule but should be based on ET rates, root depths, and soil moisture holding vs. replacement requirements.
- Computerized control systems should be installed on all new course irrigation systems to help ensure efficient irrigation application. These allow for timing adjustments at every head when systems are designed to provide individual head control.
- 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.
- Be sure that all on-site weather stations are properly calibrated and maintained.

TURF DROUGHT RESPONSE

The presence of visual symptoms of moisture stress is a simple way to determine when irrigation is needed. Use a soil moisture meter to determine moisture needs of greens and tees. Managers of golf greens cannot afford to wait until symptoms occur, because unacceptable turf quality may result. Be prepared for extended drought or restrictions by developing a written drought management plan in consultation with public water suppliers, and applicable local and state agencies.

Best Management Practices

- Use soil moisture meters to determine moisture thresholds and plant needs.
- Irrigating too shallowly encourages shallow rooting, increases soil compaction, and favors pest outbreaks.
- For golf greens and tees, most roots are in the top several inches of soil, use a soil sampling tube or soil profiler to regularly monitor and determine rooting depths.
- For fairways and roughs, use infrequent, deep irrigation to supply enough water for plants and to encourage deep rooting.
- Proper cultural practices such as aeration, 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

Irrigation system maintenance on a golf course involves four major efforts: calibration or auditing, preventive maintenance (PM), corrective maintenance, and record keeping. Good system management starts with good PM procedures and recordkeeping. Corrective maintenance is simply the act of fixing what is broken. It may be as simple as cleaning a clogged orifice, or as complex as a complete renovation of the irrigation system.

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

Best Management Practices

- Respond to day-to-day failures in a timely manner, maintain the integrity of the system as designed, and keep good records.
- System checks and routine maintenance on pumps, valves, control systems, adjustment of programs, fittings, and sprinklers should follow the manufacturer's recommendations.
- Systems need to be observed in operation at least monthly and more often if the system is problematic. This can be done during maintenance programs such as fertilizer or chemical applications where irrigation is required, or the heads can be brought on-line for a few seconds and observed for proper operation. This process detects controller or communications failures, stuck or misaligned heads, and clogged or broken nozzles.
- Part-circle sprinklers should be checked periodically for proper adjustment. This is of particular importance when irrigating with recycled (effluent or reclaimed) water so that it does not spray outside of the designated use area.
- Even under routine conditions, keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.
- Keep records of filter cleaning and/or other servicing, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.
- Application/distribution efficiencies should be checked annually. Implement a PM program to replace worn components before they waste fertilizer, chemicals, and water.
- Conduct a periodic professional irrigation audit at least once every five years.

Irrigation System Inspection Checklist

Daily

Visual field inspections for:

- _ Leaks (in pipes or heads)
- _ Stuck-on heads
- _ Flow (actual vs. projected)
- _ Meter readings
- _ Computer logs
- _ Rapid pressure loss at pump stations cycling motors
- _ Visually inspect resevoir
- _

Weekly

- _ Inspect individual clocks
- _ Run the system & watch sprinklers
- _ Cleaning filters at the pump station to remove debris
- _ Check rotation of heads
- _ Make needed adjustments
- _ Inspect for proper pressures at sprinklers (visual and measured)

Quarterly

- _ Read electrical current drawn by pumps
- _ Check voltage at breakers
- _ Record run time hours
- _ Inspect motors
- _ Inspect PRV
- _ Pressure adjustments to each zone or sprinkler

Annually

- _ Inspect all sprinklers on the course
- _ Replace worn parts
- _ Record each head
- _ Visually inspect reservoir
- _ Sprinkler nozzle replacement program by zone or area

Reference: Hawai'i Golf Maintenance BMP Handbook, 2019

- Document pumping equipment run-time hours. Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Keep sprinklers edged regularly to ensure proper distribution.
- Keep valve boxes edged regularly to be able to quickly locate and shut a section of the system off if there is a leak.
- Exercise manual isolation valves annually by closing and reopening to prevent the threads of operating stems from corroding and seizing.
- Annually disassemble, clean and service air and vacuum release valves, pressure regulating valves, and any other specialized components included in the design. These devices are commonly used where significant elevation change occurs to avoid water hammer from escaping air during spring recharge, allow complete drainage during fall system evacuation and/or over pressurization of lower elevations where pressure reduction and regulation are needed to avoid pressure surges.
- Gather all the documentation collected as part of the PM program, along with corrective maintenance records for analysis.
- Correctly identifying problems and their costs helps to determine what renovations are appropriate.
- Collecting information on the cost of maintaining the system as part of system overall evaluation, allows for planning necessary upgrades, replacement etc. and to compare after changes are made.

POND LOCATION AND DESIGN

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 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 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 with stormwater experience, 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 pretreatment zones and/or vegetative buffers to help remove nutrients and sediments. Carbon filters can be added in cases where vegetative buffers are unavailable.
- Studies of water supplies are needed for irrigation systems, and studies of waterbodies or flows on, near, and under the property are needed to properly design a course's stormwater systems and water features, and to protect water resources.
- Peninsular projections and long, narrow fingers into ponds may prevent water mixing. Ponds that are too shallow may reach high temperatures, leading to low oxygen levels 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.

Golf Course Ponds
Maintenance Challenges

- Low dissolved oxygen
- Sedimentation
- Changes in plant populations
- Nuisance vegetation
- Maintenance of littoral shelves
- Vegetation on the lakeshore
- Mammal intrusion such as beavers or muskrats

POND USE AND MAINTENANCE

Successful pond management should include a clear statement of goals and priorities to guide the development of the BMP necessary to meet those goals.

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 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.

Use an expert in aquatic management to help develop and monitor pond management programs. There are various considerations which need to be 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 emitters. Also, pond leaks should be controlled and managed properly. Use of herbicides including some colorants requires aquatic pesticide permit and may require additional pesticide certification.

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 dissolved oxygen levels. Use drop spreaders instead of rotary spreaders near these sensitive areas.
- 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 BMPs on projects upstream to reduce erosion and the resulting sedimentation.
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered dissolved oxygen levels.
- Aerate ponds and dredge or remove sediment before it becomes a problem.

More About Spillway Systems

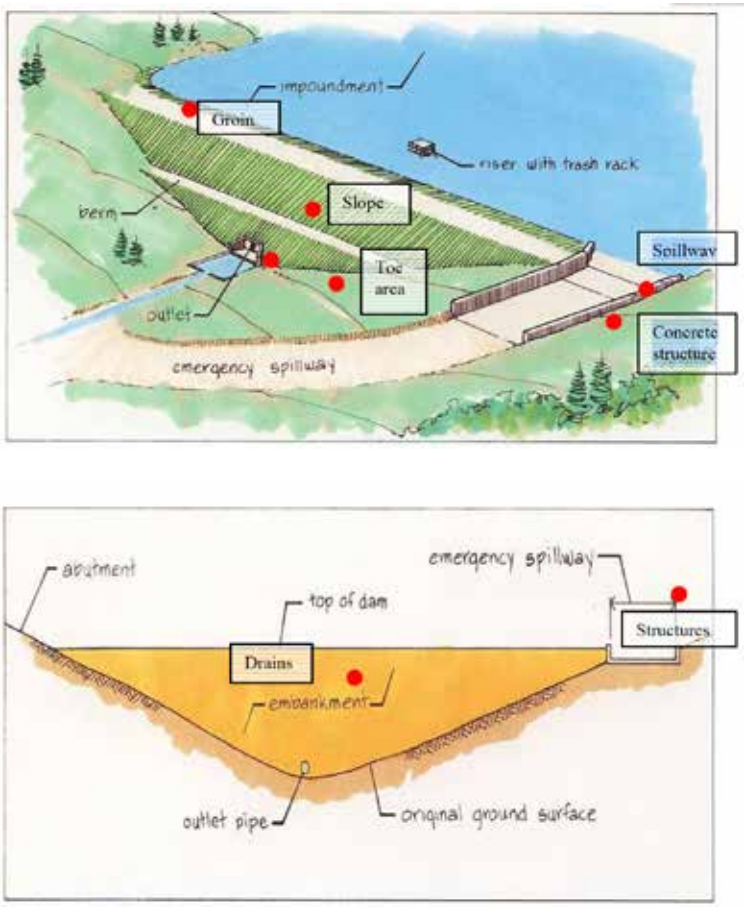
Spillway Systems are control structures over or through which flows are discharged, they include Primary Spillways through which normal flows and small storm water flows are discharged and Auxiliary or Emergency Spillways through which storm water flows (floods) are discharged.

POND WATER-LEVEL MONITOR

Evaporation losses are higher in some regions than others and vary from year to year and within the year. However, evaporative losses could approach six inches per month during the summer. Aquatic plants are more difficult to control in shallow water.

Best Management Practices

- A pond should hold surplus storage of at least 10 percent of full storage; in other words, the difference between primary spillway elevation and auxiliary spillway elevation provides 10 percent of pond volume when water level is equal to elevation of the primary spillway.
- 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 and if supplied by the irrigation supply, they should be included in irrigation water budgets.



FEMA Figure 6 | FEMA 534, Technical Manual for Dam Owners: Impacts of Plants on Earthen Dams, Figure 6, Page 5-19, September 2005.

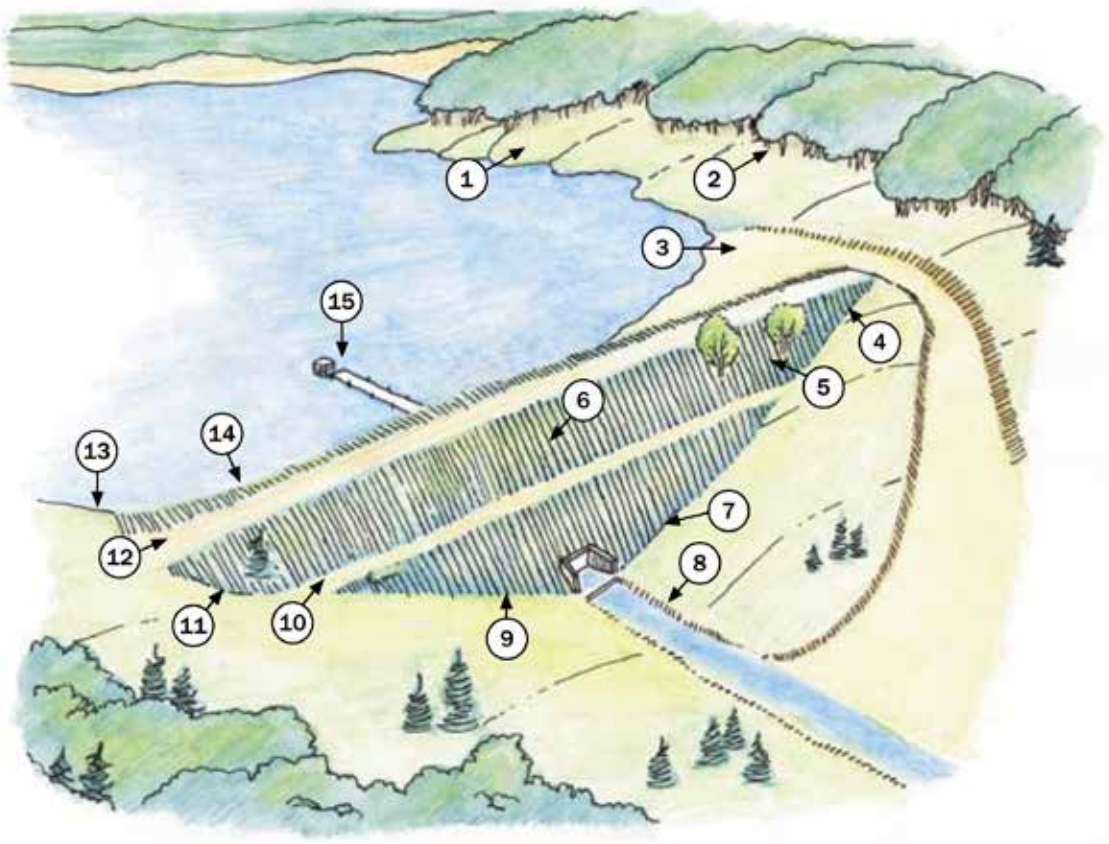


Figure 3-2. The Earthen Dam from Biological and Engineering Perspectives.

1. **Upland Areas.** Many species live in the upland areas, away from the water. Even the downstream slope, abutments, and groin areas of the dam can be considered upland in terms of habitat.
2. **Forest Fringe.** The zone between two environments (the edge) is the best place to observe those species living at and around the dam. The more habitat types at the dam, the greater number of species likely to inhabit the dam. Mountain beaver or armadillo prefer forested/wooded areas.
3. **Emergency Spillway.** Beaver often dam the spillway, causing the pond water levels to rise.
4. **Left Abutment contact.**
5. **Inappropriate Vegetation on Embankment.** Many dams contain vegetation other than mowed grass. Improper vegetation provides cover and food supply, which encourage animals to inhabit the dam.
6. **Downstream Slope.** This area is often the location where groundhogs, coyote, and fox excavate burrows. Canada geese will feed on the downstream slope, which could cause loss of protective vegetative cover and associated erosion. Species that prefer upland areas could be found in this area.
7. **Left Groin.**
8. **Discharge Conduit and Outlet Channel.** Beaver can dam the outlet structure. Aquatic species may inhabit this area depending on water flow and availability of vegetation.
9. **Toe of Embankment and right groin.**
10. **Erosion Pathways on the Embankment.** Livestock traverse the embankment creating erosion pathways.
11. **Right abutment contact.**
12. **Crest.** Livestock traverse the crest which creates ruts. The ceilings of beaver and muskrat burrows in the upstream slope are often just below the dam crest.
13. **Aquatic Fringe.** The zone where the bank meets the pond usually contains aquatic vegetation preferred by many animals such as nutria.
14. **Upstream Slope.** Beaver, muskrat, and nutria prefer the upstream slope for burrow excavation. Alligators, otters, and turtles usually live in the shallow waters near the upstream slope.
15. **Principal Spillway (with riser and trash rack).** Beavers can block principal spillways by constructing dams.

Spillway Systems Diagram

FEMA Figure 3-2 | FEMA 473, Technical Manual for Dam Owners: Impacts of Animals on Earthen Dams, Figure 3-2, Page 11, September 2005.

METERING

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 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.

Best Management Practices

- Calibrate equipment periodically to compensate for wear in pumps, nozzles, and metering systems.
- Properly calibrated flow meters, soil moisture sensors, rain shut-off devices, and/or other automated methods should be used to manage irrigation.
- Flow meters should have a run of pipe that is straight enough — both downstream and upstream — to prevent turbulence and bad readings - consult the manufacturers recommendations for the minimum length of straight pipe required in front of the meter.
- Flow meters can be used to determine how much water is applied over the irrigated area. That can then be converted to inches applied and compared to ET to confirm the average application of water applied as a percentage of ET.

IRRIGATION LEAK DETECTION

Irrigation systems are complex systems that should be closely monitored to ensure leaks are quickly detected and corrected. Golf courses without hydraulic pressure-sustaining valves are much more prone to irrigation pipe and fitting breaks because of surges in the system, creating more downtime for older systems. If staff or golfers notice part of the course is moist during dry periods and/or lush vegetation, this could be an indication of a leaking system. In addition to promptly repairing leaks, 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. It is also a good practice to log the amount of water pumped each day.
- Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings). If the system requires frequent repairs, determine why these failures are occurring. Pipe failures may be caused not only by material failure, but also by problems with the pump station.
- Ensure that pump control systems provide for emergency shutdowns caused by line breaks and allow maximum system scheduling flexibility.
- Programming of central controllers with flow management software must be performed by qualified individuals who understand the relation between pipe size, flow rates, flow velocities and friction loss (of dynamic pressure) so to not create water hammer or pressure losses by allowing zones to exceed maximum allowable values.

SPRINKLER MAINTENANCE

Good system management starts with comprehensive 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 by material failure or by problems with the pump station and/or control system programming resulting in pressure surges and spikes.
- Wiring problems could be caused by corrosion, rodent damage, insulation knicks, or frequent lightning or power surges.
- Control tubing problems could result from poor filtration or water supply chemical precipitants such as calcium carbonate.

Best Management Practices

- System checks and routine maintenance on pumps, valves, programs, controllers, 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.
- Part-circle sprinklers should be checked periodically for proper adjustment particularly on the perimeters/borders of sites using reclaimed, recycled or effluent irrigation supplies.
- Flush drip/micro-irrigation irrigation lines and filters 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 should be observed in operation at least monthly or more frequently if regularly occurring problems with the system dictate otherwise. 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 service performed, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.
- Application/distribution uniformity should be checked annually. Conduct a periodic professional irrigation audit at least once every five years. Implement a PM program to replace worn components before they waste fertilizer, chemicals, and water.
- Conduct pump efficiency tests every 1 to 5 years to monitor pump wear. Test frequency should depend on the water quality with 1 to 3-year intervals used if the water is contaminated with sand, silt, clay etc., and longer intervals of 3 to 5 years used with clean or potable water.
- Document pump motor/equipment run-time hours.
- Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Monitor pump station power consumption. Monthly bills should be monitored over time to detect a possible increase in power usage. Compare the power used with the amount of water pumped. Requiring more power to pump the same amount of water may indicate a problem with the pump motor(s), control valves, or distribution system. Quarterly checks of amperage by qualified pump personnel may more accurately indicate increased power usage and thus 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.
- Factor in rainfall and compare the total amount of water applied per irrigated acre to ET as a measure of application efficiency.
- 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. For diagnosis of PVC failure causes visit: https://edis.ifas.ufl.edu/ch171Maintain written and photo records of pipe or other component failures & repairs. This can become valuable documentation when proposing system renovations and replacements.

SYSTEM MAINTENANCE

Routine maintenance helps ensure water quality is maintained and water is used responsibly. System checks and routine maintenance include pumps, valves, programs, fittings, and sprinklers. An irrigation system should be calibrated regularly by conducting periodic irrigation audits to check actual water delivery and nozzle efficiency.

Best Management Practices

- Irrigation audits should be performed by trained technicians.
- A visual inspection should first be conducted to identify necessary repairs or corrective actions. It is essential to make repairs before carrying out other levels of evaluation.
- Pressure, flow, and precipitation rate 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 and basic schedule calculations should be executed to determine uniformity of coverage, precipitation rate, and to accurately determine irrigation run times.
- Catch-can testing should be conducted on representative areas of the golf course to ensure that the system is operating at its highest efficiency.
- Conduct an internal irrigation audit annually to facilitate a high-quality maintenance and scheduling program for the irrigation system.
- Inspect for interference with water distribution due to sprinklers below grade, or blockage by tree limbs and/or shrubs.
- 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.
- Examine turf quality and plant health for indications of irrigation malfunction or needs for scheduling adjustments.
- Be aware that early symptoms of root feeding insects may initially be misdiagnosed as droughty areas.
- Schedule documentation: make adjustments and repairs on items diagnosed during the visual inspection before conducting pressure and flow procedures

Preventive Maintenance

- In older systems, inspect irrigation pipe and look for fitting breaks caused by surges in the system. For diagnosis of PVC fitting and pipe failure visit: https://edis.ifas.ufl.edu/ch171
- 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.
- Annually service pressure regulation, pressure relief and/or pressure sustaining valves to assure proper operation.
- Check filter operations frequently; keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.
- Application/distribution efficiencies should be checked annually.
- Conduct a periodic professional irrigation audit at least once every five years.
- Document equipment run-time hours. Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Monitor the power consumption of pump stations for problems with the pump motors, control valves, or distribution system.
- Qualified pump personnel should perform quarterly checks of amperage to accurately identify increased power usage that indicates potential problems.
- Increase frequency of routine inspection/ calibration of soil moisture sensors that may be operating in high-salinity soils.
- Winterize irrigation system to prevent damage.

Corrective Maintenance

- Replace or repair all broken or worn components before the next scheduled irrigation.
- Replacement parts should have the same characteristics as the original components.
- Record keeping is an essential practice; document all corrective actions.

System Renovation

- Appropriate golf course renovations can improve system efficiencies, conserve water, improve playability, and lower operating costs.
- Correctly identify problems and their cost to determine which renovations are appropriate.
- Determine the age of the system to establish a starting point for renovation.
- Identify ways to improve system performance by maximizing the efficient use of the current system.
- Routinely document system performance to maximize the effectiveness of the renovation.
- Evaluate cost of renovation and its return on investment and other benefits including financial, course playability, and turf management (fewer weeds, disease, wet and/or dry spots, etc.)

WINTERIZATION AND SPRING STARTUP

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

Best Management Practices

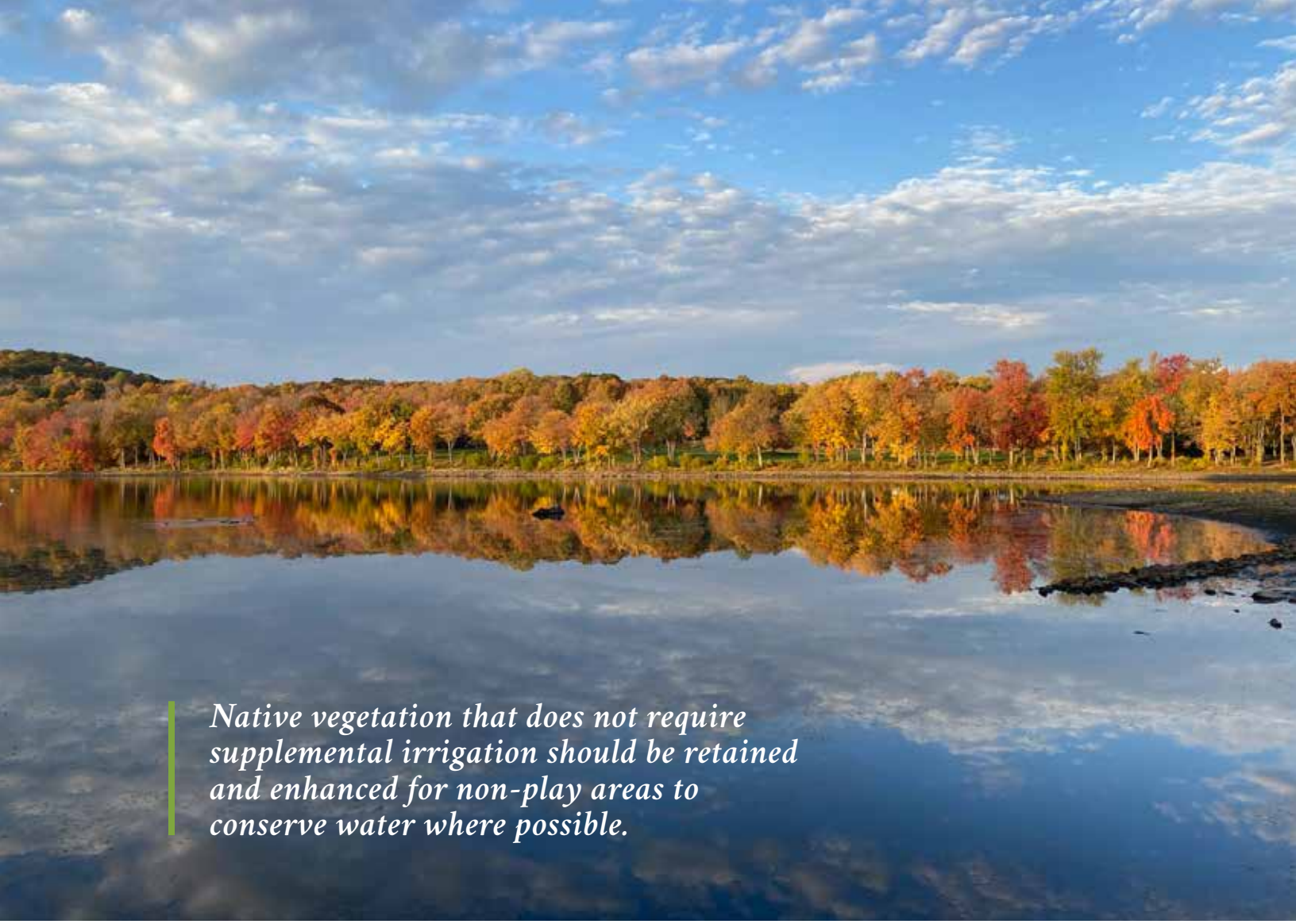
- Conduct a visual inspection of the irrigation system: inspect for mainline breaks, low pressure at the pump, and head-to-head spacing.
- Conduct a catch-can test to audit the system.
- Flush and drain above-ground irrigation system components that could hold water.
- Remove water from all conveyances 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 engine servicing/repair before winterizing.
- Recharge irrigation in the spring with water and inspect for corrective maintenance issues.
- Ensure proper irrigation system drainage design.

MAINTAINED TURF AREAS

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

Best Management Practices

- The irrigation system should be designed and installed so that the putting surface, slopes, and surrounding areas can be watered independently.
- Account for nutrients in effluent supply when making fertilizer calculations.
- Install part-circle heads that conserve water and reduce unnecessary stress to greens and surrounds.
- Avoid use of a global setting; adjust 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. If ET data has not been adjusted for turfgrass apply the appropriate crop coefficient (Kc) for warm season turf (Kc = 0.6) or cool season turf (Kc = 0.8).
- Manually adjust automated ET data to reflect wet and dry areas on the course on a global basis and adjust individual control station run times to account for shade, microclimate, etc.
- Install rain switches to shut down the irrigation system if enough rain falls in a zone.
- Use soil moisture sensors to bypass preset or to create on-demand irrigation schedules.
- Permanent irrigation sprinklers and other distribution devices should be spaced according to the manufacturer's recommendations.
- Spacing should be based on average wind conditions during irrigation.
- Triangular spacing is more uniform than square spacing.
- Periodically perform catch-can uniformity tests.
- Reducing dry spots and soil compaction improves water infiltration, which in turn reduces water use and runoff in other areas.
- Irrigation should occur in the early morning hours before air temperatures rise and relative humidity drops.
- Base plant water needs on root depth, soil water holding capacity, ET rates, recent rainfall, recent temperature extremes and soil moisture.
- Use mowing, verticutting, aeriation, wetting agents, nutrition, and other cultural practices to promote deep root development, enhance water infiltration, and soil moisture retention 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 distribution uniformity 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



Native vegetation that does not require supplemental irrigation should be retained and enhanced for non-play areas to conserve water where possible.

NON-PLAY AND LANDSCAPE AREAS

Map any environmentally sensitive areas such as sinkholes, wetlands, or flood-prone areas, and identify species classified as endangered or threatened by federal and state governments, and state species of special concern. Identify and eliminate invasive species. The most efficient and effective watering method for non-turf landscape is drip or 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 requiring minimal, if any, irrigation.

Best Management Practices

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

WELLHEAD PROTECTION

Wellhead protection is the establishment of protection zones and safe land-use practices around water supply wells in order to protect aquifers from accidental contamination. It also includes protecting wellheads from physical impacts, keeping them secure, and sampling wells according to the monitoring schedule required by the regulating authority, which is often a local health department and/or the Connecticut Department of Public Health, Drinking Water Section. Licensed water-well contractors may be needed to drill new wells to meet state requirements, local well-construction permit requirements.

When installing new wells, contact the local city regulating authority to determine permitting and construction requirements and the required isolation distances from potential sources of contamination. 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.

Additional information on private wells in Connecticut: https://portal.ct.gov/DPH/Environmental-Health/Private-Well-Water-Program/Private-Wells

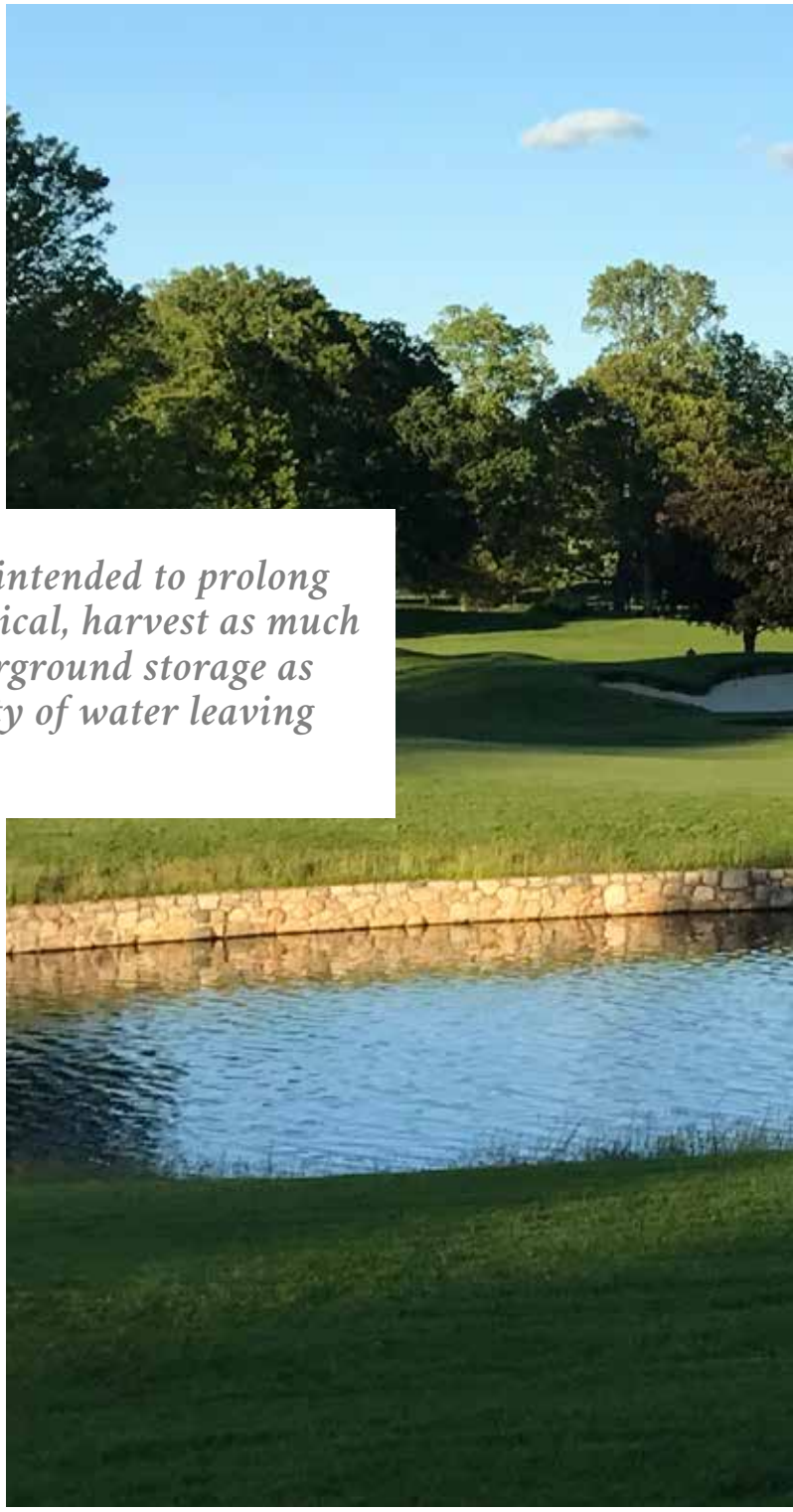
References for licensed well contractors in Connecticut: https://portal.ct.gov/-/media/Departments-and-Agencies/DPH/dph/environmental_health/private_wells/pdf/091416eLicenseRosterspdf.pdf

Best Management Practices

- Use backflow-prevention devices at the wellhead, on hoses, and at the pesticide mix/load station to prevent contamination of the water source.
- Properly close/plug abandoned or flowing wells.
- For wellheads located where runoff may move toward and contact and/or collection around any part of the wellhead from runoff may occur, the area should be graded to include berms to divert surface flow away from the wellhead.
- Site new wells so that surface water runoff does not contact or collect around any part of the wellhead, including the concrete pad or foundation; or construct a berm near the wellhead that is sufficient to prevent surface water runoff from contacting or collecting around the wellhead.
- 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.
- Conduct a well pump efficiency test every 1 to 5 years to monitor pump and electric motor wear. The frequency of testing should depend on the water quality with 1 or 3-year intervals for water contaminated with sand, silt, clay etc., and every 3 to 5 years for clean water.
- 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.
- A good source of tips to protect groundwater is the Groundwater Foundation: www.groundwater.org and https://www.cdpr.ca.gov/docs/emon/grndwtr/wellhead_protection.pdf.

GOLF COURSE BMPS AIM TO IMPROVE *the quality of water leaving the property*

Golf courses are typically large properties ranging in size from 60 to 200 acres and are but one link in a stormwater management chain. Generally, a quantity of stormwater enters the golf course area, supplemented by what falls on the golf course property, and then the stormwater leaves the golf course. Golf courses are realistically capable of having only a small impact on major stormwater flow. That impact should be to add only small increments of water over a given period of time. Engineers call this function "detention."



Stormwater Management BMPs are intended to prolong the detention process as long as practical, harvest as much of the stormwater in surface or underground storage as reasonable, and to improve the quality of water leaving the property when possible.

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

NATURAL SYSTEMS TO IMPROVE STORMWATER TREATMENT:

- When the golf course is properly designed, rain and runoff captured in water hazards and stormwater ponds may provide most or all of the supplemental water necessary for irrigation under normal conditions, though backup sources may be needed during drought conditions.
- If possible, construct ponds in a series, or "train", to treat stormwater/site runoff. The first pond will catch the "first flush", the second will provide additional filtering and the third will filter and serve as a primary withdrawal pond for irrigation; infiltrating the first inch of stormwater helps to prevent water quality impacts.
- Capture systems should be considered part of the overall treatment.
- Stormwater capture is desirable where the lowest quality of water is needed to conserve potable water, maintain hydrologic balance, and improve water treatment.

A full discussion of stormwater management recommendations is beyond the scope of this guide. For specific BMPs related to stormwater quality reference the DEEP 2004 Connecticut Stormwater Quality Manual: *https://portal.ct.gov/DEEP/Water-Regulating-and-Discharges/Stormwater/Stormwater-Manual*

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.
- Computerizing the irrigation management system not only saves labor, but is also more efficient and flexible. Golf course irrigation systems can be linked to a golf course superintendent's home or business computer, allowing the system to be remotely monitored and shut off. Often weather changes occur rapidly in the summer months, and rainstorms occur during times when irrigation managers are not on-site. In the event that an irrigation cycle is taking place and a storm occurs, a computerized rain gage shut off would allow the irrigation system to shut down automatically. By using a computerized system, the irrigation manager has the ability to set the precipitation rate at which the system automatically shuts off.
- The course site plan should maintain the natural wetland and watercourse systems and buffers, plus locate necessary stormwater management structures to upland areas. This helps maintain the natural drainage patterns and allows for recharge of runoff. A series or train of stormwater diversions, swales and basins can be designed to collect stormwater runoff for use in supplementing irrigation.
- Avoid the direct discharge of stormwater runoff from parking lots, service areas, buildings and roadways directly into wetlands and watercourses. Control quality of surface runoff with appropriate filtration practices such as grassy swales, filter strips and constructed wetlands.

Stormwater management on a golf course includes storing irrigation water, controlling erosion and sediment, enhancing wildlife habitat, removing waterborne pollutants, controlling the amount and rate of water leaving the course, and addressing aesthetic and playability concerns.

REGULATORY CONSIDERATIONS

Course owners and superintendents should investigate regulatory requirements that apply to the golf facility to protect surface and groundwater quality. Contact DEEP to arrange a pre-application meeting to discuss permitting requirements for an existing or proposed golf course irrigation system. It is likely that most golf course irrigation systems are subject to regulation, since any withdrawal (or combination of withdrawals) of surface or ground water in excess of 50,000 gallons in any twenty-four-hour period requires a water diversion permit. A pre-application meeting should expedite the permit process by allowing for discussion of alternative water sources and identification of significant environmental issues.

Best Management Practices

- Aquatic management of plants may be regulated under construction permitting and regulatory licensing requirements. Consult with federal, state, and local water management agencies before managing golf course lakes and wetland areas. https://www.gcsaa.org/uploadedfiles/Environment/Get-Started/BMPs/Best-management-practices-for-golf-course-water-use-(CT).pdf
- Consult with federal, state, and local water management agencies, and/or consult an approved management plan before performing cultural practices: fertilization, installation of plants, hand removal of plants, or mechanical harvesting.
- The introduction of aquatic triploid grass carp, biological controls, aeration, and chemical controls (herbicide/algaecide) must be approved and monitored according to permit and licensing protocols and compliance.
- The disposal of sediments from surface water ponds (stormwater detention) may be subject to regulation. Typical timeframe for water usage on golf course is April 1 to October 31. https://www.gcsaa.org/uploadedfiles/Environment/Get-Started/BMPs/Best-management-practices-for-golf-course-water-use-(CT).pdf
- Golf course management may be affected by Total Maximum Daily Loading (TMDL), mitigation, and watershed basin management action plans (BMAP).
- Wetlands are protected areas; in Connecticut all wetlands are considered High Quality Waters per Water Quality Standards; consult with DEEP and federal agencies before altering natural aquatic areas.
- Constructed wetlands should have an impervious bottom to prevent groundwater contamination.
- Studies of water supplies are needed for irrigation systems, including studies of waterbodies or flows on, near, and under the property to properly design a course's stormwater system and water features to protect water resources.
- Use a meter at each source of water withdrawal. Metering of the sources should be at the discharge side of the source pumps prior to any off-take piping
- Choose a meter that provides both a numeric cumulative volume reading and an instantaneous flow reading. This will enable the user to gage consumption and obtain a quick estimation of the flow rate.
- At least once a year, prior to the start of the irrigation season, calibrate meters in accordance with the manufacturer's recommendations.

WATER QUALITY PROTECTION

An aquatic plant management strategy should address the intended uses of the waterbody to maintain water quality. Proper documentation includes the site's physical attributes and location, the presence of invasive or weedy species, aesthetics, watershed and groundwater assessments, and other environmental considerations.

Only licensed individuals or contractors should be allowed to select and apply aquatic pesticides. Utilize physical or other controls first under a proper IPM program; pesticides should be used as a last resort. Use DEEP Bulletin 34 entitled 2002 Connecticut Guidelines for Soil Erosion and Sediment Control as the standard for BMPs for soil erosion and sediment control: *https://portal.ct.gov/DEEP/Water/Soil-Erosion-and-Sediment-Control-Guidelines/Guidelines-for-Soil-Erosion-and-Sediment-Control*

References for Invasive Aquatic Plants in Connecticut:

https://portal.ct.gov/DEEP/Invasive-Species/Invasive-Species

https://portal.ct.gov/-/media/CAES/Invasive-Aquatic-Plant-Program/Plant-Information/AquaticsGuidepdf.pdf?la=en&hash=19AC10C333F3E22B45E8A22BD3CCC10A

Best Management Practices

- Accommodate natural lake processes in the construction of lakes and ponds; include herbaceous and woody vegetation and emergent and submergent shoreline plants to reduce operational costs.
- Use integrated pest management (IPM) strategies and native or naturalized vegetation wherever practical.
- Plant grasses, other herbaceous vegetation and woody vegetation in buffer strips where existing vegetation is lacking. Plants included in a riparian buffer zone restoration or an overall habitat enhancement plan should be native and non-invasive. (DEP Non-Native Invasive & Potentially Invasive Vascular Plants in CT, March 2001)
- Select some woody vegetation to provide shade, especially along the south side of wide sections of a watercourse or water body, to provide shading, cool water temperatures and to maintain suitable dissolved oxygen levels.
- 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.
- As a general practice, keep all chemical applications 10 to 15 feet away from the water's edge when using rotary spreaders and/or boom sprayer applications
- 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.
- If possible, avoid the use of copper, at least for natural water systems. 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. https://portal.ct.gov/DEEP/Water/Watershed-Management/CTs-Watershed-Management-Program
- Identify overall goals and validate concerns of the local watershed.
- Identify surface water and flow patterns.
- Where a desired buffer width cannot be met due to course layout, prevent runoff from entering the water body at that location by diverting it to adjacent areas where adequately wide buffers can be developed and maintained. Methods of diversion can include shallow swales, low berms, and grading of fairway slopes away from stream banks.
- 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.

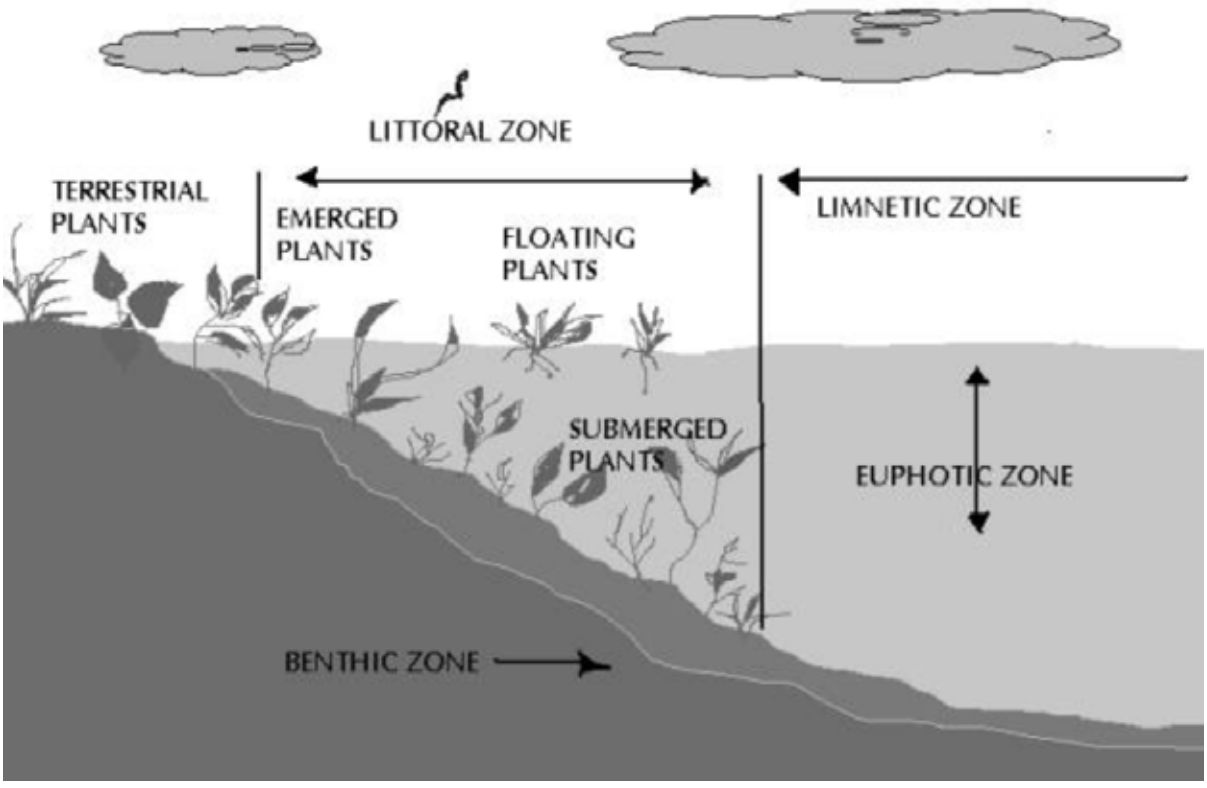
Refer to the Water Quality Monitoring and Management Section for additional information.

AQUATIC PLANTS

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 (immersed 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.

Ponds may be constructed on golf courses strictly as water hazards or for landscape purposes, but they often have the primary purpose of drainage and stormwater management and are also often a source of irrigation water. The use of aquatic plants to improve the appearance of a pond (aquascaping) can be included as part of the overall landscape design.



Lake Diagram: Littoral Zone
Source: http://wgbis.ces.iisc.ernet.in/energy/monograph1/Limpage4.html

Best Management Practices

- Properly designed ponds with a narrow fringe of vegetation along the edge are more resistant to problems than those with highly maintained turf.
- In ponds with littoral plantings, problem plants should be selectively controlled without damaging littoral shelves.
- Encourage clumps of native emergent vegetation at the shoreline.
- A comprehensive lake management plan should include strategies to control the growth of nuisance vegetation that can negatively affect a pond's water quality and treatment capacity.
- Frequently remove filamentous algae by hand and/or frequently apply algaecide to small areas of algae (spot treatment).
- To reduce the risk of oxygen depletion, use an algaecide containing hydrogen peroxide instead of one with copper or endothall.
- Ideally, littoral zones should have a slope of about 1 foot vertical to 6-10 foot horizontal to provide the best substrate for aquatic plant growth.
- Triploid grass carp (with a permit) are sometimes used as a biological control for aquatic plants.

HUMAN HEALTH CONCERNS

Be sure to address areas where standing water may provide habitat for nuisance organisms.

The use of pesticides should be part of an overall IPM strategy that includes biological controls, cultural methods, pest monitoring, and other applicable practices.

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

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

Best Management Practices

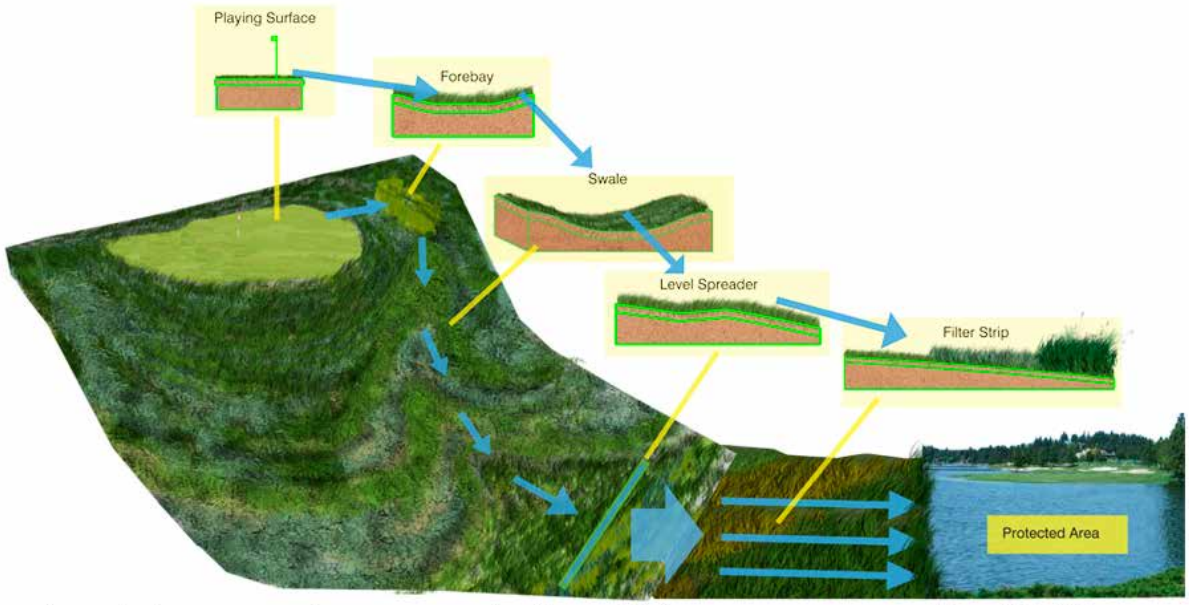
- Install stream buffers to restore natural water flows and flooding controls.
- Install buffers in play areas to stabilize and restore natural areas that will attract wildlife species.
- Install detention basins to store water and reduce flooding at peak flows.

STORMWATER, PONDS, AND LAKES

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.

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.

Most golf courses plan their lakes and water hazards to be a part of the stormwater control and treatment system. However, natural waters of the state cannot be considered treatment systems and must be protected. Lakes and ponds may also be used as a source of irrigation water. It is important to consider these functions when designing and constructing ponds. Peninsular projections and long, narrow fingers may prevent mixing. Ponds that are too shallow may reach high temperatures, leading to low oxygen levels and promoting algal growth and excess sedimentation.



A comprehensive systems approach uses a treatment train and the natural drainage systems to protect water quality at a high priority area.

Stormwater Treatment Train
Source: BMPs for NY State Golf Courses

Best Management Practices

- Institute buffers and special management zones; install swales and slight berms with a natural appearance where appropriate around the water's edge, along with buffer strips, to slow and infiltrate water and trap pollutants in the soil, where they can be naturally destroyed by soil organisms.
- 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.
- Eliminate or minimize directly connected impervious areas.
- 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. 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.
- Consider using pervious pavers for walkways, such as brick or concrete pavers separated by sand and planted with grass; and minimize use of curbing on parking areas. Where reduction is difficult, large parking areas can incorporate landscaped areas to help maintain natural recharge. Special high-permeability concrete is available for cart paths or parking lots. Pervious overflow parking should be used to accommodate seasonal parking. https://www.gcsaa.org/uploadedfiles/Environment/Get-Started/BMPs/Best-management-practices-for-golf-course-water-use-(CT).pdf
- Golf course stormwater management should include "natural systems engineering" or "soft engineering" approaches that maximize the use of natural systems to treat water. Ideally buffers should be planted with native species to provide water quality benefits, pleasing aesthetics, and habitat/food sources for wildlife.
- Discharge or divert surface runoff onto wide, relatively flat vegetated areas to promote infiltration and ground water recharge.
- A full discussion of stormwater management recommendations is beyond the scope of this report. For specific BMPs related to stormwater quality see the 2004 Connecticut Stormwater Quality Manual by the CT DEP.

PROTECTING GROUNDWATER *and surface water quality*

REGULATORY CONSIDERATIONS

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

Best Management Practices

- Aquatic management of plants may be regulated under construction permitting and regulatory licensing requirements. Consult with federal, state, and local water management agencies before managing golf course lakes and wetland areas.
- Consult with federal, state, and local water management agencies, and/or consult an approved management plan before performing cultural practices: fertilization; installation of plants; hand removal of plants or mechanical harvesting.
- The introduction of aquatic triploid grass carp, biological controls, aeration, and chemical controls (herbicide/algaecide) must be approved and monitored according to permit and licensing protocols and compliance.
- The disposal of sediments from surface-water ponds (stormwater detention) may be subject to regulation.
- Golf course owners are responsible for adhering to TMDLs, mitigation, and watershed basin management action plans (BMAP); determine if waterbodies are identified as impaired and whether or not a TMDL exists; if impaired, additional BMPs may be necessary; consult with an experienced water quality professional regarding TMDL alternative plans.
- Wetlands are protected areas; consult with federal, state, and municipal agencies before altering natural aquatic areas.
- Constructed wetlands should have an impervious bottom to prevent groundwater contamination.
- Studies of water supplies are needed for irrigation systems, including studies of waterbodies or flows on, near, and under the property are needed to properly design a course's stormwater system and water features to protect water resources.
- Develop a drought emergency plan to balance the most critical golf course water demands during times of water use restrictions.

TMDL Information by Waterbody

DEEP is available to provide TMDL information.
Contact (860) 424-3020

TMDL process and overview: https://portal.ct.gov/DEEP/Water/TMDL/Total-Maximum-Daily-Load

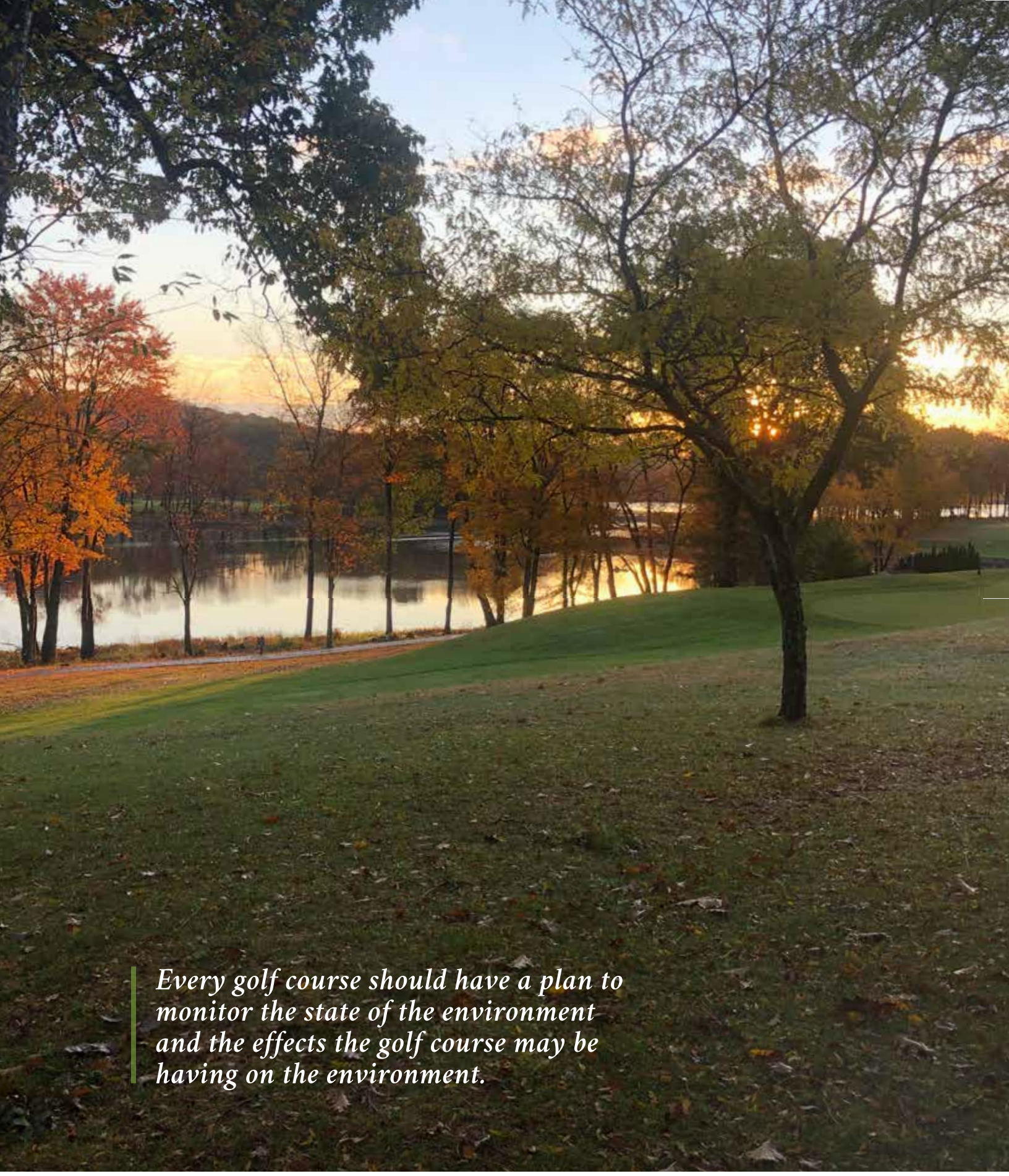
Water bodies with adopted TMDL: https://portal.ct.gov/-/media/DEEP/water/water_quality_management/305b/2020-RJ/2020-IWQR-Appendix-B2-Waterbodies-with-Adopted-TMDLs-EPA-Category-4a.pdf

SITE ANALYSIS

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 IPM and native or naturalized vegetation wherever practical.
- Apply appropriate herbicides to minimize damage to non-target littoral plantings.
- Maintain a narrow band of open water at the pond edge to control the expansion of plants into more desirable littoral plantings.
- Use appropriate aquatic herbicides to avoid turfgrass injury.
- Irrigation should not directly strike or runoff to waterbodies and no-fertilization buffers should be maintained along edges.
- Outline goals and priorities to guide the development of the BMP necessary to support the lake/aquatic management plan.
- Superintendents should monitor designated waters in their area for the persistence of highly toxic herbicides and algaecides in the environment.
- Secondary environmental effects on surface water and groundwater from the chemical control of vegetation should be monitored and recorded.
- Manage impacts from waterfowl on waterbodies; monitor for bacteria, in addition to nutrients.
- Apply fertilizer and reclaimed (reuse) irrigation/ fertigation appropriately to avoid surface and groundwater contamination.
- Use part-circle sprinklers along perimeters of natural water features to minimize their contact with reclaimed/fertigation overspray.
- If possible, avoid the use of copper or aquatic herbicides; apply copper products per label instructions to reduce the risk of negative biological impacts and impairing water quality.
- Identify possible downstream watershed areas that could receive surface water runoff from the property.
- Identify overall goals and qualify concerns of the local watershed, ground water locations in relation to the surface of the course, particularly in any areas that have a seasonally high water table (<24") or shallow bedrock (<4');
- Indicate surface water and flow patterns, stormwater flow, as well as existing and potential holding capacity.
- Indicate impervious surfaces, such as buildings, parking lots, or pathways; location of all facilities, structures, treatments and measures used for soil erosion and sedimentation control and long-term stormwater management.
- 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.



Every golf course should have a plan to monitor the state of the environment and the effects the golf course may be having on the environment.

WATER QUALITY SAMPLING PROGRAM

Monitoring is the method used to determine whether outside events are impacting the water quality entering the golf course, or whether the golf course is having a positive, neutral, or negative effect on water quality. It also provides a body of evidence on the golf course's environmental impact. A water quality monitoring program must include monitoring of surface water, groundwater, and pond sediments. It should be implemented in three phases: background, construction, and long-term management.

A water quality monitoring plan should be prepared to ensure the ongoing protection of groundwater and surface-water quality after construction is completed. The same sites should be monitored during the preconstruction phase, although the monitoring plan can be modified based on site-specific conditions. Sampling 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.

Sampling parameters are determined based on golf course operation and basin-specific parameters of concern (these may be identified by local/state TMDL Programs). Typically, samples should be analyzed for nutrients, pH and alkalinity, sediments, suspended solids, dissolved oxygen (DO), heavy metals, bacteria, any pesticides expected to be used on the golf course; in addition to any other chemicals identified in TMDLs, TMDL alts or watershed-based plans. Seasonally the total dissolved salt concentrations (specific conductance) may become an issue if runoff from streets and highways contains deicing salts. This can potentially become a turf management issue if this saline water is captured and used for irrigation.

Ongoing, routine water sampling provides meaningful trends over time. A single sample is rarely meaningful in isolation. Post-construction surface-water quality sampling should begin with the installation and maintenance of golf course turf and landscaping. Samples should be collected a minimum of three times per year. Should there be no discharge on the scheduled sample date, samples should be taken during the next discharge event.

Post-construction surface-water quality sampling should continue through the first three years of operation and during the wet and dry seasons every third year thereafter, provided that all required water quality monitoring has been completed and the development continues to implement all current management plans. It may also be wise to sample if a significant change has been made in course operation or design that could affect nearby water quality.

Golf course management must have good data to make good decisions. Sampling parameters should be determined based on golf course operation and any basin-specific parameters of concern (identified by the TMDL program or local regulators). The purpose of quality assurance/quality control (QA/QC) is to ensure that chemical, physical, biological, microbiological, and toxicological data are appropriate and reliable. Data should be collected and analyzed using scientifically sound procedures. It is strongly recommended that a certified laboratory be utilized, and all QA/QC procedures followed.

Golf courses should also sample for macroinvertebrates as determined useful by water quality specialists.

Consideration must be given to procedures that are simple, cost effective, and technically sound, and that minimize sampling related biases and ensure data integrity.

Reference additional information:

https://portal.ct.gov/DEEP/Water/Inland-Water-Monitoring/Lake-Water-Quality-Monitoring

Best Management Practices

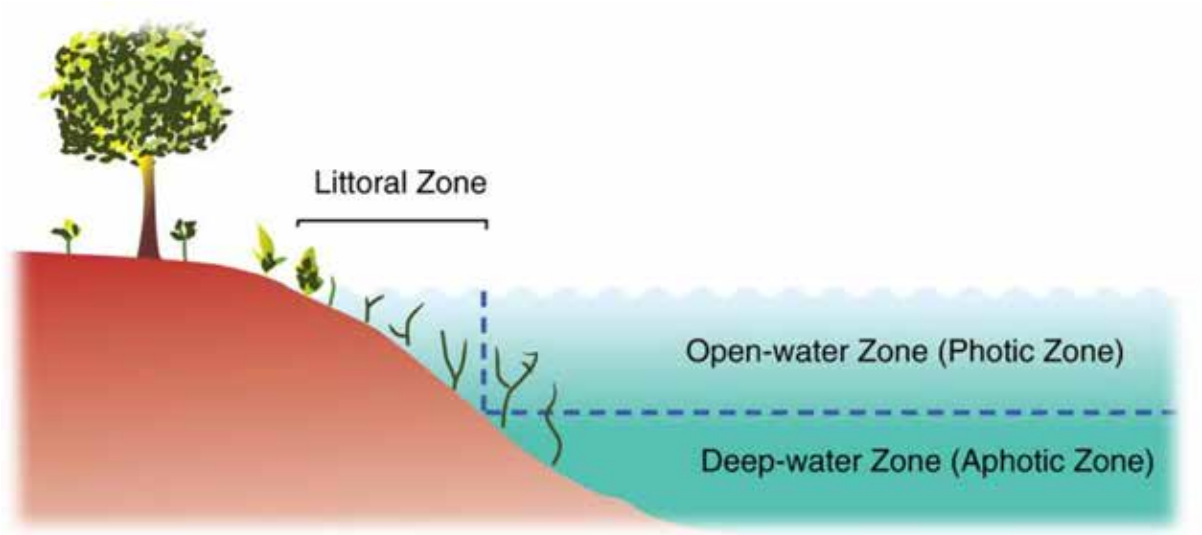
- Seek professional assistance from an environmental specialist to design an appropriate water sample collection strategy.
- Determine sites to be analyzed, use reputable equipment/qualified technicians.
- Demonstrate responsible land and water use practices based on water data.
- Define data values appropriately based on the associated BMP used to protect water quality.
- Record observations of fish, wildlife, and general pond conditions.
- The parameters chosen for measurement must be good indicators of water quality. General parameters are temperature, pH, specific conductance, dissolved oxygen and nutrients
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered DO levels.
- Install desirable native plants to naturally buffer DO loss and fluctuation.
- Generally accepted DO thresholds below which fish are stressed (3-4 ppm) or die (2 ppm) can be used as guides to implement mitigation strategies (e.g., artificial aeration). Reduce stress on fish by keeping DO levels of property ponds above 4 ppm, measured in early morning hours (between dawn and 8 am). Critical DO levels often happen at night when algae aren't photosynthesizing, a morning measurement is more indicative of whether or not there are problems.
- 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.
- Have silt fences, sand bags, hay bales or other suitable soil entrapment barriers in place at all times during construction to prevent soil and other runoff contaminant movement from unexpected rain storms.
- 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 2 inches or higher to slow and filter overland flow to water bodies.
- Remove excess sediments to reduce irrigation system failures.
- Treat dredged materials as a toxic substance. Avoid contact with turf.
- Locate littoral shelves at the pond's inlets and outlets to reduce problems with the playability and maintainability of a water hazard.

BUFFER ZONES

Golf course stormwater management should include "natural systems engineering" or "soft engineering" approaches that maximize the use of natural systems to treat water. Buffers around the shore of a waterbody or other sensitive areas filter and purify runoff as it passes across the buffer. Ideally, plant buffers with native species provide a triple play of water quality benefits, pleasing aesthetics, and habitat/food sources for wildlife. As discussed above, it is important to continue these plantings into the water to provide emergent vegetation for aquatic life, even if the pond is not used for stormwater treatment. Effective BMPs filter and trap sediment, incorporate site-specific natural/organic fertilization, and place limits on pesticide use, primarily focusing on the control of invasive species.

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. Mow buffers on in-play areas in riparian areas to heights up to 4 inches. Mow in the direction that allows the mower discharge chute to direct clippings away from riparian areas.
- 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. As a general practice, keep all chemical applications 10 to 15 feet away from the water's edge when using rotary spreaders and/or boom sprayer applications.
- 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. A riparian buffer, for the purposes of this document, is a riparian zone that is managed in a vegetated condition in order to achieve water quality protection or improvement.
- An appropriate-sized buffer (steeper slope requires great buffer width) of turf mowed at a higher height of cut and minimally fertilized with enhanced-efficiency fertilizers can provide an effective buffer.
- Use plant buffers with native species to provide pleasing aesthetics, habitat, and food sources for wildlife.
- Ideally, littoral zones should have a slope of about 1 foot vertical to 6-10 foot horizontal (6% to 10%).
- Encourage clumps of native emergent vegetation at the shoreline.
- Establish special management zones around



Littoral Zone Diagram

Source: https://www.pinellascounty.org/environment/watershed/pdf/adoptapond/Florida_Lakes_and_Ponds_Guidebook.pdf

pond edges.

- Reverse-grade around the perimeter to control surface water runoff into ponds and reduce nutrient loads.
- Planting on slopes with less than a 6-foot horizontal to a 1-foot vertical may not be as successful over the long term.
- Construct random small dips and ridges of a few inches to a foot to promote diversity within the plant community and provide a healthier and more productive littoral zone.
- All or most of the out-of-play water bodies should have shoreline buffers planted with native or well-adapted noninvasive vegetation to provide food and shelter for wildlife.
- Practice good fertilizer management to reduce the nutrient runoff into ponds that causes algae blooms and ultimately reduces DO levels.
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered DO levels.
- Aerate shallow lakes less than 6 feet in depth to maintain acceptable DO levels. Aeration of deep lakes is also beneficial to mix stratified layers of water of differing temperatures.
- 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 alga blooms and other phytoplankton; apply appropriate fertilizer rates and application setbacks.
- Dredge or remove sediment to protect beneficial organisms that contribute to the lakes food web and overall lake health.

WETLAND PROTECTION

Several states protect wetlands as waters of the state by rule of law. Wetlands act both as filters for pollutant removal and as nurseries for many species. Many people do not realize the vital role they play in purifying surface waters. The biological activity of plants, fish, animals, insects, and especially bacteria and fungi in a healthy, diverse wetland is the recycling factory of our ecosystem. With care, many golf holes have been threaded through sensitive areas.

When incorporated into a golf course design, wetlands should be maintained as preserves and separated from managed turf areas with native vegetation or structural buffers. Constructed or disturbed wetlands may be permitted to be an integral part of the stormwater management system. Manmade buffers should be designed to improve habitat diversity and include a mixture of fast and slow-growing native trees, shrubs, or grasses to provide a diverse habitat for wildlife.

Best Management Practices

- Establish wetlands where water enters lakes to slow water flow and trap sediments.
- Maintain appropriate silt fencing and BMP on projects upstream to prevent erosion and sedimentation.
- Natural waters cannot be considered treatment systems and must be protected. (Natural waters do not include treatment wetlands.)
- Establish a low- to no-maintenance level within a 75-foot buffer along non-tidal and tidal wetlands.
- Establish and maintain a 100-foot riparian buffer around wetlands, springs, and spring runs.
- Do not fertilize riparian buffer areas above the high-water mark. Leave them in a natural state

SEDIMENT

During construction and/or renovation, temporary barriers and traps (i.e. silt fencing) must be used to prevent sediments from being washed off-site into water bodies. Wherever possible, keep a vegetative cover on the site until it is actually ready for construction, and then plant, sod, or otherwise cover it as soon as possible to prevent erosion.

Best Management Practices

- Use shoreline grasses to prevent bank erosion.
- Use dry detention basins/catchments to buffer flooding and excessive runoff.
- When constructing drainage systems, pay close attention to engineering details such as subsoil preparation, the placement of gravel, slopes, and backfilling.
- Internal golf course drains should not drain directly into an open waterbody but should discharge through pretreatment zones and/or vegetative buffers to help remove nutrients and sediments. https://www.gcsaa.org/uploadedfiles/Environment/Get-Started/BMPs/Best-management-practices-for-golf-course-water-use-(CT).pdf
- Maintain a vegetative cover on construction sites until it is actually ready for construction.
- Control cart traffic to avoid highly erodible areas.
- Use DEP Bulletin 34 entitled 2002 Connecticut Guidelines for Soil Erosion and Sediment Control as the standard for BMPs for soil erosion and sediment control. https://www.gcsaa.org/uploadedfiles/Environment/Get-Started/BMPs/Best-management-practices-for-golf-course-water-use-(CT).pdf

SODIC/SALINE CONDITIONS

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

Best Management Practices

- Use surface water to mix (blend) affected groundwater to lower the total salt concentration.
- Routinely monitor water quality to ensure that salt concentrations are at 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. https://portal.ct.gov/CAES/Soil%20Office/Soil%20Office/Soil%20Testing%20Offices%20Instructions
- Select alternative turfgrass and landscape plants that are more salt-tolerant.
- Reduce salt accumulations by flushing soils as needed. Initiate the process with the irrigation source that is more saline and complete the process with a higher-quality water source.
- Design irrigation systems to account for flushing of salt accumulation from soil.
- Amend soil and water to lower the ESP/SAR of sodic areas.
- Evaluate BMP to determine effectiveness toward managing sodic/saline conditions.

Additional information on current TMDLs, proposed TMDLs, or alternative plans in Connecticut:

https://portal.ct.gov/DEEP/Water/TMDL/Total-Maximum-Daily-Load#:~:text=A%20TMDL%20is%20an%20Action,kind%20of%20like%20a%20budget.&text=TMDLs%20provide%20the%20framework%20for,%2C%20recreation%2C%20or%20other%20uses.

FERTILIZATION AND NUTRIENT MANAGEMENT

are key in supplying essential nutrients to turfgrass

Proper fertilization and nutrient management are a key cultural practice that supplies essential nutrients to turfgrass plants. A sound fertilization program utilizes information from soil and tissue analysis in order to ensure turfgrass health, performance, and recovery. Proper fertilization in combination with other culture practices allow for sustainable turfgrass while reducing other chemical inputs.

REGULATORY CONSIDERATIONS

- Local and state regulations are in place to better manage nutrient risks based on the unique conditions that exist by location. Designing a nutrient management plan within these regulations addresses local concerns minimizes risks to each unique ecosystem.
- Depending on the location, regulatory agencies may include federal, state, or local policies.
- In Connecticut, there are varied terrain and considerations. All BMP policies should be tailored to local regulations.

The goal of a proper nutrient management program should be to apply minimal nutrients to achieve an acceptable playing surface in the most efficient manner helping the plant to recover from the many stresses that it faces.

OVERVIEW

- There are at least 17 nutrients essential for turfgrass growth.
- These nutrients are separated into 2 categories, macronutrients & micronutrients.
- Macronutrients are such as Nitrogen, Carbon, Oxygen, Phosphorous, Potassium, Calcium, Magnesium, & Sulfur are required in relatively large amount.
- Micronutrients such as Iron, Manganese, Zinc, Boron, Molybdenum, Copper, Chlorine, & Nickel are usually required in lower amounts.
- Turfgrasses obtain Oxygen, Hydrogen, & Carbon from the atmosphere and water, the remainder are obtained primarily through roots in the soil. (Some may be obtained by foliar applications).
- Soil testing is an important component in deciding what nutrients and in what quantities that each nutrient is required for plant health.
- Factors affecting fertilizer application decisions include plant species, soil pH, & site conditions.
- Reference the New England Regional Nitrogen and Phosphorus Fertilizer and Associated Management Practice Recommendations for additional BMPs: https://extension.unh.edu/resources/files/Resource002468_Rep11092.pdf

Best Management Practices

- Apply nutrients when turfgrass is actively growing
- Apply N rates and intervals to maintain moderate growth and recuperative potential
- Use light, frequent applications (spoon feeding) to provide consistent nutrition and minimize potential for leaching and runoff.
- Apply slow-release N fertilizer at the appropriate time of year to maximize the products release characteristics.
- Select a N:K fertility ration based on turf use, rootzone, and clippings management
- 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.
- Be aware of different spreaders and understand the advantages and disadvantages of each.
- Calibrate spreaders regularly to reduce environmental risk and increase efficiency.
- Reduce environmental risk by properly storing and loading fertilizer and cleaning up any spills.
- Avoid applying fertilizers to soils that are at, or near, field capacity or following rain events that leave the soils wet.
- Do not apply fertilizer when the National Weather Service has issued a flood watch, tropical storm or hurricane watch or warning or if heavy rains are likely.

SOIL TESTING

The purpose of soil testing is to provide a detailed report which includes measurable variables including pH, soil organic matter, soil salts, and nutrients available for plant use. It also offers a prediction of a plants response to applied nutrients. Proper use of testing results includes analysis, interpretation, and recommendations. Through these and record keeping, decisions can be made to apply those nutrients that are deficient and need to be applied for turf health and sustainability.

Best Management Practices

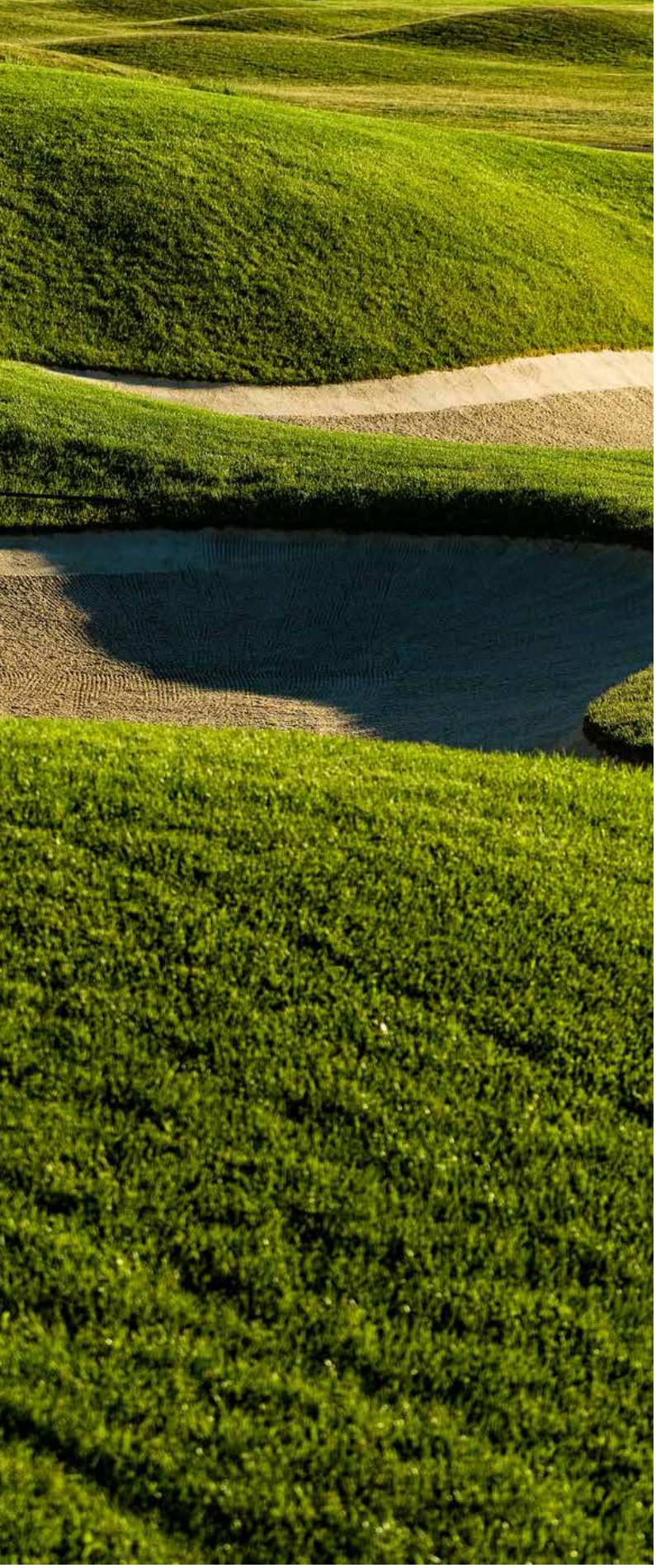
- Accurate and consistent sampling is essential to providing useful information over any period of time.
- Divide course into measurable components such as greens, fairways, tees, etc. for each hole or area to be tested.
- Take 10-15 samples from each area and blend together to get a uniform and representative mixture.
- Each soil sample should be taken at an equal depth.
- The purpose of a soil test is to provide the grower with a prediction of a plant's response to an applied nutrient.
- If the location has correlation data between a given nutrient applied to a soil and a response to that nutrient by turfgrass, then recommendations may provide expected results.
- If the location does not have correlation data, then soil test recommendations may be of little value.
- Use an extraction method appropriate for the soil and remain consistent in using this method when comparing test results from different periods of time.
- Keeping soil tests from previous years will allow you to observe changes over time and make appropriate decisions in the future.

Soil testing in Connecticut

Soil testing laboratories report results as Sufficiency Level of Available Nutrients (SLAN), Base Cation Saturation Ratio (BCSR), and Minimum Level for Sustainable Nutrition (MLSN).

Whichever basis is used, it should be maintained for future comparisons.

Soil testing facilities:
https://portal.ct.gov/CAES/Soil-Office/Soil-Office/Soil-Testing-Offices-Instructions
http://www.soiltest.uconn.edu/sampling.php
http://www.istrc.com/



PLANT TISSUE ANALYSIS

Plant tissue analysis is a valuable tool for guiding fertilizer recommendations. With tissue analysis, the clippings are analyzed for nutrient concentration that is actually in the plant. These values are compared to a critical level range indicating deficiency, sufficiency, or excess. Some believe this method is more accurate since it measures the actual concentrations of nutrients actually taken up by the plant. Some of the shortfalls of this method are cost, testing availability, and speed of results. When using tissue analysis, it is recommended that the following should be monitored. Turfgrass quality, clipping yield, and performance. By recording and analyzing these variables, future nutrient management can be established.

Best Management Practices

- Tissue samples may be collected during regular mowing.
- Do not collect tissue after any event that may alter nutrient analysis.
- Place tissue in paper bags. Do not use plastic.
- If possible, allow tissue samples to air dry before mailing them.
- Poor quality turfgrass that is of concern should be sampled separately from higher quality turfgrass.
- When turfgrass begins to show signs of nutrient stress, a sample should be collected immediately.
- More frequent tissue sampling allows more accurate assessment of turfgrass nutrient status and how it changes over time.
- The quantity of tissue analysis should be based on individual site needs. Two to four site tests per year are common on greens while one to 2 tests per year are common on fairways and tees.
- Keeping tissue tests from previous years will allow you to observe changes over time.
- Tissue testing can provide good evidence of the impact of nutrient management programs.

FERTILIZERS USED IN GOLF COURSE MANAGEMENT

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.

MACRONUTRIENTS

Macronutrients are required in greater quantities and include Nitrogen(N), Phosphorous(P), & Potassium(K). Understanding the role of each of these macronutrients within the plant will provide you with a greater understanding of why these nutrients play such a key role in proper turf management.

The Role of Nitrogen(N)

- Nitrogen is typically required in greater quantities by turfgrasses than any other element except carbon(C), hydrogen(H), and oxygen(O). Nitrogen plays an important role in numerous plant functions including being an essential component of amino acids, proteins, and nucleic acids.
- The goal of all applied nutrients is to maximize plant uptake while minimizing nutrient losses. Understanding each process will increase ability to make sound management decisions and increase profitability while reducing environmental risk.
- To aid in this, you must understand the fate and transformation of nitrogen(N) along with the release mechanisms and factors affecting N release from various 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 how they are released. Each N source is unique and should be managed accordingly. Applying a polymer coated urea in the same manner as a sulfur coated urea greatly reduces the value of the polymer coated urea. Similarly, applying a 2 lb rate of N from an ammonium sulfate may cause burning but on the other hand, applying a 2 lb rate of a polymer coated urea may not yield the quick response of an ammonium sulfate urea. Rate, application date, location, and turfgrass species should all be considered in the nutrient application decision.

Nutrient Management Terminology

- Grade or analysis is the percent by weight of Nitrogen (N), Phosphorous fertilizer (P2O5) and Potassium fertilizer (K2O) that is guaranteed to be in the fertilizer.
- A complete fertilizer contains N, P2O5, and K2O.
- The laws governing the labeling of fertilizer vary greatly among states. Consult UConn/UConn CAHNR or DEEP for additional information.
- Whichever basis is used, it should be maintained for future comparisons.

Label

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

Soluble nitrogen sources:

- Urea (46-0-0)
- 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)

Advantages and disadvantages of fast-release nitrogen sources

Advantages

- High percentage of N by weight.
- Provides an immediate response.
- Minimal temperature dependency that provides good response under cold temperatures in spring and fall.
- Relatively inexpensive per unit of N.

Disadvantages

- Provide only a short-term response. Effectiveness lasts only four weeks or less, which necessitates more frequent applications.
- High salt index and a high foliar burn potential. It needs to be watered in immediately after application.
- Higher leaching potential because of solubility.
- Higher volatilization potential especially with the ammonium-containing forms.
- Higher denitrification potential especially with the nitrate containing forms.
- Impart an acidifying effect in the soil solution.

Fast release sources of nitrogen(N) are often characterized by short bursts of growth followed by slow growth resulting in a peak and valley growth response by turfgrasses that may result in compromised root growth.

Slow-release nitrogen sources:

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

Advantages and disadvantages of slow-release N formulations

Advantages

- Provide more uniform turfgrass growth during the growing season and do not produce peak and valley growth.
- Lower salt index and a lower foliar burn potential in most situations.
- Have a long-term turfgrass response and can carry over from year to year.
- Lower potential for leaching, denitrification, and volatilization losses.
- Need to be applied less frequently; and with the natural organic forms, they often supply other nutrients.

Disadvantages

- Higher cost per unit of N.
- May not supply sufficient N needed by the grass.
- Some are more dependent on temperature for release than the fast-release forms.

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

Some fertilizers combine both slow and fast release forms combining the advantages of both.

Urease and nitrification inhibitors:

- Urease inhibitors reduce the activity of the urease enzyme resulting in a reduction of volatilization and increase in plant available N.
- Nitrification inhibitors reduce the activity of Nitrosomonas bacteria, which are responsible for the conversion of NH4 to NO2. This reduced activity results in a reduction of N loss via denitrification and an increase in plant available N.

The role of Phosphorous(P)

- Phosphorous can be a growth limiting factor for many organisms and is a major contributor to eutrophication of water bodies. Proper timing and rates should be adhered to in order to reduce the risk of off-site movement.
- Phosphorous forms high-energy compounds that are used to transfer energy within the plant. Phosphorous may remain in an organic form or may become incorporated into organic compounds and application rates should be based upon soil test results from documented correlations demonstrating a turf response to soil test phosphorous levels.
- The role of phosphorous in turfgrass culture is important in seed germination, seedling vigor, & rooting responses. Therefore, phosphorus is critical in turfgrass establishment and should be incorporated during establishment when soil tests indicate a deficiency.

P deficiency symptoms:

- Initially, reduced shoot growth and dark green color may be observed
- Later, lower leaves may turn reddish at the tips and then the color may progress down the blades.

P fertilizer sources:

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

The role of Potassium(K):

- Potassium is of no environmental concern, but can be an economic concern, especially when potassium is over utilized, which is quite common. As a general rule, concentrations of potassium are about 1/3 to ½ of Nitrogen.
- Potassium is not a component of any organic compound and moves readily within the plant. Potassium is a key driver of osmoregulation which has been documented to increase stress tolerance.

K deficiency symptoms:

- Except under severe, documented deficiencies, K may not have an observable influence on turfgrass appearance. Yellowing of older leaves followed by tip dieback and scorching of leaf margins have been reported.
- Tissue concentrations of less than 1% are considered deficient.

K sufficiency ranges:

Consult UConn/UConn CAHNR for sufficiency ranges for the specific location

P fertilizer sources:

- Potassium sulfate
- Potassium chloride
- Potassium nitrate

SECONDARY MACRONUTRIENTS

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

The role of Calcium (Ca)

- Primarily a component of cell walls & structure
- Consult UConn/UConn CAHNR for sufficiency ranges in the specific location.
- Found in gypsum, limestone, & calcium chloride.

The role of Magnesium (Mg)

- Central ion in the chlorophyll molecule and chlorophyll synthesis
- Consult UConn/UConn CAHNR for sufficiency ranges in the specific location.
- Found in Sul-Po-Mag, dolomitic limestone, & magnesium sulfate.

The role of Sulfur(S)

- Metabolized into the amino acid, cysteine, which is used in various proteins and enzymes.
- Consult UConn/UConn CAHNR for sufficiency ranges in the specific location.
- Found in ammonium sulfate, elemental sulfur, gypsum, and potassium sulfate.

MICRONUTRIENTS

- Understanding the role of micronutrients within the plant should provide you greater understanding of why these nutrients play such a key role in proper turfgrass management.
- Micronutrients are just as essential as macronutrients, but they are required in very small quantities compared to macronutrients. Micronutrients include iron (Fe), manganese (Mn), boron(B), copper (Cu), Zinc (Zn), molybdenum (Mo), and Chlorine (Cl).
- Consult UConn/UConn CAHNR for sufficiency ranges of micronutrients in the specific location.

The role of iron (Fe)

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

The role of Manganese (Mn)

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

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 is involved in photosynthesis
- Cofactor for 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 catalytic functions of enzymes.

The role of Chlorine (Cl)

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

Plant Growth Regulators (PGRs)

PGRs have been used on golf course turf for decades for a variety of purposes such as controlling seed heads, improving density, reducing growth, improving color, reducing irrigation and fertility needs, improving stress tolerance, suppressing annual bluegrass, and improving overall turf quality. There are a number of PGRs on the market, but it is gibberellic acid (GA) inhibitors that are most widely used by golf course superintendents. These chemicals have been divided into six classes based on mode of action; the following table shows the most widely used PGRs.

PGR chemical classes, modes of action, chemical names, and products:

PGR Class	Mode of Action	Chemical and Trade names
A	Late gibberellic acid inhibitor	Trinexapac-ethyl (Primo Maxx) Prohexadione-Ca (Anuew)
B	Early gibberellic acid inhibitor	Flurprimidol (Cutless) Paclobutrazol (Trimmit 2SC)
C	Cell division inhibitor	Mefluidide (Embark)
D	Herbicide	Methiozolin (Poa Cure) Glyphosate (Roundup)
E	Phytohormone	Ethephon (Proxy)
F	Natural growth regulator	Seaweed extracts, humic acids

These products have been well researched and are most often used on putting greens. The type A products such as trinexapac-ethyl are used to improve the quality of annual bluegrass by increasing the wear tolerance, color, density, water management, and speed of ball roll. They have been shown to improve the ability of Poa annua to survive the stresses of hot summers and increase its competitive ability against creeping bentgrass. During the spring when seed heads are a problem, the Type E plant growth regulator, ethephon, sometimes in combination with trinexapac-ethyl, is used to control seeds and greatly improve the quality of the turf and roll of the golf ball.

Where annual bluegrass is unwanted, the Type B PGRs are used to inhibit growth of annual bluegrass while promoting the growth of bentgrass, giving it a competitive edge. These products are used in conversion projects where greens are transformed from a predominantly annual bluegrass surface to a bent surface or on new bent greens to keep the Poa annua out. The Type D PGR herbicide, Methiozolin, is the best material for completely eliminating Annual bluegrass or maintaining pure bent greens. A properly timed program of applications in the spring and fall can effectively help to solve most annual bluegrass control challenges.

The GA inhibitors affect turf grass growth by reducing clipping yield through the suppression of gibberellic acid in the plant. After a period of time, the suppression will wane, and turf will go through a period of increased clipping yield, which is referred to as the rebound effect. To help maintain the suppression phase of the PGR, reapplications need to be made before the rebound phase occurs. This is done by tracking growing degree days (GDDs) following the application of a PGR. Each type of plant growth regulator has its own level of degradation based on the rate applied and temperature levels at that time of year. Charts showing the reapplication thresholds for each PGR are available to help determine the number of GDDs before applying the next application. Rather than using a calendar-based application schedule, use of GDDs is the only way to avoid the over regulation of turf, which can cause significant damage, or conversely, the rebound phase.

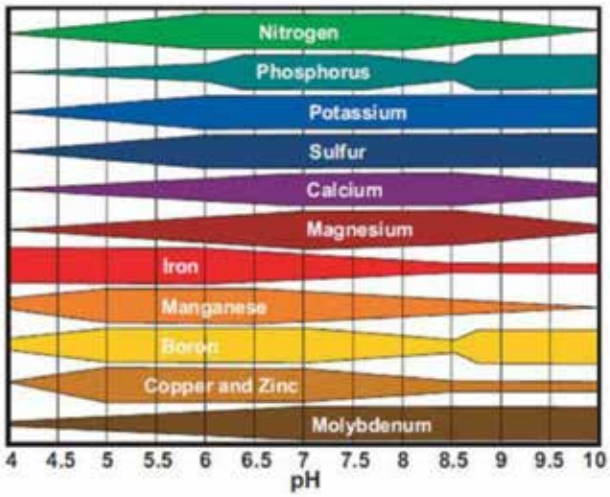
Improved ball roll is one of the most popular reasons that golf course superintendents use PGRs. Some improvement in smoothness can also be expected and although the gain in speed may not be great, one of the other significant benefits of suppressing the growth of putting greens is the maintenance of the speed throughout all hours of the day. This benefit is especially appreciated by those golfers playing later in the evening.

Best Management Practices

- Use PGRs on playing surfaces to aid in improving overall turf quality and reduce irrigation needs.
- To find the most effective timing for PGR applications, use the corresponding GDDs threshold indicated on the published charts.
- Use PGRs to help gain green speed, that method is more effective and results in healthier turf than excessively low cutting heights or very frequent mowing schedules.
- Use ethephon or mefluidide in the spring to control seed heads on annual bluegrass putting greens.
- Apply trinexapac-ethyl all season long on annual bluegrass putting greens to improve turf quality and putting green speed.
- When trying to reduce annual bluegrass populations in greens, tees or fairways, use the type B PGRs flurprimidol or palobutrazol.
- Use any of the GA inhibitors to reduce clipping yields on golf course surfaces to help lower maintenance costs and improve turf quality.
- An annual bluegrass elimination program is best accomplished by using methiozolin.
- Use seaweed extracts and humic acids to help improve turf quality while reducing nitrogen inputs and avoiding excessive growth.

Nutrient Availability Relative to Soil pH

In most cases, a pH of 6-7 is ideal because it provides the greatest availability of all essential nutrients for turfgrass.



Source: R. Goldy, Michigan State University Extension

SOIL PH

- Identifying and maintaining soil pH plays an important role in turfgrass growth. Nutrient availability along with flora and fauna activities are closely associated with the pH of the soil. Soil pH is the result of chemical reactions that take place in the soil, and affect the degree of acidity or alkalinity of a soil solution.
- Soil pH in Connecticut may vary but most turfgrass soils are in the range of 5.0 to 7.0. The soil pH is usually a function of precipitation in a region which induces more leaching of Ca, Mg, & K ions which are replaced with H & Al ions. Connecticut soils tend to be more acidic. Other factors that affect soil pH are parent material of the soil, organic matter content of the soil, and fertilizing practices. Nitrogen applications generally have an acidifying affect because of the release of H ions.
- In general, most turfgrasses can tolerate a wide range of soil pH's, but it is recommended that Connecticut soils have a pH of 6.0 to 7.0. Kentucky bluegrass does best with a pH between 6.5-7.0 while ryegrass and bentgrass can tolerate a slightly lower pH.
- At extreme pH values, certain essential nutrients become less available, while others become more available leading to excessive availability. At highly acidic levels of pH, there is a decrease in microbial activity which can lead to decreased mineralization and decomposition of organic matter causing potential loss of favorable soil structure, and excessive thatch buildup.

CORRECTING ACIDIC SOILS

When soil test shows an acidic soil, the following materials are most common:

- Calcitic limestone- $CaCo_3$
- Dolomitic limestone- $CaMg(CO_3)$

Soil tests are the only way to determine if the turf soil requires lime. The rate required for liming materials is partly determined by soil texture. Soils with more clay and silt require more lime than sandier soils. Soils with higher organic matter content may also require more lime than a soil with a lower organic matter content.

It is recommended that since most Connecticut soils are sandier, a maximum rate of 50#/1000 square feet be applied at any one time on established turfgrass stands. If soil tests call for more lime, then split applications should be utilized with a few months' interval in between. When establishing new turf, the total limestone requirement may be incorporated into the top 4"-6" of soil before seeding.

Lime moves slowly through the soil profile at a rate of .5"-1" per year. Therefore, it may take 2 or more years for the lime to increase the pH of the rootzone. It is important to not allow the pH to drop too low before applying corrective measures. It is recommended to test soil every 2 years to determine pH and make corrective applications. Fall applications are best as are applications during aeration to move lime more quickly into the rootzone.

CORRECTING SOIL ALKALINITY

If a soil test shows a pH of above 8.0, then it must be lowered. In this situation, an application of Sulfur(S) at a rate 3#-5#/ 1000 square feet to decrease pH to more favorable levels. Sulfur can be applied by using elemental Sulfur, Ammonium sulfate, iron sulfate, or potassium sulfate.

Best Management Practices

- Maintain a pH near 6.8 to optimize nutrient availability and reduce fertilizer requirements
- To increase soil pH, apply a liming material (calcium carbonate, calcium oxide, dolomitic limestone) that contains Ca or Ca/Mg and neutralizes acidity.
- To lower soil pH, products containing Sulfur(S) should be applied.
- In some cases, utilizing injection pumps into irrigation water to address pH can be beneficial.

Biostimulants to Reduce Environmental Stress

By definition a biostimulant is an organic material that when applied in small quantities, enhances plant growth and development. They are said to increase the activity of some physiological plant processes. On fine turfgrasses these products are marketed as soil amendments or as an additive to fertilizers. In general, they are used to reduce environmental stress effects of all kinds on grasses allowing them to withstand the rigors of heat, cold, drought, dollar spot, nematodes, high salinity levels, and elevated UV light intensities. They have also been shown to improve grass growth and root development.

Many materials have been shown to have biostimulant effects such as seaweed extracts, humic acids, triazole fungicides, amino acids, potassium silicate, and salicylic acid. Products that contain acibenzolar, various pigments, fosetyl and cytokinins also have stress reducing properties.

Best Management Practices

- Seek out the best biostimulants by reviewing data from university studies, independent research, and talking with peers.
- Include amino acids and products containing humic acids and cytokinins, such as seaweed extracts in sprays on fine turf.
- Begin spraying stress reducing biostimulants just prior to the onset of the hottest months of the summer to condition turf to withstand the rigors of the busy, stressful season.
- Use biostimulants regularly as an additive to spoon feeding fertility programs for highly stressed turf such as putting greens.
- When using biostimulants, mineral fertility inputs can be reduced which will help to improve environmental conditions.

MOWING IS THE MOST IMPORTANT *cultural practice when developing a management plan*

MOWING

Mowing is the most basic yet most important cultural practice to consider when developing a management plan. Mowing practices have an impact on turf growth, density, texture, color, root development, and wear tolerance. Frequent mowing will increase shoot density and tillering. It will also decrease root and rhizome growth as a result of plant stress associated with removal of leaf tissue. Infrequent mowing results in alternating cycles of vegetative growth followed by scalping, which further depletes food reserves of the plants.

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

Maintaining an optimal root-to-shoot ratio is critical. Turfgrass plants that are mowed too low will require a substantial amount of time to provide the food needed to produce shoot tissue for future photosynthesis. If turf is mowed too low in one event, an imbalance occurs between the remaining vegetative tissue and the root system, resulting in more roots being present than the plant needs physiologically. As a result, the plants will slough off the unneeded roots. Root growth is least affected when no more than 30 to 40 percent of leaf area is removed in a single mowing. Failure to mow properly will result in weakened turf with poor density and quality.

Table 6-2. Mowing heights commonly utilized for golf course playing surfaces in New England.*

Species	Greens Regular Membership play	Greens Tournament conditions	Collars, Tees, and Approaches	Fairways	Rough (primary)
	inches				
Creeping bentgrass	0.1 - 0.14	0.09 - 0.125	0.25 - 0.4	0.35 - 0.5	-
Velvet bentgrass	0.1 - 0.14	0.09 - 0.125	0.25 - 0.4	-	-
Perennial ryegrass	-	-	0.4 - 0.5	0.4 - 0.5	1.5 - 3
Kentucky bluegrass **	-	-	0.5	0.5 - 0.65	1.5 - 3
Fine Fescue	-	-	0.4 - 0.5	0.4 - 0.5	-
Tall fescue (turf-type)	-	-	-	-	1.5 - 3

**Variables that often dictate mowing heights include playing surface, turfgrass species and/or cultivar, foot traffic (amount of play), budget, rolling, and whether the golf course is set up for tournament play or regular play.*
***When selecting Kentucky bluegrass varieties for tees and fairways, select cultivars that are tolerant of 0.5-inch mowing heights.*

Recommended golf course mowing heights, by area
Source: Best Management Practices for New England Golf Courses, February 2020

Mowing frequency required during active growth to conform to 1/3 rule based on various mowing heights

Mowing Height (Inches)	1/3 rule Height (inches)	Frequency
0.12	0.18	Every 1-1.15 days
0.25	0.37	Every 2 days
0.50	0.75	Every 2-3 days
1.0	1.5	Every 3-4 days
1.5	2.25	Every 4-5 days
2.0	3.0	Every 5-6 days
3.0	4.5	Every 6-7 days

Cultural practices are an important part of golf course turf management, working hand-in-hand as part of IPM, water and irrigation management, plus golf course playability.

Best Management Practices

- Maintain turfgrass mowing heights within the ranges of adaptation for the species and cultivars being grown.
- Mowing frequency should increase during periods of rapid growth and decrease during dry, stressful periods.
- If turf becomes too tall, it should not be mowed down to the desired height all at once. Such severe scalping reduces turf density and can result in a dramatic reduction in root growth. Tall grass should be mowed frequently and height gradually decreased until desired height of cut is achieved.
- Shade affects turfgrass growth by filtering out photo-synthetically active radiation. As a result, turfgrass plants respond by growing upright in an effort to capture more light to meet their photosynthetic needs. As a result, mowing height should be increased by at least 30% to improve the health of turf grown in a shaded environment.
- The use of the plant growth 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 cloudy weather or drought can have a significant impact on turf health. Increase mowing heights as much as use will allow in order to increase photosynthetic capacity and rooting depth of plants.
- Use proper mowing equipment.
- Reel mowers are ideally suited for maintaining turfgrass stands that require a height of cut below 1.5 inches. They produce the best quality when compared to other types of mowers.
- Rotary mowers, when sharp and properly adjusted, deliver acceptable cutting quality for turf that is to be cut above 1 inch in height. They are more versatile on uneven terrain compared to reel mowers. Dull blades will result in shredding of leaf tissue, increasing water loss and the potential for disease development.
- Flail mowers are most often used to maintain utility turf areas that are mowed infrequently and do not have a high aesthetic requirement.

- Mowing patterns influence both the aesthetic and functional characteristics of a turf surface.
- Turfgrass clippings are a source of nutrients, containing 2% to 4% nitrogen on a dry-weight basis, as well as significant amounts of phosphorus and potassium.
- Nutrients contained in clippings can be sources of pollution and should be handled properly.
- Clippings should be returned to the site during the mowing process unless the presence of grass clippings will have a detrimental impact on play. Cases when clippings should be removed include times when the amount of clippings is so large that it could smother the underlying grass or on golf greens where clippings might affect ball roll.
- Collected clippings should be disposed of properly to prevent undesirable odors near play areas and to prevent fire hazards. Consider composting clippings or dispersing them evenly in natural areas where they can decompose naturally without accumulating in piles.
- Alternate between mowing, rolling, and mowing when turf shows signs of stress.
- Do not dispose of compost clippings near ponds, streams, or on impervious surfaces.
- Remove clippings during periods of weed seed production, to reduce disease spread, to eliminate potential smothering of turfgrass plants from excessive clipping volume, or when clippings interfere with functional use of turf.

CULTIVATION

Turfgrasses are unique in three ways: they tolerate frequent close mowing; they persist under traffic conditions; and they form a dense, contiguous community. These characteristics make turfgrasses ideal for functional outdoor spaces like golf courses. However, high traffic areas such as fairways, tees, and putting greens can deteriorate with routine use.

The negative impacts of soil compaction and high wear will be evident in concentrated traffic areas. Thatch accumulation can be problematic in less trafficked areas. The surface of the soil profile (top three inches) needs to be actively managed to enhance turfgrass health by improving water movement, increasing atmospheric gas exchange, reducing root penetration resistance, and removing thatch accumulation. Accumulation of excessive thatch and organic matter will reduce root growth, reduce water infiltration, cause scalping, create an undesirable playing surface, and encourage disease and insect activity.

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. Light and frequent applications of sand will smooth the playing surface, control thatch, and potentially change the physical characteristics of the underlying soil when done in conjunction with core aerification.

Best Management Practices

- Core aerification involves removal of small cores or plugs from the soil profile. Cores are usually 0.25 to 0.75 inch in diameter. Annual core aerification programs should be designed to remove 15%-20% of the surface area. Use ISTRC to determine specific needs. http://www.istrc.com/ 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 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. 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 less effective. It is best accomplished on moist soils.
- A spiker breaks up crusts on the soil surface, disrupt algae layers, and improve water infiltration.
- Vertical mowing (verticutting) can achieve a number of different goals. The grain of a putting green can be reduced by setting a verticutter to a depth that just nicks the surface of the turf. Deeper penetration of knives will stimulate new growth by cutting through stolons and rhizomes while removing accumulated thatch.
- Verticutting depth for thatch removal should reach the bottom of the thatch layer and extend into the surface of the soil beneath the thatch.
- Dethatching with a verticutter is an aggressive practice that is not recommended on golf putting greens because of the damage that occurs and the extensive recovery time required.
- Initiate vertical mowing when thatch level reaches 0.25 to 0.5 inch in depth. Shallow vertical mowing should be completed at least monthly on putting greens to prevent excessive thatch accumulation.
- Groomers, or miniature vertical mowers attached to the front of reels, are effective at improving management of grain and improving plant density through cutting of stolons.
- Top-dress the playing surface with sand following core aerification and heavy vertical mowing to aid in recovery of turf. Rates will vary from 0.125 to 0.25 inch in depth and will depend on the capacity of the turf canopy to absorb the material without burying the plants.
- Light, frequent applications of topdressing sand on putting greens can smooth out minor surface irregularities, aiding in the management of thatch accumulation.
- Use weed-free topdressing materials with a particle size similar to the underlying root zone.
- Use of finer materials can result in layering and can have a negative impact on water infiltration.
- Daily rolling of putting surfaces following mowing can increase putting speeds by roughly 10%, allowing for improved ball roll without lowering height of cut.
- To minimize potential for compaction caused by rolling, use light weight rollers.

Objectives of Sand Topdressing

- Dilute thatch accumulation
- Smooth the playing surface
- Maintain surface drainage
- Increase infiltration
- Increase soil macroporosity at the surface by increasing the sand content of the soil
- Increase surface firmness

TOPDRESSING

The goal of topdressing is to keep the crown of the turfgrass plant as close to the soil surface as possible by physically removing organic matter and thatch through cultivation and adding desirable rootzone material to the surface by sand topdressing. Obtaining this goal through proper management enables the turfgrass plant to maximize root development, minimize any disruption in water or air movement, and minimize pest pressure (disease/insect).

The particle size of topdressing material must be compatible with the existing rootzone material and topdressing materials should have the same particle size distribution as the construction mix or be coarser in texture. Topdressing materials finer in texture than the original construction sand can negatively impact rootzone infiltration rates and result in excessive moisture retention in the topdressing layer. Soil modification with sand of the top three inches results in higher infiltration rates and reduced runoff.

Best Management Practices

- Apply higher rates of topdressing to putting greens in the spring and fall in conjunction with more aggressive forms of cultivation, harvest cores and fill holes with topdressing (Carrow, 2003). Apply lighter, more frequent sand applications (every seven to 14 days) throughout the growing season; or match sand applications with plant growth potential.
- Laboratory test prospective topdressing materials using ASTM F1632, also known as the Standard Test Method for Particle Size Analysis and Sand Shape Grading of Golf Course Putting Green and Sport Field Rootzone Mixes. Compare the results to USGA guidelines for particle size distribution to determine the suitability as potential topdressing materials.
- Laboratory test prospective topdressing materials using ASTM F1815, also known as the Standard Test Methods for Saturated Hydraulic Conductivity, Water Retention, Porosity, and Bulk Density of Putting Green and Sports Turf Rootzones, to ensure they meet USGA guidelines for hydraulic conductivity.
- Sample existing greens on the golf course (15 to 20 subsamples at 4-inch depth or to the current topdressing layer depth if previously top-dressed) and laboratory test using ASTM F1632, and compare with the results with prospective topdressing materials to ensure compatibility.
- Accredited labs such as:
  - International Sports Turf Research Center
  - Turf & Soil Diagnostics

BUNKERS

In the rules of golf, a bunker is defined as a hazard consisting of a prepared area of ground, often a hollow, from which turf or soil has been removed and replaced with sand or the like. Bunkers are an integral part of nearly all golf courses and can be said to represent the personality of a course. Architects include bunkers in the design to provide aesthetic appeal and strategy by indicating the line of play.

Bunkers are defined as a hazard and provide some degree of difficulty to hit the ball out. The playability and management of bunkers is designed by the golf course architect and can vary greatly depending on the wishes of owners and skill levels of the intended golfers. They can result in an expensive item on the golf course, sometimes requiring more labor and expense to maintain than putting greens.

Three of the most important elements in constructing bunkers are drainage, liner, and sand selection. The drainage installed on the bunker floor will determine the level of moisture and firmness of the sand depending on how extensive the drainage system is and how quickly moisture leaves the bunker floor. The liner installed on the base of the bunker is of great importance in helping to avoid contamination of the sand and the reduction of sand washing down bunker banks during heavy rainfall. There are somewhere between six to 10 liners to choose from, each with a different methodology and particular materials. Most will do an excellent job.

Factors such as particle size, shape, color, uniformity and crusting potential, are all factors that contribute to creating aesthetics and playability.

The selection of sand is important because this item has the most influence on playability. Conducting a sand analysis with an accredited lab is recommended. The most important factor to evaluate may be the penetrometer reading, which will give a good prediction of the tendency of a sand to result in "fried egg " lies. Generally, a penetrometer reading above 2.20 will result in a sand with a low potential for the ball to bury. The infiltration rate is another parameter that is important in determining a favorable bunker sand. A minimum rate of 30 inches per hour is suggested. It is difficult to predict how a bunker sand will actually play, so it is recommended that a golf course acquire a few potential sands and create test bunkers for golf pros, committee members, and other interested players to trial before making a decision. Visits to other golf courses is another way to test out various bunkers' sands.

Sand depth and weather are important parameters in the final playability of a bunker sand. The USGA recommends an average sand depth of 4 to 6 inches at the base of the bunker and 2 to 3 inches on the faces. Finally, the maintenance of bunkers will ultimately create the playability of the surface.

Bunkers can be raked in two ways, either with a motorized bunker rake or by hand raking. Smaller bunkers must be raked by hand, while larger ones lend themselves to the labor-saving motorized units. Many different types of rakes and methodologies are used to create a smooth surface for the best playability. One of the most economical methods of raking is the "Aussie" method which involves only raking the base of the bunker, leaving the banks untouched to firm up and allow the balls to run down into the middle.

Frequent rainfall or irrigation and shallow raking will end in firm bunker surfaces, while dry weather and deep raking tend to create a soft surface. Golfer preference for bunker playability is a very personal thing with many players preferring a soft surface while others enjoy very firm sand.

Best Management Practices

- Consider maintenance costs and golfer clientele when designing bunkers. High flashed faces, numerous capes or intricate edges, revetted, and greater numbers of bunkers will increase difficulty and drive up costs.
- When constructing bunkers include extensive herringbone drainage and a well-researched bunker liner.
- Contour bunker surrounds so that they do not drain surface water into the bunker resulting in washouts.
- Irrigation should be installed that will water the bunker banks as well as the sand to keep it from becoming too dry.
- Create test bunkers to help select a new sand.
- Use an accredited lab to test bunker sands to help in making a good sand selection.
- For best playability, install bunker sand depth with 4 – 6" of sand on the bunker floor and 2 -3" of sand on banks.
- Strive to maintain a weed-free, smooth sand with a minimum potential for "fried egg" lies along with firm bunker banks.
- Rake bunkers 4x per week to help maintain a consistent surface, touch them up on other days to save labor.
- Mow bunker banks weekly with edging completed on a 2 to 4-week interval.
- Probe sand to maintain proper depths every two weeks or so depending on whether bunkers are flat or highly contoured.
- To keep bunkers looking their best, when they begin to look dirty and contaminated, remove the top 1-2" of sand and replace it with new sand.
- When bunkers get too firm, use a motorized bunker rake with cultivating tines to fluff up the sand and improve playability.
- Golf course architects recommend rebuilding bunkers on a 7-year interval; this timetable can change depending on the speed of bunker degradation

Resource for sand analysis:

Turf & Soil Diagnostics
35 King Street, Trumansburg, NY 14886
855-769-4231
http://www.turfdiag.com/

SHADE AND TREE MANAGEMENT

In general, most turfgrasses perform best in full sun. Excessive shade reduces photosynthesis and air circulation, thus increasing the susceptibility of the turf to pest and disease problems. It is important to maintain healthy trees and prune as needed.

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 relocated, or their canopy should be thinned to promote good turf growth.
- Understand the variability in sun angles at different times of the year and how this affects turf health.
- Conduct a shade audit to identify problem areas. Use apps like “Sun Seeker” to identify the trees causing shade.
- Working with an arborist, conduct a tree survey that identifies each tree’s location, species, health, life expectancy, safety concerns, value and special maintenance requirements.

INTEGRATED PEST MANAGEMENT IS *a common-sense approach to manageing pests*

Integrated Pest Management (IPM) is a common-sense approach to managing pests. The objective is to give priority to the least toxic pesticide when applications are necessary. This helps reduce risk of pesticide exposure to people, animals, and the environment. It also helps with managing expenses and conserving energy.

Golf course superintendents must understand what IPM is and how to implement it for each pest group, including insects, diseases, weeds, and nematodes. It is important to have a thorough knowledge of types of pests, lifecycles and/or conditions that favor pests, ways to prevent pests, and methods of pest control. IPM benefits can include less pesticide use, less disruption of natural biological control, reduced risk to human health, improved efficiencies and cost-effectiveness.

IPM aims to reduce conventional pesticide use, when feasible, by using an integration of multiple tactics to control pests, including cultural or mechanical, biological, genetic, and chemical controls.

5 Key Steps for IPM

1. Scouting, Identification, Monitoring
2. Setting "Action Level" or Thresholds
3. Making Decisions - control method(s)/timing
4. Evaluation
5. Education

Best Management Practices

- Always adhere to local, state, and federal regulations for pesticide application, restricted use pesticides (RUP), and biological controls
- Proper records of all pesticide applications should be kept according to local, state, or federal requirements
- Collect soil samples annually to assess soil fertility and pH; proper soil pH and fertility help prevent diseases and promote plant health to reduce potential for insect and weed invasion
- Establish a written IPM plan. Monitor, observe, and document turf conditions regularly (daily, weekly, or monthly, depending on the pest), scout which pests are present, level of damage, determine pest thresholds, and necessary control strategies
- Scout to identify key pests on key plants; determine pest's lifecycle, know which life stage to target (e.g., for an insect, whether egg, larva/nymph, pupa, or adult)
- Decide which pest management practice (mechanical, chemical, biological) is appropriate and carry out corrective actions
- Use proper cultural, mechanical, or physical methods to prevent problems (e.g., prepare site, choose correct turfgrass for Connecticut; select resistant cultivars), reduce pest habitat, practice good sanitation, pruning, dethatching
- Consider biological controls that support natural predators and beneficial organisms to reduce pests
- Mow when grass is dry to avoid spread of turf diseases; maintain sharp cutting edges to avoid stress; properly manage grass clippings (reference Cultural Practices BMP Section)
- Chemical pesticide applications should be carefully chosen for effective, site-specific pest control; use properly timed preventive chemical applications only when professional judgment indicates they are likely to control the target pest effectively, with minimal environmental and economic impact
- Rotate chemicals and modes of action to reduce resistance in pests; always follow label instructions
- Train employees on pest identification, pesticide selection, application techniques; entomologists and other specialists are available from the University of Connecticut - UConn Plant Diagnostics Laboratory https://plant.lab.uconn.edu/, Connecticut Department of Energy and Environmental Protection (DEEP) https://portal.ct.gov/DEEP/Pesticides/Integrated-Pest-Management/Integrated-Pest-Management, and Connecticut Agricultural Experiment Station (CAES) https://portal.ct.gov/CAES/ABOUT-CAES/How-To-Contact/How-to-Contact-The-Station other extension agencies for assistance with pest identification
- Determine whether corrective actions reduced or prevented pest populations; were economical and minimized risks; record and use information when making future decisions
- Maintain a supply of PPE for use when working on pesticide application equipment.

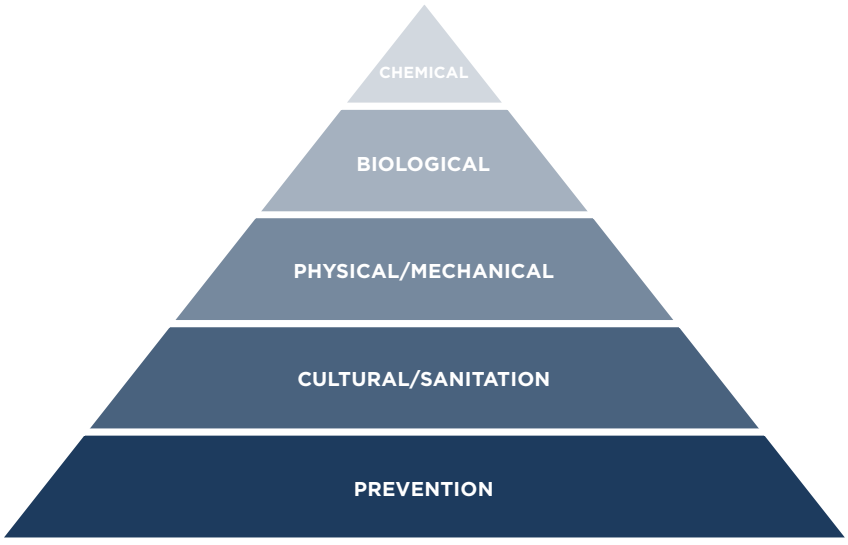
IPM PLAN & MONITORING

IPM on golf courses focuses on identifying pests, choosing pest-resistant varieties of grasses and other plants, enhancing habitat for natural pest predators, scouting to determine pest populations and acceptable thresholds, and applying biological and other potentially less-toxic alternatives whenever possible. Chemical controls should minimize impacts on the environment and potential for development of pesticide resistance.

WRITTEN PLAN

A written IPM plan should be established to provide guidance and align crew members. IPM includes biological controls, cultural methods, chemical controls, pest monitoring, and other applicable practices. The written plan should establish responsibilities, pest action thresholds, a system of communication, and pesticide-use hierarchy. A pest-control strategy should only be used when the pest is causing, or is expected to cause, more damage than what can be reasonably and economically tolerated. A control strategy should reduce pest numbers to an acceptable level, while minimizing harm to non-targeted organisms and the environment.

Reference a sample IPM Plan for Turf from DEEP at https://portal.ct.gov/-/media/DEEP/pesticides/IPM/IPMOrnamentalandTurfPlanpdf.pdf.



IPM Pyramid

Key Factors for Pesticide Selection

- Effectiveness
- Method and frequency of application
- Potential toxicity to non-target species
- Cost
- Site characteristics
- Solubility
- Persistence

DEEP Assistance with IPM

For technical assistance and support with evaluating existing IPM programs, contact:

Department of Energy and Environmental Protection
Bureau of Materials Management & Compliance Assurance
Pesticide Management Program

79 Elm Street
Hartford, CT 06106

Telephone: 860-424-3369

https://portal.ct.gov/DEEP/Pesticides/Integrated-Pest-Management/Integrated-Pest-Management

PEST THRESHOLDS & SCOUTING

Include “scouting” of locations and steps for all areas of the course in the IPM written plan. Scout to identify populations, pest damage, determine acceptable thresholds, and what control strategies are needed. Scouting methods include visual inspection, soil sampling, soap flushes, and insect trapping. Keep a record of scouting results for historical information, to document numbers of pests, patterns of pest activity, size of area affected, successes and failures. Use this information when making future decisions. Use Growing Degree Day (GDDs) calculations for assistance in monitoring for pest presence.

Educating golfers and maintenance personnel can raise understanding and tolerance of minor aesthetic damage without compromising plant health, play, and aesthetics. Pest thresholds help guide application decisions and associated education, while minimizing economic and environmental costs. Pest population, lifecycle stage of the pest, and life stage of the plant are several factors considered to determine thresholds.

Reference samples of suggested insect pest thresholds:

DEEP https://portal.ct.gov/-/media/DEEP/pesticides/IPM/IPMOrnamentalandTurfPlanpdf.pdf
University of Connecticut http://cag.uconn.edu/documents/Turfgrass-IPM-manual-s.pdf

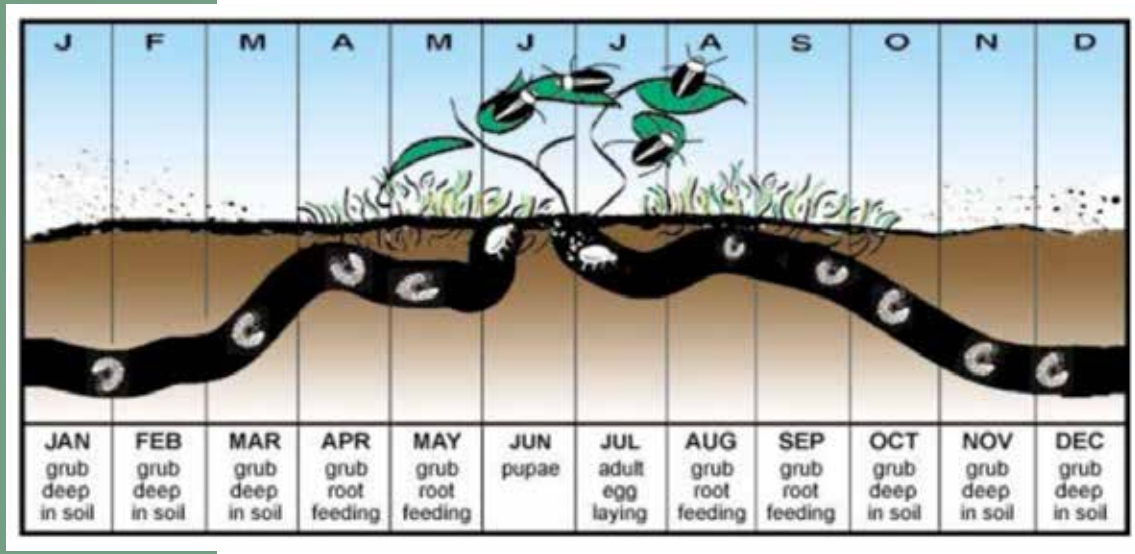
Note that some recommended action thresholds may be lower (6 to 10 grubs per square foot) depending upon species. Additional threshold reference for the Annual bluegrass weevil:

https://ecommons.cornell.edu/bitstream/handle/1813/42417/ann-bluegrass-weevil-FS-NYSIPM.pdf?sequence=1
http://www.turfgrassdiseasesolutions.com/sys/docs/12/factsheetoriginal.pdf

No Grubs!

The Lifecycle & Thresholds for Destructive White Grubs

White grubs are the most destructive insect pest of cool season turfgrasses. Turfgrass damage occurs once larvae have grown to second or third instars (Sept-Oct) and where there are >15 larvae per square foot. Understand the pest lifecycle in order to set thresholds that will guide decisions.



White grub life stages and locations throughout the year
(Hadley and Hawley, 1934).
Reference: http://ipm.uconn.edu/documents/view.php?id=628

MONITORING

Monitor, observe, and document the presence and development of pests regularly – this could include daily, weekly, or monthly monitoring, depending on the pests. Note time of day, month, year, weather, and flowering stages of nearby plants to determine conditions which are conducive to outbreaks. Map outbreak locations (including number of insects per unit area, disease patch size, and percent of area affected) to identify patterns and susceptible areas. Problem areas might include the edges of fairways, shady sites, or poorly drained areas. Document with photos when possible; use GGDs.

Personnel should be trained to determine the pest's lifecycle and know which life stage to target. For example, for an insect pest - identify whether it is an egg, larva/nymph, pupa, or adult. It is important for staff to document, identify, and record key pest activities on key plants. Signs of the pest may include mushrooms, animal damage, insect frass, or webbing. Symptoms of the pest may include chlorosis, dieback, growth reduction, defoliation, mounds, or tunnels. The staff should note which corrective actions reduced or prevented pest populations and they should be trained to understand what actions are most economical, while minimizing risks. Help with diagnostics is available at https://plant.lab.uconn.edu/.

Common Insect Pests in Connecticut

Surface Feeding Insects

- Annual bluegrass weevil (Hyperodes weevil)
- European crane fly
- Chinch bugs
- Sod webworms
- Bluegrass billbugs
- Black cutworm

Root Feeding Insects

- Annual bluegrass weevil (Hyperodes weevil)
- European crane fly
- White Grub Species
- European chafer
- Oriental beetle
- Japanese beetle
- Asiatic garden beetle
- Black turfgrass ataenius

Other

- Ants
- Earthworms & castings
- Ticks
- Cicada killers
- Mosquitos
- Moles, voles, and shrews

References/Resources:

http://ipm.uconn.edu/documents/view.php?id=628

http://cag.uconn.edu/documents/Turfgrass-IPM-manual-s.pdf

https://ecommons.cornell.edu/bitstream/handle/1813/42417/ann-bluegrass-weevil-FS-NYSIPM.pdf?sequence=1

https://www.gcsaa.org/gcm/2017/march/a-survey-of-annual-bluegrass-weevil-management#:~:text=Annual%20bluegrass%20weevil%20larvae%20can,feeding%20(5%2C6).

PEST GROUPS

Insects

Insects can be destructive to turfgrass and disruptive to play. It is important to correctly identify the responsible insect pest and pest lifecycle to determine the best course of management. Identification often involves sending samples to diagnostic clinics. Specialists are available from UConn through the Plant Diagnostic Laboratory at PlantDiagnosticLab@uconn.edu to assist with pest identification. Insect pests may damage the plant by surface feeding or root feeding. Turfgrass managers have multiple tactics and tools that can be used to control turf insect pests, including cultural and chemical practices.

Surface feeding insects prosper in thatch. Manage thatch depth through core cultivation, verti-cutting, and topdressing. Root feeding insects include white grub species which are the most destructive insect pest of cool season turfgrasses.

Healthy, well-managed turfgrass is more likely to resist insect problems and has better recuperative potential than stressed, unhealthy turf. Cultural factors that influence stress include organic layer management, fertility programs, water management, and mowing height selection. Correct conditions that produce stressful environments for turf. (e.g., improve airflow and drainage, reduce or eliminate shade, etc.)

The appropriate (most effective) preventive insecticide can be applied to susceptible turfgrasses when unacceptable levels of insect damages are likely to occur. Certain well-studied biological control agents (i.e., entomopathogenic nematodes, fungi, and bacteria) can be used against certain turf insect pests.

Record and map insect outbreaks. Identify trends to help guide future treatments and focus on changing conditions within susceptible areas to reduce insect outbreaks. For a listing of insect pests in Connecticut, visit: https://portal.ct.gov/CAES/Publications/Publications/Listing-of-all-Available-InsectPest-Plant-and-Miscellaneous-Fact-Sheets.

Beware of Invasive Species!
Emerald Ash Borer (EAB)

Invasive, or non-native, species which are alien to Connecticut's ecosystem can cause harm to native species or possibly human health. The EAB feeds on ash trees, including the white ash, green or red ash, and the black ash. To report a possible EAB find, call the Connecticut Agricultural Experiment Station at 203-974-8474 or email: CAES.StateEntomologist@ct.gov. When reporting a potential invasive insect find, do not move the insect or wood from the site.

Additional EAB information: https://portal.ct.gov/DEEP/Forestry/Forest-Protection/Emerald-Ash-Borer-EAB#Connecticut

Additional information on other Invasive Species such as the Asian Longhorned Beetle, Spotted Lanternfly, gypsy moth, Japanese beetle, hemlock woolly adelgid, and European elm bark beetle:

https://portal.ct.gov/DEEP/Invasive-Species/Invasive-Species

https://portal.ct.gov/DEEP/Forestry/Forest-Protection/Asian-Longhorned-Beetle

https://portal.ct.gov/DEEP/Forestry/Forest-Protection/Spotted-Lanternfly

Kicking Ticks!
5 BMPs for Tick Control

The deer tick (Ixodes scapularis) or black-legged tick is the arthropod responsible for Lyme disease which may be found in Connecticut with wooded areas or ornamental and shaded areas (in proximity to a woodlot). These five steps can help control exposure to ticks:

- Personal protection (staff and golfers) - wear light-colored clothing with pants tucked into socks; frequent visual inspection of clothing and skin
- Clear debris – keep grass cut regularly, remove brush piles, keep property free of leaves, trim shrubs, edge areas to modify habitat and increase sun exposure
- Create natural barriers - create a 3' barrier from shaded or wooded areas using stone or wood chips
- Discourage deer habitat – choose plants, shrubs, and trees that deer are not attracted to; enclose property with fencing to reduce deer onsite
- Chemical controls – time applications from late May to early June to reduce nymphal ticks

Resources

https://portal.ct.gov/DPH/Epidemiology-and-Emerging-Infections/Ticks

http://grounds-mag.com/mag/grounds_maintenance_controlling_deer_ticks/

https://www.ctpost.com/local/article/Tracking-the-terrain-harboring-disease-carrying-14977322.php

Common Turfgrass Diseases in Connecticut

- Dollar spot, *Sclerotinia homoeocarpa*
- Anthracnose
- Brown patch, *Rhizoctonia solani*
- Gray snow mold, *Typhula incarnata*
- Pink snow mold, *Michrodochium nivale*
- Fairy ring, various Basidiomycetes fungi
- Pythium blight, *Pythium spp.*
- Fusarium blight, *Fusarium spp.*
- Gray leaf spot, *Pyricularia grisea*
- Melting-out & drechslera leaf spots
- Necrotic ring spot, *Leptosphaeria korrea*
- Powdery mildew, *Erysiphe graminis*
- Red thread, *Laetisaria fuciformis*
- Smut, *Ustilago striiformis*
- Summer patch, *Magnaporthe poae*
- Leaf spot
- Brown ring patch/*Waitea* Patch, *Waitea Circinata*
- Root Pythium & Pythium Root dysfunction
- Take-All Patch

Reference: http://cag.uconn.edu/documents/Turfgrass-IPM-manual-s.pdf

Diseases

Sound cultural practices are important for maintaining healthy turfgrass to prevent disease outbreaks. Plant pathogens can impact plant health and quality of turf, which in turn affects play. There are three components to consider with disease outbreaks: the host, pathogen, and environment – referred to as the "disease triangle". Conditions such as excess soil moisture or mowing when turf is wet can influence fungal disease outbreaks. In order to correctly identify the disease pathogen, samples may be sent to diagnostic clinics such as UConn's Turfgrass Disease Diagnostic Center at https://cahnr.uconn.edu/turflab/

ultural factors which can reduce the likelihood of disease include organic layer management, fertility programs, water management, and mowing height selection. Proper cultural practices can help correct conditions that produce stressful turf environments (e.g., improve airflow and drainage, and reduce or eliminate shade). Many diseases are caused by moist conditions. A beneficial way to limit the infestation is to irrigate deeper and less frequently, if conditions allow. Healthy, well-managed turfgrass is less likely to develop disease given its better recuperative potential.

Fungicide use should be integrated into an overall management strategy for a golf course. Record and map disease outbreaks identify trends to guide future treatments, and alter conditions in susceptible areas to reduce disease outbreaks. The appropriate (most effective) preventive fungicide can be applied to susceptible turfgrasses when unacceptable levels of disease are likely to occur.

Weeds

Weed infestation can affect the health of turfgrass, negatively impacting plant life and playing surface. People, animals, birds, wind, and water can distribute seeds which reproduce into weeds. Weeds also spread vegetatively - tubers, corms, rhizomes, stolons, creeping stems, or bulbs. Weeds compete with turf for space, water, light, and nutrients. They produce additional problems acting as hosts for plant pathogens, nematodes, and insects; in addition to producing allergic reactions and skin irritants.

The best defense against weeds is proper cultural practices and nutrient management to support healthy turfgrass, integrated with an intelligent herbicide program. A successful weed management program consists of:

- Preventing weeds from being introduced into an area
- Selecting appropriate turf species or cultivars adapted to prevalent environmental conditions to reduce weed encroachment
- Using proper turfgrass and nutrient management in combination with cultural practices to promote vigorous, competitive turf
- Properly identifying weeds and understanding lifecycles
- Understanding all IPM control measures, properly selecting and using appropriate herbicide, if necessary

Adopt or maintain cultural practices that protect turfgrass from environmental stresses such as shade, drought, and extreme temperatures in order to prevent weed encroachment. Proper turf management practices include correct and appropriate use of fertilizers and chemicals, proper mowing height and frequency, proper soil aeration, and regulated traffic to reduce physical damage and compaction. Proper fertilization helps resist diseases, weeds, and insects; it is essential for turfgrasses to sustain desirable color, growth density, and vigor. Dense, thick turfgrass helps prevent weeds from establishing; avoid scalping, which reduces turf density and increases weed establishment. Use weed-free materials for topdressing. Aggressive overseeding has been shown to reduce weed populations as a reduced-pesticide method.

Record and map weed infestations to help identify site specific issues for preventative actions. Address damage from turfgrass pests such as diseases, insects, nematodes, and animals to prevent density/canopy loss to broadleaf weeds. Invasive weeds in Connecticut include the Japanese knotweed, Purple loosestrife, and Giant Hogweed. For a list of common Connecticut weeds which exist in the presence of adverse site conditions, visit http://cag.uconn.edu/documents/Turfgrass-IPM-manual-s.pdf.

Nematodes

Plant-parasitic nematodes adversely affect turfgrass health. These microscopic roundworms (unsegmented), usually between 0.0156 and 0.125 inch in length, debilitate the root system of susceptible turfgrasses. The roots under nematode attack may be very short, with few root hairs, or appear dark and rotten.

Plant-parasitic nematodes cause turf to be less efficient at water and nutrient uptake and make it more susceptible to environmental stresses. Weakened turf favors pest infestation and weeds. Turfgrasses begin showing signs of nematode injury during stress, drought, high temperatures, low temperatures, and wear.

Recommended practices when nematode activity is suspected:

- Assay the soil and turfgrass roots to determine extent of the problem
- Only apply nematicide on golf course turf based on assay results
- Divert traffic from areas stressed by insects, nematodes, diseases, or weeds
- Increase mowing height to reduce plant stress associated with nematodes (in addition to root-feeding insects, disease outbreaks, or peak weed-seed germination)
- Reduce or eliminate other biotic/abiotic stresse

Fungi Can Be Your Friend!

Endophyte-enhanced Turfgrass Cultivars to Fight Insect Pests

Endophytes, in relation to turfgrass, are intercellular fungi that form symbiotic relationships with turf species. Turf species that commonly benefit from endophytes are perennial ryegrass, tall fescue, and fine fescue. Endophytes survive by utilizing energy produced by the plant and in return provide numerous benefits like deterring Surface feeding insects, resisting heat stress, and fighting dollar spot - which can aid in reductions of water use and pesticides.

Reference: https://turf.umn.edu/news/endophytes-friendly-fungi-turfgrass

CONTROL METHODS

Turfgrass Selection & Maintenance

Selecting pest-resistant cultivars or plant species could potentially help reduce pesticide usage. A species grown outside of its zone of adaptation is typically more prone to pest problems. Species and cultivars should be managed under conditions similar to the intended use (e.g., not exceeding mowing height limitations that a grass was bred or selected for). Reference the National Turfgrass Evaluation Program for help with cultivar selection: http://www.ntep.org/

Proper cultural practices are important to reduce plant stress and keep turf healthy. Pests can be minimized through proper irrigation, mowing (height, frequency, pattern), clipping management, topdressing, core aerification, and venting. For example, varying mowing pattern encourages vertical growth, increases tolerance from wear, and minimizes soil compaction. Core aerification reduces compaction, increases infiltration capacity, and encourages root growth – however may produce adverse effects, so should be managed appropriately (i.e. topdressing turf area with suitable soil).

Avoid use of turfgrass in heavily shaded areas and select shade-adapted grasses for areas receiving partial sun or shade. Minimize stress and leaf wetness by correcting dead spots and air-circulation issues by pruning understory and adjusting irrigation scheduling. When pest populations are low, mechanical control methods such as vacuuming, hand pulling weeds, and extracting pests may be used.

Educate builders, developers, golf course and landscape architects, sod producers, and golfers on which plants are best suited to Connecticut. Turfgrasses must be selected which are appropriate within the climate zone and region of the golf course. This helps turfgrass health and tolerances to minimize irrigation requirements, fertilization needs, and pesticide use. For information on turfgrass species, visit http://ntep.org/contents2.shtml.

Reference Planning, Design, and Construction, Irrigation, and Cultural Practices for additional BMPs.

Cultural Practice	Disease	Response	References
Fertilization	Anthracnose	Weekly applications of nitrogen at 0.1 lb./1,000ft2 reduced disease severity.	Inguagiato et al., 2008
		Maintaining a foliar N concentration equal or greater than 3.4% reduced anthracnose severity.	Inguagiato and Guillard, 2016
	Brown patch	Brown patch was more severe in plots treated with nitrogen, but nitrogen did not affect fungicide performance.	Fidanza and Dernoeden, 1996
	Dollar spot	Dollar spot was less severe in plots treated with nitrogen.	Williams et al., 1996
	Pythium blight	Pythium blight severity increased with nitrogen application.	Moore et al., 1963
	Red thread	Disease was more severe in nitrogen-deficient turf.	Cahill et al., 1983
	Summer patch	Patch severity was reduced with application of ammonium sulfate compared with calcium nitrate.	Thompson et al., 1995
	Take-all patch	Acceptable levels of control were achieved in plots treated with ammonium chloride.	Dernoeden, 1987
Mowing	Anthracnose	Anthracnose severity was reduced with increased mowing height.	Inguagiato et al., 2009
	Brown patch	Clipping removal had no effect on disease.	Settle et al., 2001
	Dollar spot	Morning mowing reduced disease.	Ellram et al., 2007, Williams et al., 1996
		Clipping removal had no effect on disease.	Williams et al., 1996
	Pythium blight	Clipping removal had no effect on disease.	Settle et al., 2001
Irrigation	Anthracnose	Minimizing drought stress, while avoiding continuous high soil water content reduced disease severity.	Roberts et al., 2011
	Brown patch	Daily irrigation did not affect brown patch.	Settle et al., 2001
		Irrigation reduced brown patch severity.	Rowell, 1951
		Daily irrigation reduced brown patch severity on perennial ryegrass.	Jiang et al., 1998
	Pythium blight	Daily irrigation aggravated Pythium blight in some cases.	Settle et al., 2001
Other	Anthracnose	Light-frequent or heavy-infrequent sand topdressing resulted in lower anthracnose severity.	Inguagiato et al., 2012
		Lightweight rolling every other day reduced anthracnose.	Roberts et al., 2012
		Shallow verticutting did not affect anthracnose severity.	Inguagiato et al., 2008
	Dollar spot	Rolling to remove dew reduced disease.	Williams et al., 1996
		Dew displacement reduced disease.	Ellram et al., 2007
		Dew displacement improved efficacy of chlorothalonil.	McDonald et al., 2006
		Lightweight rolling daily reduced dollar spot.	Giordano et al., 2012.

Table adapted from A Practical Guide to Turfgrass Fungicides. Latin, 2011. American Phytopathological Society. St. Paul, MN.

Effect of various cultural practices on turfgrass diseases.

Source: Best Management Practices for New England Golf Courses

Turfgrass Tolerances

Species	Establishment Rate	Leaf Texture	Density	Cold	Heat	Drought	Shade	Acid	Submer-sion	Salinity	Wear
Kentucky bluegrass	2-3	3	2-3	4	2-3	3	1	2-3	2	1	2-3
Roughstalk bluegrass	4	2-3	2-3	4	1	1	3-4	2-3	3-4	1	>1
Supina bluegrass	3	2-3	3	3	2-3	1	4	3	?	1	4
Canada bluegrass	2-3	3	1	4	4	2	4	2	2	1	
Annual bluegrass	3	2-3	3	1	1	1	2	2-3	3-4	1	3
Creeping bentgrass	3	2-3	3	4	3	1	2-3	3	4	3-4	2-3
Colonial bentgrass	3	2-3	3	3	2	3	2-3	3	2	1	1-2
Velvet bentgrass	3-4	1	3	3	1	1	2-3	3	3	1	3
Redtop	3-4	3	1-2	3	1	3	2-3	3	3-4	3	1
Creeping red fescue	3-4	1	3	3	2	4	4	4	1	1	1-2
Chewings fescue	3-4	1	3	3	2	4	4	4	1	1	1-2
Sheep fescue	3-4	1	3	3	2	4	4	4	1	1	1-2
Hard fescue	3-4	1	3	3	2	4	4	4	1	1	1
Tall fescue	3-4	3-4	1-2	2	3	4	2-3	4	3	3	3-4
Perennial ryegrass	4	2-3	2-3	2-3	2-3	2-3	1	2-3	2	2	3
Annual ryegrass	4	3-4	2	>1	2	2	1	2-3	2	2	3-4
Zoysiagrass	1	3-4	3	4	3	2-3	4	2	3	4	
Buffalograss	4										

Establishment Rate: 1 = Very Slow 2 = Slow 3 = Medium 4 = Fast
Leaf Texture: 1 = Very Fine 2 = Fine 3 = Medium 4 = Coarse
Density Potential: 1 = Low 2 = Medium 3 = High
Tolerances: >1 = Very Poor 1 = Poor 2 = Fair 3 = Good 4 = Excellent

Turfgrass Species Characteristics

Species	Mowing Height (inches)	Mowing Quality	Nutrient Needs	Pest Potential	Thatch Tendency	Recuperative Potential
Kentucky bluegrass	1-2.5	4	med-high	med-high	med-high	3-4
Roughstalk bluegrass	0.5	3	med	low-med	low-med	3
Supina bluegrass	0.2	3	high	low-med	med-high	3-4
Canada bluegrass	3-4	1	low	low	low	3
Annual bluegrass	0.3	3	high	high	med-high	3
Creeping bentgrass	0.25	3	high	high	high	3-4
Colonial bentgrass	0.25	3	low-med	med-high	med-high	1-2
Velvet bentgrass	0.2	3	low-med	med-high	med-high	1
Redtop	0.5-3	2	low	low	low-med	1
Creeping red fescue	1.5-2.5	1	low	low-med	med-high	1-2
Chewings fescue	1-2.5	1	low	low-med	med-high	1-2
Sheep fescue	2-3	1	low	low-med	low	1
Hard fescue	2-3	1	low	low-med	low	1
Tall fescue	1.5–3	3	med	low-med	low	1-2
Perennial ryegrass	1.5–2	2-3	med-high	med-high	low	3
Annual ryegrass	1.5–2	2-3	med-high	med-high	low	3
Zoysiagrass	.5-1	2	low-med	low	high	3-4

Mowing Quality and Recuperative Potential: 1 = Poor 2 = Fair 3 = Good 4 = Excellent

Source: *http://cag.uconn.edu/documents/Turfgrass-IPM-manual-s.pdf*

Biological Controls

The biological component of IPM involves the release and/or conservation of biological control agents, such as predators, parasites, and pathogens. Entomologists at the University of Connecticut and the Connecticut Agricultural Experiment Station Valley and New Haven Laboratories can provide informational resources.

https://portal.ct.gov/CAES/ABOUT-CAES/How-To-Contact/How-to-Contact-The-Station

https://portal.ct.gov/CAES/Fact-Sheets/Entomology/Approaches-to-the-Biological-Control-of-Insect-Pests

Areas on the golf course can be modified to better support natural predators and beneficial organisms (e.g.; diversifying landscaping with flowering plants to provide sources of pollen and nectar). This natural control can have immediate and long-term impacts including reduced pesticide use, improved native plant growth, lower energy use, water and cost reductions.

Understand the lifecycles of beneficials. When feasible, avoid applying pesticides to roughs, driving ranges, or other low-use areas to provide a refuge for beneficial organisms. Targeted areas for biological controls should attract natural predators and protect them from pesticide applications. Plant insectary plants that provide pollen or nectar sources. Regularly monitor to spot outbreaks and transfer beneficial insects into the area needed.

Nematodes can serve as a biological control organism. There are two nematode families Steinernematidae and Heterorhabditidae that can be useful for insect pest management, Nematodes infect hosts such as white grubs and billbug larvae by releasing bacteria within the host causing it to die. Nematodes are considered an environmentally friendly pest control option, as they occur naturally without need for genetic modification. It is important to select the appropriate nematode species for the targeted pest. To test a nematode shipment for effectiveness, contact the Connecticut Agricultural Experiment Station Valley Laboratory in Windsor, CT.

Beneficial Organisms in Connecticut

- Rove beetles for controlling sod webworm
- Ground beetles feed on chinch bugs, cutworms, sod webworms, and grubs
- Big-eyed bugs, *Geocoris bullatus* and *G. uliginosus*, for controlling chinch bugs
- Entomopathogenic nematodes (EPN) to control white grubs
- Endophyte-enhance perennial ryegrass, tall fescue, and fine fescue to control chinch bugs, billbugs, and turf-feeding caterpillars

The Environmental Protection Agency has identified alternatives to conventional pesticides.

Reduced Risk Pesticides for Use on Golf Course Turf

Fungicides	Herbicides	Insecticides
boscalid	penoxsulam	clothianidin *neonicotinoid
penthiopyrad	carfentrazone-ethyl	*chlorantraniliprole*
trifloxystrobin	mesotrione	*cyantraniliprole*
fludioxonil	bispyribac-sodium	fipronil
azoxystrobin		spinosad

Source: https://www.epa.gov/pesticide-registration/reduced-risk-and-organophosphate-alternative-decisions-conventional

Reduced Risk Pesticides

- Low impact on human health
- Lower toxicity to non-target organisms (birds, fish, plants)
- Low potential for groundwater contamination
- Low use rates
- Low pest resistance potential
- Compatibility with IPM practices

Biopesticides

- Derived from natural materials (e.g.; animals, plants, bacteria, certain minerals)
- Usually inherently less toxic than conventional
- Generally affect only target pest & closely related organisms
- Often effective in small quantities & decomposes quickly, resulting in lower exposures & pollution
- Compatibility with IPM practices

For more information:

https://www.epa.gov/pesticide-registration/conventional-reduced-risk-pesticide-program

https://www.epa.gov/ingredients-used-pesticide-products/what-are-biopesticides

Conventional Pesticides

IPM involves prevention and suppression to reduce pest numbers or damage to an acceptable level. A pest-control strategy using pesticides should be used after, or in alignment with, proper cultural practices to control for pests. 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 should be evaluated on effectiveness against the pest, mode of action, life stage of the pest, personnel hazards, non-target effects, potential off-site movement, method (spot treatment vs widespread applications), frequency (some low toxicity herbicides may require multiple applications) of application, and cost. An additional evaluation measure which may be considered is the environmental impact quotient (EIQ). The EIQ provides criteria to supplement knowledge of efficacy, cost, and resistance management in helping to determine chemical pesticide options when necessary.

For EIQ information:
http://turf.cals.cornell.edu/pests-and-weeds/environmental-impact-quotient-eiq-explained/
https://nysipm.cornell.edu/eiq/calculator-field-use-eiq/

Pesticides are designed to control or alter behavior of pests - a control strategy should reduce pest numbers to an acceptable level, while minimizing harm to non-targeted organisms. Growing degree days (GDD or DD) are a measure of the "heat units" (related to temperature and the amount of time per day that an insect spends actively growing) that accumulate over time. Monitoring GDD accumulation can help determine when specific insect pests are likely to be present in order to determine best control strategy.

Several available tools and resources may be found at:
http://uspest.org/cgi-bin/ddmodel.us
http://gddtracker.msu.edu/
http://turf.eas.cornell.edu/

Train employees on proper pest identification and pesticide selection techniques. Choose the product most appropriate for the pest and mix only the quantity of pesticide needed in order to avoid disposal problems, protect non-target organisms, and reduce costs. Spot-treat pests whenever appropriate. Rotate pesticide modes-of-action to reduce likelihood of resistance.

For information on rotation and resistance management reference:
https://www.frac.info/fungicide-resistance-management
https://www.hracglobal.com/
https://irac-online.org/

Always follow label instructions; state and federal pesticide laws require it. Note environmental hazards and groundwater advisories included on labels. Follow guidelines provided by the Fungicide Resistance Action Committee, Herbicide Resistance Action Committee, and Insecticide Resistance Action Committee. DEEP may be contacted for more information about IPM or other pesticide concerns.

IPM principles include proper record-keeping of pest control activity to establish proof of use, application of protocols, and refer to past infestations in order to select best future course of action. Records must be kept for five years from the date of application.

For more information, visit: *https://portal.ct.gov/DEEP/Pesticides/Pesticide-Control-Statutes-Clarification#:~:text=A%20pesticide%20application%20business%20shall,or%20amended%2C%20whichever%20is%20later.*

RECORD-KEEPING

Record pesticide applications, along with results of scouting, to develop historical information, document patterns of pest activity, and note successes and failures. Record-keeping is required to comply with the federal Superfund Amendments and Reauthorization Act (SARA, Title III). Certain pesticides are also classified as RUP, refer to https://portal.ct.gov/-/media/DEEP/pesticides/restrictedpermitusepesticidespdf.pdf.

Record-keeping and supervisory written instruction requirements apply per Connecticut General Statutes and Regulations. Supervisory written instructions are required to be maintained as part of the permanent pesticide application record. Records must be maintained for 5 years. Refer to: https://portal.ct.gov/-/media/DEEP/pesticides/Certification/Supervisor/Statsandregspdf.pdf

There are several resources available to assist with record-keeping, examples include:

Playbooks for Golf https://goplaybooks.com/coverage.html
Sparks https://sparks2.com/
PeRK https://cropwatch.unl.edu/unl-releases-perk-20-pesticide-recordkeeping-app

IPM Record Keeping

Pesticide Application Record	Details
Name of golf course	
Date and time of application	
Name of applicator	
Certification number	
Supervisor name	
Person directing or authorizing application	
Weather conditions at time of application	
Target pest(s)	
Pesticide used (trade name, active ingredient, amount of formulation, amount of water)	
EPA Registration number	
Adjuvant/surfactant and amount applied, if used	
Area treated (acres or square feet) and location	
Total amount of pesticide used - rate of application, ounces/gallon pounds/square feet	
Application Equipment	
Additional remarks (e.g., severity of infestation or life stage of pest)	
Follow-up to check effectiveness of application	

Reference the Pesticide Management Section for pesticide management, PPE, and storage BMPs.

PESTICIDE SELECTION SHOULD BE BASED ON *effectiveness, toxicity and site characteristics*

The judicious use of pesticides is generally required, as part of an IPM program, to minimize damage to golf course playing surfaces caused by disease, insects, and weeds in Connecticut. When an application is deemed necessary, pesticide selection should be based on effectiveness, toxicity to non-target species, site characteristics, solubility and persistence in the environment, and cost. Golf course superintendents should consider these factors to minimize human and environmental risk associated with pesticide use.

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 IPM.

HUMAN HEALTH RISKS

Pesticides belong to numerous chemical classes that vary greatly in their toxicity. However, the risk to human health associated with pesticide use depends on both pesticide toxicity and the level of exposure. Exposure is related to how much an individual is exposed to a pesticide. Thus, the risk of a very highly toxic pesticide may actually be very low, if the exposure is sufficiently small. There are 4 pesticide signal words that help decide what level of risk is present when applying.

Best Management Practices

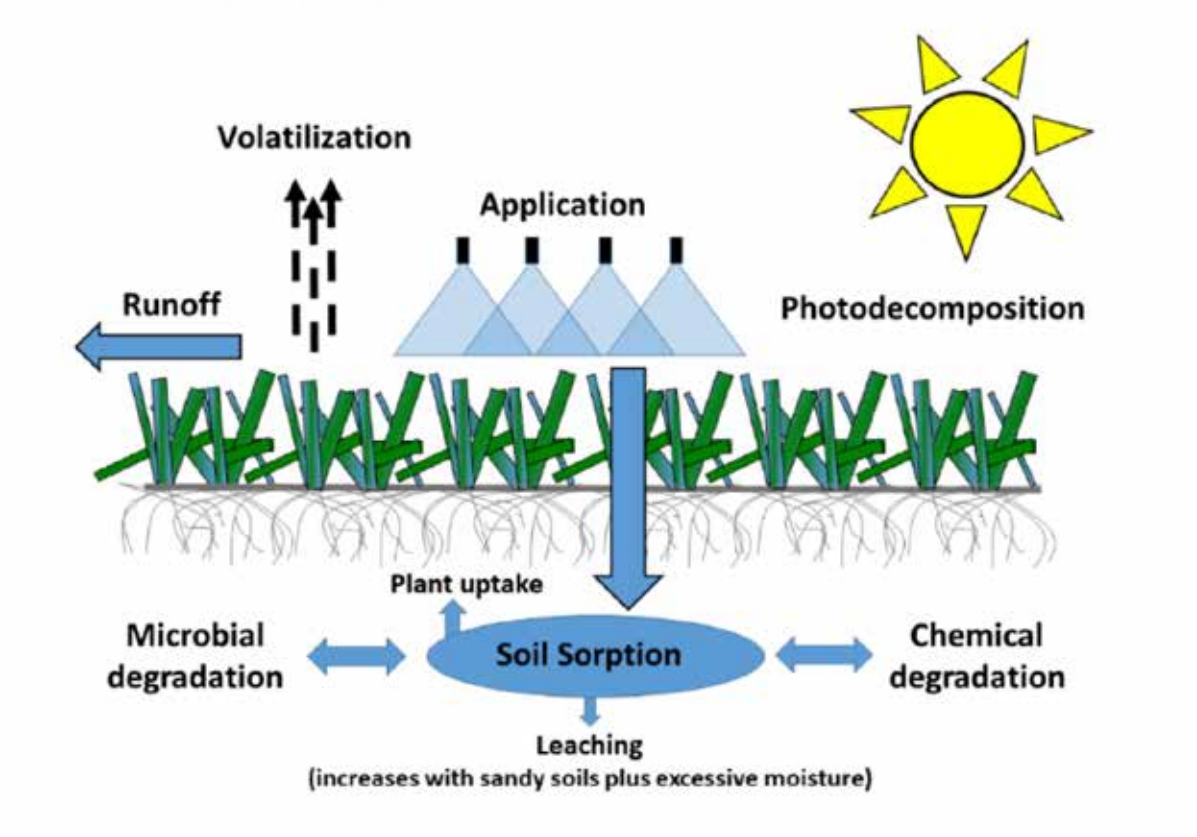
- Select the least toxic pesticide with the lowest exposure potential. Visit the EIQ, Environmental Impact Quotient. https://nysipm.cornell.edu/eiq/
- Use Reduced Risk Pesticides when appropriate
- Wear PPE required by the pesticide label
- Restrict staff and golfer entry to pesticide treated areas for at least one hour following application; follow re-entry restrictions listed on label requirements. If restrictions are not listed on the pesticide label, wait until sprays have dried and dusts have settled, at least one hour
- Irrigate pesticides targeting soilborne pests following application to reduce exposure to foliar residues and assure that the pesticide reaches the target
- Know the first aid and emergency response procedures for the product being used prior to starting in case excessive exposure occurs

ENVIRONMENTAL FATE AND TRANSPORT

Pesticides applied to any environment have the potential to interact with wildlife or migrate into surface and subsurface waters. Environmental implications of a pesticide can often be determined by the environmental hazards statement found on pesticide product labels. The "Environmental Hazards" are found under the general heading "Precautionary Statements," which provides language advising the user of the potential hazards to the environment and off target organisms – found under three headings: general environmental hazards, non-target toxicity, and endangered species protection.

Best Management Practices

- Select pesticides that have a low drift, runoff, and leaching potential; labels provide warnings about these potential issues with each product
- 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.)
- Select pesticides with reduced impact on pollinators.
- Select pesticides that, when applied according to the label, have no known effect on endangered species present on the facility.



Sources of Pesticide Degradation and Loss in the Environment
Reproduced from Fundamentals of Turfgrass and Agricultural Chemistry. McCarty et al., 2003.

PESTICIDE STORAGE AND HANDLING

Follow all labels – improper storage constitutes misuse of pesticide. Storage and handling of pesticides in their concentrated form poses the greatest potential risk the applicator and environment. For this reason, storage facilities must be properly sited, designed, constructed, and operated. Storage facilities should facilitate the secure, dry, and in some cases temperature-controlled storage of pesticides; provide safe working conditions for personnel with easy access to PPE; and provide secondary containment of incidental spills due to normal mixing/loading practices and secondary containment of large accidental spills and be ventilated. PPE should never be stored in the pesticide storage area. Fire extinguishers suitable for chemical fires should be readily available. Store herbicides away from other pesticides, many herbicides volatilize or off-gas and can contaminate other products.

Storage areas should be located to minimize risk to human health and the environment associated with potential spills, contaminated runoff, or fire. The location should be easily accessible to service vehicles in case of an emergency. Pesticide storage facilities should be at least 400 feet downhill from drinking water supplies and 200 feet from surface water. They should not be placed within a 100-year floodplain, and storm runoff should be diverted around them. Pesticide storage should always be locked and have signage indicating, Danger, Keep Out, Chemical Hazards, or similar. The local fire department should be informed about the storage unit, what it contains, and where it is located.

Best Management Practices

- Store, mix, and load pesticides away from sites that directly link to surface water or groundwater.
- Whenever possible, 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.
- Powders should never be stored below liquids
- 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.
- Light and fan switches should be located outside the building, so that both can be turned on before employees enter the building and can be turned off after they leave the building.
- Avoid temperatures less than 40°F or greater than 100°F inside the pesticide storage facility.
- Personal protective equipment should be easily accessible and stored immediately outside the pesticide storage area.
- Place a spill containment kit and fire extinguisher in the storage area, in the mix/load area, and on the spray rig.

PESTICIDE INVENTORY & STORAGE

Pesticides degrade over time. Do not store large quantities of pesticides for long periods, only mix the amount you plan on using. Adopt the "first in–first out" principle, using the oldest products first to ensure that the product shelf life does not expire. When bringing in new product, date the labels to be able to identify the oldest in inventory. Avoid storing pesticides more than two years old and make sure temperatures do not exceed 100° F or drop below 40° F at any time. Utilize computer software systems to record inventory and use. Safety Data Sheets (SDS) and copies of labels for all pesticides on hand should be kept in an easily identifiable location, outside the pesticide storage facility.

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 are on every package and container.
- Arrange containers so the labels are clearly visible. Securely fasten loose labels to ensure containers and associated labels are kept together.
- Damaged labels should be replaced immediately.
- Store flammable pesticides separate from those that are nonflammable.
- Store liquid materials below dry materials to prevent leaks from contaminating dry products.
- Ensure that oil containers and small fuel containers (service containers) are properly labeled and stored within the facility
- Date containers when they are received to inform rotations
- Keep a separate notebook with copies labels and SDS sheets outside of the storage area in an office.
- Consult inventory when planning and before making purchases.
- Have inventory easily acceptable for review in case of fire to help containment issues.
- Control temperature to avoid extreme hot or cold.

PESTICIDE MIXING/WASHING

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).

Handling open pesticide containers, measuring pesticide materials, or working with pesticide application equipment presents an exposure risk to the handlers and the environment. Applicators and handlers must put on label-required PPE prior to opening pesticide packages. Consider using closed systems when available.

Best Management Practices

- Loading pesticides and mixing them with water or oil diluents should be done over an impermeable surface, so that spills can be collected and managed.
- The mixing station surface should offer 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 be removed from the sump and properly managed and disposed of.
- Apply liquids and sediments from the sump as you would a pesticide, strictly following label instructions.
- Sweep up solid materials and use as intended.
- 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. Caution: do not mix herbicide rinsate with other products.

PERSONAL PROTECTIVE EQUIPMENT

Based on exposure, pesticide handlers and applicators are at the greatest risk for potential adverse health effects. Exposure to pesticides can be mitigated by practicing good work habits and adopting modern pesticide mix/load equipment (e.g., closed-system loading) that reduce potential exposure. PPE statements on pesticide labels provide the applicator with important information about protection. Handling concentrated pesticide products has the greatest potential for exposure as an applicator.

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.
- Always use appropriate PPE where pesticide residues may be present.
- Ensure that PPE meets rigorous testing standards and is not just the least expensive.
- Store PPE where it is easily accessible but not in the pesticide storage area.
- Forbid employees who apply pesticides from wearing facility uniforms home where they may come into contact with children.
- Provide laundering facilities or uniform service for employee uniforms.
- The federal Occupational Safety and Health Administration (OSHA) requires employers to fit-test workers annually who must wear tight-fitting respirators.
- Meet requirements for OSHA 1910.134 Respiratory Protection Program: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=12716&p_table=standards

Worker Pesticide Safety: PPE Respirators

When a respirator is required by pesticide product labeling, the correct respirator specified by the label must be used. Prior to using a respirator, the employer must provide the handler with the following:

- Medical evaluation
- Annual fit testing
- Annual respirator training

The handler employer must keep records of medical determinations (proof of medical evaluations), fit testing, and respirator training for two years from the date conducted.

References for additional information:

https://www.epa.gov/pesticide-worker-safety/personal-protective-equipment-pesticide-handlers

https://www.epa.gov/pesticide-worker-safety/pesticide-worker-protection-standard-how-comply-manual

https://www.osha.gov/Publications/3384small-entity-for-respiratory-protection-standard-rev.pdf

PESTICIDE CONTAINER MANAGEMENT

The containers of some commonly used pesticides are classified as hazardous waste 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 high fines and/or criminal penalties. However, pesticide containers that have been properly rinsed can be handled and disposed of as nonhazardous solid waste.

Best Management Practices

- Refer to the label for disposal requirements
- Rinse pesticide containers immediately in order to remove the most residue; determine proper management and disposal of residue in accordance with label instructions.
- Rinse containers during the mixing and loading process and add rinsate water to the finished spray mix.
- Rinse emptied pesticide containers by either triple rinsing or pressure rinsing.
- Puncture empty, rinsed pesticide containers and dispose of them according to the label.

EMERGENCY PREPAREDNESS AND SPILL RESPONSE

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

An emergency response plan containing actions to take and personnel to contact in the event of a spill or accident should be in place. The plan should include the following information:

- Names and quantities of pesticides in inventory.
- Location of property, including a map and directions (to relay over phone in emergency).
- Names, addresses, and phone numbers of the designated spokesperson, superintendent, and key employees.
- Plan of facility showing pesticide storage locations, flammable materials, electrical service, water supply, fuel storage tanks, fire hydrants, storm drains, and nearby wetlands, ponds, or streams.
- Location of emergency equipment supplies.
- Contact information for fire, police, hospital, pesticide bureau, spill clean-up firm, board of health, and facility owner.

Ensure that copies of the plan are located near the pesticide storage facility and the office and distributed to local police and fire departments. Maintain copies in English and any other language commonly used by employees. Be sure to update the information regularly for local police and fire departments.

Best Management Practices

- Develop a golf course facility emergency response plan that includes procedures to control, contain, collect, and store spilled materials.
- An inventory of the pesticides kept in the storage building and the SDS for the chemicals used in the operation should be accessible on the premises, but not kept in the pesticide storage room itself.
- Prominently post “Important Telephone Numbers” including CHEMTREC, for emergency information on hazards or actions to take in the event of a spill.
- Poison Control Center 1-800-222-1222
- DEEP 24-hour Emergency spill reporting (860) 424-3338 www.deep.pesticideprogram@ct.gov
- Ensure an adequately sized spill containment kit is readily available.
- Designate a spokesperson who will speak on behalf of the facility should an emergency occur.

Safety First! Through Community Engagement

Host a tour for local emergency response teams (for example, fire fighters, etc.) to show them the facilities and discuss the emergency response plan. Or at a minimum, inform them of bulk storage of pesticides and provide the emergency response plan, including a map of the facility with the storage location noted. Seek advice on ways to improve the plan.

SPRAYERS, NOZZLES, AND CALIBRATION

Various types and sizes of application equipment are readily available. The size of the equipment (tank size, boom width, etc.) should match the scale of the target area. Larger ride-on sprayers are more efficient for large areas, while small walk-behind boom sprayers are well suited for smaller areas. Smaller boom lengths may increase the accuracy of applications, minimizing overspray on non-target areas. Individual nozzle control on global positioning system (GPS) assisted boom sprayers can further minimize overspray of non-target areas and has resulted in 25 percent less pesticide applied at some golf courses (USGA Green Section, 2016).

Properly calibrated application equipment is paramount to mitigating environmental and human health concerns. Sprayer output is dependent on several variables (e.g., speed, nozzle size, pressure). Spray coverage is often reduced at greater application speeds, regardless of nozzle size. To maximize efficacy of pesticide applications, applicators should consider optimization of spray coverage versus efficiency of labor when choosing spray speeds.

Best Management Practices

- Use an appropriately sized applicator for the size of area being treated.
- Equipment too large in size requires greater volumes to prime the system. This can result in significant waste that must be properly managed and disposed of.
- Use wide-angle, air-induction, flat-fan nozzles to minimize spray drift to non-target areas.
- Ensure that the spray technician is experienced, licensed with a supervisor on site, and properly trained.
- Minimize off-target movement of pesticides by using properly configured application equipment.
- Properly calibrate all application equipment at the beginning of each season (at a minimum) and after equipment modifications.
- Check equipment daily when in use.
- Use recommended spray volumes for the targeted pest to maximize efficacy.
- Calibration of walk-behind applicators should be conducted for each person making the application to take into consideration their walking speed and other variables.

PESTICIDE RECORD KEEPING

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

Best Management Practices

- Keep and maintain records of all pesticides used to meet legal (federal, state, and local) reporting requirements. https://portal.ct.gov/-/media/DEEP/pesticides/Certification/Supervisor/Statsandregspdf.pdf
- www.portal.ct.gov to pay the $250 Golf Course Annual Fee.
- https://portal.ct.gov/DEEP/Pesticides/Pesticide-Management-Program; annual fee for golf courses which have a course length of greater than 1,000 yards. This fee must be paid to the Department of Energy and Environmental Protection no later than December 31 of each year.
- Visit State of Connecticut website and have a minimum of one certified supervisor and one operator for applications. $200 fee required.
- Use records to monitor pest control efforts and to plan future management actions.
- Use electronic or hard-copy forms and software tools to track pesticide inventory and use.
- Keep a backup set of records in a safe but separate storage area.

Pesticide Supervisor and Applicator Examinations

Process and Requirements:

https://portal.ct.gov/DEEP/Pesticides/Supervisor-Certification/Certification-Process-and-Requirements-for-Supervisors

Supervisor Category Explanation: https://portal.ct.gov/-/media/DEEP/pesticides/Certification/Supervisor/Catinfopdf.pdf

Name of Exam	Exam Categories
Agricultural Pest Control	1A: Plant
Aquatic Pest Control	5: Aquatic Pest Control
Custom Ground Pest Control	• 3A: Ornamental and Turf • 3B: Golf Course Superintendent • 3C: Interior Plantscape • 3D: Arborist
Demonstration and Research	10: Demonstration & Research
Forest Pest Control	2: Forest Pest Control

Industrial, Institutional and Structural Pest Control	• 7A: General Pest Control
	• 7B: Termite and Wood Destroying Organisms
	• 7C: Fumigation
	  ◦ 7Ci: Structural
	  ◦ 7Cii: Soil
	  ◦ 7Ciii: Pipe
	• 7D: Rodent Control
	• 7E: Bird Control
	• 7F: Mosquitoes and Biting Flies
	• 7G: Wood Preservation
	• 7I: Cooling Tower

Public Health	8: Public Health (governmental only)
Regulatory Pest Control	9: Regulatory (governmental only)
Rights of Way	6: Right of Way

Source: www.portal.ct.gov

PROPER MAINTENANCE OPERATIONS HELP *provide a save and enjoyable work environment*

Proper maintenance facility design and operations helps provide a safe and enjoyable work environment for golf maintenance crews, in addition to golfers and onsite visitors.

REGULATORY CONSIDERATIONS

Local and regional regulations may be in place by municipality or county. Consult the proper regulatory officials to determine any concerns.

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 fines, cleanup costs, and civil lawsuits if these chemicals are not managed properly.

Emergency Contact Numbers

Poison Control Center 1-800-222-1222

DEEP 24-hour Emergency Spill Reporting
(860) 424-3338
www.deep.pesticideprogram@ct.gov

Maintenance operations BMPs help promote environmental stewardship through waste management, disposal, and conservation measures.

STORAGE AREAS

Chemical Storage

Store pesticides in an IPM Control Center; a lockable concrete or metal building. Store pesticides according to label requirements and away from fertilizer storage facilities.

The floor of the building should be impervious in case of accidental spills or releases. Locate the pesticide storage away from other buildings, especially fertilizer storage facilities.

If the fertilizer storage building is metal, then steps should be taken to protect the metal building from degradation by fertilizer (such as adding painted plywood around the walls). The use of a dehumidifier would be beneficial in protecting the fertilizer from water absorption. The building should be large enough to allow a small forklift to deliver fertilizer by pallet.

Best Management Practices

- Storage buildings should have appropriate warning signs and placards.
- Follow all PPE statements on pesticide labels.
- Store PPE away from pesticide storage areas in an area that is easily accessible.
- Develop an emergency response plan and educate all golf course personnel regarding emergency procedures on a regular basis.
- Individuals conducting emergency chemical cleanups should be properly trained under requirements of federal Occupational Safety and Health Administration (OSHA).
- Floors of chemical storage buildings should be impervious and sealed with chemical-resistant paint.
- Floors of chemical storage buildings should have a continuous sill to contain spills and should not have a drain. A sump is acceptable.
- Shelving should be fabricated from plastic or reinforced metal. Metal shelving should be painted to avoid corrosion. Wood shelving should never be used because of its ability to absorb spilled pesticides.
- 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. 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 in containers that might be mistaken as packaging for food or drink.
- Arrange containers so the labels are clearly visible. Securely fasten loose labels to ensure containers and associated labels are kept together.
- Damaged labels should be replaced immediately.
- Store flammable pesticides separate from those that are nonflammable.
- Store liquid materials below dry materials to prevent leaks from contaminating dry products.
- Ensure that oil containers and small fuel containers (service containers) are properly labeled and stored within the facility

Reference the Pesticide Management Section for additional pesticide storage BMPs.

Soil Storage

The soil storage area should have a roof and could be located in proximity to the fertilizer storage area. Deliveries may be deposited outside the storage bins and then pushed into the bin with a front-end loader.

Keep the area covered to prevent rain or moisture from reaching the material and wind from dispersing weed seeds into topdressing. Block walls that separate sand, topdressing, and rock should be filled solid with concrete. Ceiling fans could be installed to reduce moisture retention.

Equipment Maintenance & Storage

Equipment storage and maintenance facilities should be designed to prevent the accidental discharge of chemicals, fuels, or contaminated wash water from reaching water sources. Properly storing and maintaining equipment also extends the useful life of machines and reduce repairs.

Each piece of equipment should have a designated spot, delineated with colored lines, and indicated with its name or number and should be parked in the same spot every day. Proper location provides for identification of equipment if it develops a leak (oil, hydraulics, etc.) and increases accountability for maintaining optimal operating condition.

The facility logistics planning should allow for all equipment to be moved in and out of the storage area without having to relocate other equipment. Overhead doors located on both sides of the equipment storage area would allow for ease in moving equipment entering and leaving the building and providing air flow. Overhead fans in the equipment storage area facilitate air flow, in addition to reducing moisture on equipment.

Used oil from equipment should be properly managed and disposed of; including collection and storage in a container set on containment. Used oil should be analyzed as necessary to determine whether or not it is a hazardous waste

Reference DEEP for additional information: https://portal.ct.gov/DEEP/Waste-Management-and-Disposal/Management-of-Used-Oil

Best Management Practices

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

Equipment Washing

Equipment washing should be conducted under controlled conditions in an appropriate contained area with minimal risk to the environment to prevent adverse wash water runoff impacts whenever possible. Equipment washing guidelines and restrictions should be established that reduce the potential for pollutants to reach surface water, or groundwater.

Proper cleaning of equipment helps prevent residues from reaching surface waters, groundwater, drainage pipes, or storm sewers. The residues from washing equipment include grass clippings, soil, soap, oil, fertilizer, and pesticide.

A primary concern when washing mowing equipment is the nitrogen and phosphorus nutrients in grass clippings. Using compressed air to blow clippings off mowers before washing can help reduce the amount of nutrients that enter drains via wash water. The best practice is to have a dedicated wash area with a catch basin to collect remaining grass clippings. Clippings can be collected, then composted or removed to a designated debris area. When formal washing areas are not available, a "dog leash" system using a short, portable hose to wash off the grass at random locations, away from surface waters, wells, or storm drains, is an option.

For equipment with possible pesticide residue, BMPs should be followed to ensure that wash water does not become a pollution source. Captured wash water can be used as a dilute pesticide per label, or it may be pumped into a rinsate storage tank for use in the next application and used as a dilute pesticide per the label.

Best Management Practices

- Brush or blow off accumulated grass clippings from equipment using compressed air before washing.
- Wash equipment on a concrete pad or asphalt pad that collects the water. After the collected material dries, collect and dispose of it properly.
- Washing areas for equipment not contaminated with pesticide residues should drain into oil/water separators before draining into sanitary sewers or holding tanks.
- Do not wash pesticide-application equipment on pads with oil/water separators. Do not wash near wells, surface water, or storm drains.
- Use spring-loaded spray nozzles to reduce water usage during washing.
- Minimize the use of detergents. Use only biodegradable, non-phosphate detergents.
- Use non-containment wash water for irrigation.
- Do not discharge non-contaminated wastewater during or immediately after a rainstorm, since the added flow may exceed the permitted storage volume of the storm water system.
- Do not discharge wash water to surface water, groundwater, or susceptible/leachable soils either directly or indirectly through ditches, storm drains, or canals.
- Never discharge to a sanitary sewer system without written approval from the appropriate entity and ensuring appropriate permits have been obtained.
- Never discharge to a septic tank.
- Do not wash equipment on a pesticide mixing and loading pad. This keeps grass clippings and other debris from becoming contaminated with pesticides.
- Solvents and degreasers should be used over a collection basin or pad that collects all used material.

WASTE HANDLING

Facilities must properly dispose of waste. A golf course maintenance facility generates numerous kinds of waste. Fluorescent or LED lights, glass containers, plastic, tires, metal, paper products, solvents, chemical containers, batteries, used oils, used or contaminated fuel, paints, aluminum cans, and wood. It is imperative that a proper recycling and waste removal program is installed to minimize the quantity of waste reaching landfills and to comply with Connecticut's recycling laws. Reference for DEEP recycling information, including items designated and mandated for recycling: https://portal.ct.gov/DEEP/Reduce-Reuse-Recycle/Recycling-Its-the-Law

Waste generated from pesticide activities must be disposed according to label instructions and is discussed more in detail in the "Pesticide Management" section.

Best Management Practices

- Label all containers for the purpose of storing oils, solvents, degreasers, and fuels.
- Maintain tally of all hazardous wastes generated so that the facility can handle the wastes properly depending on their generator status (CESQG, SQG or LQG).
- Have separate areas designated and labeled for recyclables and waste.
- Consult an expert in composting and recycling for optimal design and processes.

Waste Disposal Area

This area should be located away from normal employee activity, but close enough to be reasonably functional. Proper access for waste pick-up vehicles should be considered and a spill kit is recommended to address any spills that may occur.

Paper, Plastic, Glass, Aluminum Recycling

Office paper, recyclable plastics, glass, and aluminum must be recycled since these are among the list of Connecticut's designated recyclable items (reference list at https://portal.ct.gov/DEEP/Reduce-Reuse-Recycle/Recycling-Its-the-Law). Place containers for recycling aluminum cans and glass or plastic soft drink bottles at convenient locations on the golf course.

Composting

Composting can reduce the amount of grass clippings and debris, such as leaves, or routine, healthy landscape trimmings that would normally go to a landfill. Composted materials can be used effectively to improve the soil for topdressing, non-putting surface areas, and donated or sold to offsite vendors.

Fuel Facilities

Fueling facilities should be designed, constructed, maintained and monitored to local or state codes. Check codes for regulations on storage tanks; aboveground storage tanks (AST) is the preferred storage method because it is easier to monitor for leakage. An underground storage tank (UST) must have leak detection monitoring for compliance. Leaks or spills must be contained or cleaned up immediately.

Proper fueling sites have impervious surfaces, spill containment and recovery facilities, located away from surface waters and water wells. Floor drains should be eliminated or removed unless they drain to containment storage tanks or pits.

Best Management Practices

- Located on impervious surfaces under roofed areas whenever possible.
- Fueling areas should have spill containment and recovery facilities located nearby.
- A record keeping log of fuel added and discharged.
- Visually inspect the tank for leaks and documented in an inspection log.
- Have automatic shut off valves located away from pumps in case of emergency.
- Post "No Smoking" signs near the fueling facility.
- Properly and clearly label fuel storage tanks.

Connecticut's Recycling Laws

Contracting for waste & recycling services

To comply with Connecticut's recycling laws, ensure that a contract between the facility and its waste hauler for the collection of solid waste (i.e. trash) also includes a provision for collection of designated recyclable (i.e. mandatory) items – either by the same collector or by a different collector as identified by the golf course. In addition, ensure each collector provides clear instructions on how to separate designated recyclable items.

References for recycling laws and designated recyclable items:

https://portal.ct.gov/DEEP/Reduce-Reuse-Recycle/Recycling-Its-the-Law

https://portal.ct.gov/DEEP/Reduce-Reuse-Recycle/Recycling-Laws---Annotated-List#designated

DEEP Storage Permitting Requirements and Regulations

https://portal.ct.gov/DEEP/Search-Results?SearchKeyword=fuel%20storage

Additional permitting requirements

https://portal.ct.gov/DEEP/Permits-and-Licenses/Permitting-Factsheets/List-of-General-Permits-Fact-Sheet#Waste

MAINTENANCE FACILITY

Maintenance facilities accommodate needs such as lunch or break rooms for staff, equipment and supplies storage, and mechanics areas. All areas should be properly ventilated and well-lit. Numerous activities should be considered to help contribute to water, energy, and cost reductions:

- Restrict water flow to the maximum necessary for adequate use
- Use automatic shutoffs on faucets
- Install 1.5-gallon tanks on toilets
- Use motion detectors to turn on lights when staff is present

Employee Restroom/Locker Room/ Shower

Design restrooms to promote superior personal hygiene, ensuring they are easy to clean with adequate space/ amenities to service several employees simultaneously. The locker room should be immediately adjacent to the restrooms and incorporate full-length lockers with at least one shower. A semi-gloss, high quality paint should be used for ease of cleaning.

A dry deck type material can be used on portions of the floor to prevent slippage and spread of bacteria. Both of these rooms should be insulated and air conditioned. Hand blowers should be used instead of paper towels.

Source: Hawai'i Golf Course Maintenance Handbook of Best Management Practices

Employee Break Room and Training Area

Maintenance facilities should include an employee lunch/break room, which can also serve as a professional training area for technical seminars. The area should promote a clean, organized, and relaxed atmosphere. The size of the golf course operation and number of employees on the maintenance crew will determine the appropriate size of the lunchroom. There should also be adequate space for administrative and managerial offices. Important items to include:

- Adequate tables/chairs for dining and training
- One to five microwave ovens (reduces time for meal preparation)
- One to two adequately-sized (energy saver) refrigerators
- Drinking water with dispenser, coffeemaker, refreshment vending machine
- Kitchen area with sink, water, sufficient cabinet area
- Adequate space and organization, including light, easy-to-clean colors/walls, plus labeled containers for storage and kitchen utensils
- Bins to collect mandatory recyclables (such as plastic or glass drink containers)
- Erasable or electronic communication board
- Air conditioned and insulated, with overhead fans for air flow

Mechanics Workshop and Office

Equipment is serviced and repaired in the mechanics workshop – it must be designed with adequate space for oil changes, reel grinding, and other jobs. An assortment of lifts (portable, flush floor mounted and beam supported) should be utilized to assist with moving equipment and minimizing risk of injury.

An overhead lube center (grease/oil dispensers supported by compressed air and connected to bulk drums) reduced the need for floor space and stores large drums out of the general view and work area. Necessities such as empty gas cans, towels and miscellaneous supplies can be stored in cabinets throughout the shop. Ensure all combustible products are stored in fire resistant cabinets. All wastes should be subjected to a waste determination and all hazardous wastes should be properly managed and disposed of.

Large work benches provide ease for working at waist level and can decrease risk of back injury. Large benches can also be fitted with underneath storage. An air-conditioned office with desk, computer, files, phone, and storage should be adjoining; a shatter-proof window facing the shop area would allow the mechanic a full view of the shop from the office. Lastly, a sink and hand dryer should be available in the shop.

Golf Course/ Workplace Safety

Golf courses are intensely managed landscapes with many staff members working onsite daily, along with daily golfers present and playing throughout the course. This level of activity creates the possibilities for injuries to occur and a necessity for various programs to assure safety while working or playing on a golf course property.

While golfers have the responsibility to safely drive their golf cart and avoid injuring other golfers with their clubs and golf balls, the management of each course is usually responsible for keeping them safe from lightning strikes by installing a lightning detection system. Those systems detect lightning strikes at a designated distance from the course (usually 5 miles). They include a siren which alerts players of approaching storms via a loud horn. It is mandatory that golfers cease play and seek shelter when the alarm sounds. A different tone indicates when it is safe to resume play on the course.

Best Management Practices

- Install an automatic warning system to alert golfers of approaching lightning storms.
- Hire a professional to conduct a facility-wide safety evaluation.
- Invite insurance company representative to help identify workplace hazards at the facility.
- Be familiar with OSHA safety requirements.
- Set up a regular schedule for safety training with staff.
- Regularly discuss PPE usage and maintain a supply for staff.
- Provide training for key staff in CPR and first aid protocols.
- Develop an emergency response plan.
- Establish a hazardous communication program (SDS sheets).
- Schedule safety training programs and mock drills.
- Install emergency wireless call boxes around the golf course.
- Set up a first aid supply area with an Automatic External Defibrillator (AED) and notify all staff of its storage location.
- Interface with local EMS.
- Acquire videos or written overviews of safety issues for staff training.
- Important topics for safety training include workplace safety and emergency response; hearing and eye safety; safe operation of mowers; back safety and lifting; fire prevention; utility vehicle safety; heat stress; sun protection; hazard communication; slips, trips and falls; chainsaw safety; blood-born pathogen guidelines; etc.

ENERGY CONSERVATION IS *an important initiative in Connecticut*

Energy conservation is an important initiative in Connecticut with Energize Connecticut leading the way. More information, along with programs for rebates and incentives are located at https://www.energizect.com/your-business/find-a-solution?hometype=95&areaofinterest=169,211.

The GCSAA Golf Course Environmental Profile, Phase II, Vol. V (GCSAA 2017), estimates that turf maintenance accounts for 47 percent of energy use at a golf facility, with total facility uses encompassing clubhouses, swimming pools, tennis courts, and various other operations. The study identifies six major energy sources for golf course use: electricity, gasoline, diesel, natural gas, propane, and heating oil. The most common in Connecticut is heating oil at 45 percent or natural gas at 35 percent. Solar is one option in Connecticut which would allow for utilization of heat pumps. on a per capita basis Connecticut is the sixth lowest energy consuming state in the nation. www.eia.gov

Connecticut superintendents can work toward achieving energy reductions through implementing BMPs which drive behaviors and processes, improve product efficiencies, encourage optimal design, support innovative solutions, and promote education.

Lower energy consumption can generate efficiencies and cost savings up to 25 percent. Reductions in energy use and facility costs support stewardship and sustainable actions that will help create a better atmosphere for residents and visitors.

Best Management Practices

- Measure annual energy use for electricity, natural gas, gasoline, and diesel; propane, and heating oil input data from monthly utility statements utilizing 2 years of data.
- Set baseline year to track improvements and future reductions; determine carbon footprint when practicable
- Analyze data to identify efficiencies, prioritize reduction targets and set attainable goals; monitor metrics regularly to confirm compliance.
- Share data with entire operation to ensure success and to identify other areas that need improvement.
- Prioritize opportunities and establish steps to implement initiatives, identify resources, projected energy and cost savings; incorporate all stake holders to increase ownership.
- Establish and communicate position statement and energy policy; relate to guests, members, community
- Audit and replace lighting and irrigation component use to identify efficiency opportunities www.energizect.com
- Identify opportunities for product rebates and incentives with local supplier www.eversource.com
- Ensure efficient operation and maintenance of pump station, irrigation pumps, controls, components. Utilize manufacturer data to fine tune specifications and optimize conservation.
- Incorporate energy efficiency and conservation measures into location, design, construction; collaborate with stakeholders to prioritize energy conservation.
- Communicate with utility provider, insurance company, regulatory officials. www.eversource.com www.portal.ct.gov
- Follow diligently State regulations, use guidelines from U.S. Green Building Council (LEED certification program)
- Educate, train, motivate employees on energy efficiency practices

DATA ANALYSIS

It is important to understand consumption in order to follow through with a plan that can benefit the facility and the environment. To understand consumption the facility should be audited professionally or collect and review several years of actual consumption from utility statements and receipts. Data should be incorporated into a baseline to measure going forward. When practicable, conduct a carbon footprint analysis using total energy consumption to determine emissions, consult an expert if needed.

Install meters and gauges and ensure they are operating properly on property. Because of demands and power requirements for the pump station Eversource will set up a separate power supply that will be monitored and billed separately. Pump stations account for the largest draw on properties and tracking this way increases efficiency. When practicable, segregate data on meters by area including maintenance buildings, clubhouse, tennis facilities, pools, or additional amenities for optimal monitoring and control.

Energy Use Conversion Factor:

To understand aggregate energy used on a golf course for electricity, natural gas, gasoline, diesel, propane, and heating oil, a conversion factor to BTU for each energy input may be used. (reference chart footnote 12 GCSAA 2017* US Department of Energy)

ANALYZING DATA & SETTING ENERGY REDUCTION GOALS

Look at consumption metrics by month, area, day of week, and time of day. Factors to consider during analysis year-over-year, by month, or quarterly include:

- Electricity utilization during peak hours 8 a.m. to 8 p.m.
- Demand for air conditioning is low during spring and fall due to normally mild temps
- Events and seasonality result in switches from heating oil to electricity
- Faulty or damaged equipment

Look for trends or spikes that could dictate problems. Tracking these numbers will allow for a quicker response in repairs.

Equipment maintenance does impact energy use and needs to be considered when analyzing data. Equipment maintenance and replacement schedules have to be considered along with reviewing what energy is used (e.g., switching to hybrid diesel-electric fairway mowers vs. hydraulic diesel motors may change energy use composition). Equipment inventory should be conducted on a regular basis; logging date of first use, total energy used, issues, and total operational hours. This will help with future capital acquisitions.

Energy Use Intensity:

Energy use intensity, or EUI, expresses a building's energy use as a function of its size or other characteristics. It's calculated by dividing the total energy consumed by the building in one year (measured in kBtu or GJ) by the total gross floor area of the building. A low EUI signifies good energy performance. EUI helps to benchmark and gauge the effect of renovations and expansion within clubhouses or other built environments. Example benchmarks and conversion data may be found at www.energystar.gov.

After establishing priorities, determine annual goals for energy use versus prior year. Goals for energy conservation could encompass initiatives related to infrastructure, equipment, behavior, processes, and agronomic practices. Aim for SMART goals which are Specific, Measurable, Attainable, Relevant, and Timely. Share goals with employees at monthly meetings and post them in a clearly visible area

MONITORING, TRACKING, AND COMMUNICATION

Establish a tracking mechanism to monitor energy use regularly. At a minimum, create a spreadsheet detailing units of measurement, energy used by day, month, meter or department, rates, weather, and energy conversion factors. There are tools and software services available for tracking, such as Energy Star. If feasible, particularly at resort facilities, consider energy management software which can provide robust data and controls, incorporating intelligent building automation systems and monitoring. Calculate savings achieved through energy reductions to track progress and support energy efficient capital investments.

Analyze data weekly or monthly to confirm progress toward goal attainment and note inefficiencies, spikes, or issues. Establish performance parameters to optimize irrigation pumps. Communicate results with employees on a weekly basis and post signage showing monthly progress to goal attainment to encourage teamwork and innovation, address opportunity areas, and reward successes. Consider scorecards and/or benchmarking performance between departments, or against similar-sized facilities.

BEHAVIOR

An energy management plan (EMP) moves priorities forward by aligning stakeholders around common goals. It creates structure, accountability, and a timeline. It is a continuous improvement process centered around the concept of "Plan-Do-Check-Act" which incorporates a roadmap, implementation, monitoring, and adjustments. The goals of an EMP often intersect with other BMPs, increasing impact across areas. For example, an effective preventive maintenance program can improve equipment efficiency and reliability. Irrigation efficiencies, leak detection, and monitoring can improve energy performance. Conversely, energy management practices can help lower maintenance, increase equipment life, and lower emissions.

Recommendations for energy efficiency opportunities come from a variety of sources, including reference materials, industry success stories, staff, consultants, or energy providers. Include relevant stakeholders and key management 'champions' as part of the energy management team. This includes employees responsible for a specific job or task, managers, and departments influential in decision-making or processes. Effective engagement of stakeholders and champions will drive efficiencies, reduce bottlenecks, and positively impact departments.

WHAT TO INCLUDE IN EMP: PRIORITIZING, DETERMINING STEPS, ASSIGNING TASKS

Focus efforts by choosing the top three to five energy conservation opportunities based on analysis or energy audit.

Infrastructure updates, equipment replacement, behavioral changes and agronomic practices can all be priority initiatives completed by each facility. Benefits should be considered with long- and short-term costs to properly designate priority initiatives by energy source (electricity, fuel, etc.)

- Establish steps to implement by identifying:
- Departments involved
- Projected energy reductions
- Estimated cost savings
- Timeframe

Accountability and teamwork can be maximized when all task owners have priorities aligned.

IMPLEMENTATION

Tie EMP progress to overall energy reduction goals. Communication and engagement should happen on several levels.

- Engage energy management team weekly and/or monthly to review progress
- Engage leadership team regularly to provide updates to support investment decisions and show progress
- Communicate with all staff regularly, including updates to employees within stakeholders' departments
- Share EMP conservation highlights and achievements with members and guests

POLICY AND PERFORMANCE GUIDELINES

Employees and guests should be able to recognize that energy conservation is a priority within the operation. Behavior changes will have to take place and will take time. The facility should have a commitment to following a set standard on energy conservation.

The turf department should include goals around irrigation systems, pump stations, landscaping and the broader framework of the operation.

Energy Management Tip!

Create a checklist of energy reduction behavioral best management practices for the clubhouse, golf maintenance facility, and other buildings on property. This can be used as a self-audit and guide toward continuous improvement.

BEHAVIORAL PRACTICES: LIGHTING, HVAC, IRRIGATION/WATER, AND EQUIPMENT

Heating, ventilating, air conditioning (HVAC) may account for 40 to 50 percent of total electricity usage for a building (e.g., clubhouse). Lighting may account for more than 20 percent of total electricity used in a building. Hot water within facilities is used for showers, hand-washing, and restaurant operations. Miscellaneous equipment, such as office equipment, can represent more than 20 percent of electricity used in a building.

Turning off devices and administering a regular maintenance program will help lower electricity expenses. Keeping mechanical systems clean improves HVAC efficiency by 10 to 20 percent.

The pump station is the largest user of energy during the summer months for golf course maintenance. The pump station should be professionally engineered with monitoring devices to show abnormal flow, increased pressure or substantial gallon variances from central computer. To minimize power consumption and protect the pipes in ground the pumps should be VFD. Power surges will happen due to demand and the system should be engineered to allow a variance and keep operating. The actual field heads should be audited annually (at a minimum) to show discrepancies and fine-tune efficiency.

Irrigation should be scheduled during off peak hours if possible. Newer systems have remote monitoring of pumps and flow to identify problems before they escalate.

For new equipment purchases throughout the club, consider programs like Energy Star or the EPA's WaterSense program for product labeling to identify products with high energy efficiency. Newer equipment purchases will come with rebates and www.energizect.com should be visited to maximize savings.

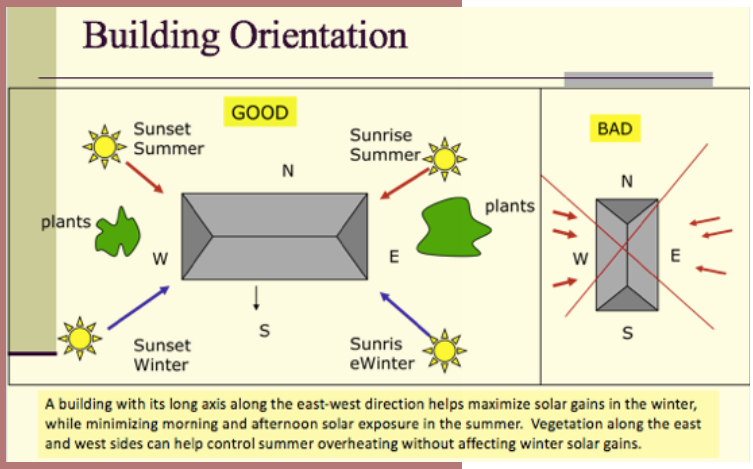
Golf Club Energy Reduction Best Management Practices Behavioral Checklist

Lighting	Y/N	HVAC	Y/N	Irrigation/Water	Y/N	Equipment	Y/N
Conduct a lighting audit		Clean & change air filters regularly		Maintain plumbing fixtures/piping to avoid losses		Check electricity meters at least once per month	
Arrange interior space to optimize natural light & comfort zones		Utilize ceiling fans		Run irrigation early in the morning or late at night		Operate machines according to manufacturers' recommendations for energy efficiency	
Initiate 'lights off' employee awareness campaign		Ensure HVAC units have proper ventilation		Repair leaks		Avoid automatically turning on kitchen equipment when arriving in morning	
Display reminders & visual management signage		Turn off air/set heating at minimum in unoccupied rooms		Check insulation on hot water pipes to reduce heat losses		Consider temperature of kitchen rooms when installing or relocating refrigerators/freezers	
Code light switches (labels or color) to switch on only those needed		Close exterior doors when not in use		Check laundry room equipment regularly for leaks		Turn off food & beverage equipment when not in use	
Reduce general lighting during daytime				Water less area, apply hand watering		Do not exceed oven preheating times	
Turn exterior lighting on only at night; utilize timekeepers				Evaluate cleaning practices (dry vs. wet washing)		Open refrigerators & freezers only when necessary	
Train staff & invite guests/ members to get involved						Defrost refrigerators & clean door seals monthly	
Maintain routine preventive maintenance on lighting equipment						Fill dishwashers & washing machines to maximum capacity	
Turn off lights in unoccupied rooms						Use low temperature wash cycles & avoid overloading dryers	
Limit pool lighting that is not required for safety						Conduct regular PM on equipment, vehicles	
						Run washer/dryer during off peak hours	
						Do not leave televisions on standby	
						Switch off equipment (copiers, computers, printers, coffee) when not in use	
						Charge golf carts & equipment during off-peak hours (evening/ early a.m.)	
						Encourage car sharing; designate EV parking & charging stations	
						Source products locally to reduce logistics/transportation fuel consumption	
						Log equipment use including hours operated, length of use, patterns to determine efficiencies (e.g., shift to off-peak hours, minimize use per week, etc.)	

Source: Radius Sports Group, LLC. 2019

Energy Management Tip!

Create a checklist of energy reduction product selection best management practices for the clubhouse, golf maintenance facility, and other buildings on property. This can be used as a self-audit and guide toward continuous improvement. Sample checklist below and reference Hawaiian Electric General Best Practices in Appendix B.



Source: Energy for Sustainability, Randolph & Masters, 2008.

EQUIPMENT AND MATERIALS EFFICIENCIES

Evaluate new technologies, products, or upgrades that improve efficiencies through meetings with suppliers. Examine fuel types, level of energy required, and use of alternative energy or fuels. Shifting to hybrid mowers and electric golf carts helps reduce fuel consumption and lowers greenhouse gas emissions.

Renovations and new construction provide an opportunity to integrate energy saving efficiencies into the plans. Engaging partners early will allow all parties involved to design the finished product within the club's energy conservation position statement. Architects and contractors can also be held to standards focusing on energy reductions during the project.

Investment determinations should be focused on integrating energy conservation measures.

Energy Considerations During Design

- Building location
- Building orientation
- Vegetation
- Lifecycle assessment on materials
- Technology/smart building automation
- Monitoring systems
- Programmable scheduling and controls

In planning for construction, source locally when practical. Heavy or bulky materials will take significantly less resources if only traveling a small distance. This reduces embodied energy (energy used in the extraction, production, transportation and construction of a building material) to lower the carbon footprint. Energy conservation measures and suppliers may be found through the US Green Building Council, including details on the LEED framework and certification for highly energy efficient, green buildings; also the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, or ASHRAE for energy efficiency standards and guidelines.

Golf Club Energy Reduction Best Management Practices
Product Selection Checklist

Lighting	Y/N	HVAC	Y/N	Irrigation/Water	Y/N	Equipment	Y/N
Install LED lighting and/or retrofit devices		Install energy-efficient air conditioning/chiller equipment		Install shower flow restriction devices to reduce water usage		Choose programmable thermostats	
Replace less efficient T12s with low-wattage T8 & T5 lamps with electronic ballasts		Install HVAC fans & pumps with variable frequency drives (VFDs) that control pump speeds		Install insulation on water heater tanks and pipe		Install onsite photovoltaic solar panels for onsite electricty generation	
Replace incandescent bulbs with CFLs which use less energy & last longer		Install window film to reduce air/heat loss		Install energy efficient water-heating equipment		Install National Electrical Manufacturers Association's (NEMA) premium efficiency-rated pump motors	
Replace fluorescent light exit signs with LEDs		Maximize envelope efficiency; choose high performance insulation systems		Install aerators to reduce demand for hot water		Install solar/geothermal pumps for pools	
Install induction lighting in hard-to-reach places & public facilities		Add insulation for windows & doors, such as weather stripping & thresholds		Install water-saving devices (flow regulators, water flow sensors, self-closing taps, low-flush toilets)		Select a well-engineered pump station with variable frequency drives (VFDs) to minimize water & energy use	
Install pulse-start metal halide & high-pressure sodium lamps in spaces with prolonged use & high ceilings		Utilize energy management systems		Install prescriptive irrigation systems to manage use & detect leaks		Select hybrid equipment including fairway mowers	
Add occupancy sensors or programmable timers		Decrease daytime thermostat setting		Audit irrigation system		Choose electric or battery-powered golf carts	
Install light tubes & natural light maximizers		Install a night setback system to lower room temperature at night		Install localized devices (micro- sprinklers, drip irrigation) for plants & ornamentals		Choose Energy Star rated equipment for clubhouse operations	
		Install an economizer to use outdoor air for cooling		Incorporate native plants to reduce water & energy use			
		Install a timer on supply air fans		Install rooftop solar thermal panels for water heating			
		Install double-glazed windows		Incorporate drought resistant, salt tolerant turf (e.g., paspalum) to lower irrigation needs			
		Shade windows from sun to limit HVAC needs (awnings, automatic louvres, curtains, blinds, screens, heat reflecting sheets, trees)					
		Incorporate a green roof with vegetation or cool roof (white or cool colored)					

Source: Radius Sports Group, LLC. 2020

Solar Site Considerations: location (roof or ground mounted), area, orientation and tilt, and shading.

- A roof facing south, southeast or southwest
- A 35- to 50-degree roof tilt
- Clear access to the sun for most of the day unobstructed by trees
- Adequate space on roof or property
- A roof in good condition

ONSITE SOLAR ELECTRICITY GENERATION

An increasing number of golf clubs are installing solar to provide onsite electricity. When evaluating benefits and costs, look at the long-term effect and payback period, in addition to employee and community well-being.

EDUCATION

Educating and engaging employees is an important part of the process. Making it fun and enjoyable will encourage everyone to participate and feel good about the contributions being made. Tips and quizzes help keep it relevant and weekly challenges with rewards help motivation. Continuous education may be completed through email, print and verbal stakeholder meetings.

Communication is important to keep energy reductions moving forward in departments. Successes should be celebrated. During weekly staff training a small portion can be dedicated to energy to keep it relevant year-round. Suggestion boxes for stakeholders and guests can help for continuous improvement.

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