

Neighborhood Stormwater Pond Maintenance Log and Resources

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Welcome!

What is viewed as a community recreation and water feature, minimizes risk of neighborhood flooding, and protects local water quality? Your stormwater pond! These features in suburban and urban developments across South Carolina require little maintenance and serve many vital roles in your community. Keeping drainage ditches and pipes clear of debris, ensuring that outfalls and discharge locations are unobstructed, and balancing the nutrients going to your pond are just a few ways that neighborhoods can protect this asset and ensure its function and longevity.

This manual has been created to provide your community with the most current information to properly manage your stormwater pond, gained from experts in the field who have assisted communities in stormwater pond management for many years. We recommend keeping this information in a 3-ring binder with the different sections below. This will allow your community to keep information on your pond centralized in one location, even as responsibilities change hands, and will enable you to easily add any other material you need to keep on hand, including as-built drawings of your pond and any maintenance agreements in place.

- The Information section provides a basic overview of common stormwater pond maintenance issues and some tips on how to avoid them. Use this information to educate the residents of your community on how best to care for your pond. After all, some of the most common pond issues are contributed to by individual residents, such as excess nutrients leading to algal blooms.
- The Stormwater Pond Identification section is for you to document important attributes of each pond serving your community, such as age, depth, and volume, which will help ensure the continuation of information as boards and committees change over time. Contact South Carolina Department of Health and Environmental Control's Office of Ocean and Coastal Resource Management (SCDHEC OCRM) for help on locating information on your pond (permits, plats, etc).
- The Maintenance Log section should be used to help your community track stormwater pond maintenance concerns and actions. This will enable your community to identify patterns and track the effectiveness of solutions so as to minimize the likelihood of those issues re-occurring.
- The Maintenance Inspection section should be used as a guide to inspecting your community's ponds. Keep in mind that unique conditions of your ponds may require different inspection items.
- The Reference Contact list is provided to identify what agencies/organizations may be available to assist with your stormwater pond questions. Remember to take notes, as agency personnel and departments may change over time.

Responsibility for the proper maintenance and management of stormwater ponds transfers from the developer to the homeowners' association (or other community organization) a short time after completion. Check your community's contracts/agreements to fully understand the extent of your responsibilities.

Regularly updated guidance and information, and the source for much of this binder, can be found online at www.clemson.edu/stormwaterponds.

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1.0 Managing Stormwater Ponds



This binder assists homeowners associations (HOAs), community managers, and waterfront residents with choosing the best management options for maintaining their community's stormwater ponds. This binder is a diagnostic tool that provides recommendations for fixing and preventing common problems that develop as stormwater ponds age, such as aquatic weeds, fish kills, shoreline erosion, poor water quality, nuisance wildlife, and much more.

BEFORE YOU GET STARTED, EVERY RESIDENT MUST KNOW...

Stormwater ponds are extremely important components of your community's drainage system. They are designed to

provide two critical services:

- 1) they prevent flooding by suppressing surges of stormwater runoff that wash from lawns, buildings, and paved surfaces; and
- 2) they protect water quality by holding water long enough so that sediment and attached and other pollutants settle to the bottom of the pond before discharge to nearby rivers or beaches.

The primary purpose of all stormwater ponds is to manage stormwater runoff generated by impervious surfaces such as rooftops and pavement. (See section on Pond Construction and Sedimentation for more details.) These ponds are not designed to be recreational ponds for fishing or boating, and they are not permitted solely for beautification of the landscape. They are engineered devices, intended to moderate flood surges and reduce stormwater pollution. As with other engineered devices, stormwater ponds require maintenance to prevent them from falling into disrepair. That being said, stormwater ponds that are well maintained may provide additional benefits beyond simply managing stormwater, such as nature watching, boating, and improved property values.

******Note****** According to SC Nonpoint Discharge Elimination System permitting, communities that are delegated to carry forward stormwater permitting regulation must mandate that all structural stormwater control measures be maintained in perpetuity. Stormwater ponds and associated infrastructure would meet this criterion in these permitted areas at a minimum. Therefore, maintenance of infrastructure and ponds in new or redeveloped sites must be maintained by the homeowner's association or appropriate group to be within compliance of federal and state regulations.

Potential additional requirements may include documenting the maintenance of infrastructure in covenants and restrictions, demonstrating the transfer of ownership of stormwater infrastructure at the time of the transfer of developer's rights, and legally-binding agreements accepting ownership and maintenance responsibility.

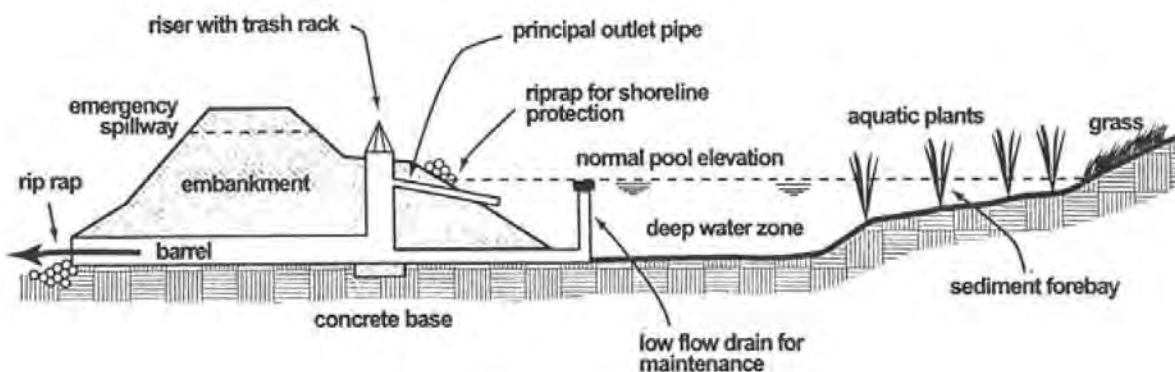
2.0 Stormwater Pond Design, Construction, and Sedimentation

Stormwater retention ponds are designed to minimize the adverse effects that impervious surfaces have on watersheds. Impervious surfaces (i.e., paved surfaces, buildings, etc.) increase the volume of surface runoff in a watershed because they prevent rain water from infiltrating into the soil. Also, pollutants that collect on impervious surfaces are not filtered by the soil or plants and are conveyed directly to rivers and beaches without treatment. To reduce the potential flooding and water quality problems, stormwater regulations require new developments to capture and manage runoff. Stormwater ponds help developments meet stormwater regulations by reducing the potential for flash flooding and removing sediments and other pollutants carried in stormwater runoff.

2.1 How do stormwater ponds work?

Flood Control: Stormwater ponds detain stormwater in order to prevent flooding and minimize erosion. They do so by collecting runoff in a basin of a predetermined volume. The basin is designed to fill with water during the storm and discharge the water through an outlet structure which releases water at a rate similar to the rate of flow before the watershed was developed. To capture runoff, each stormwater pond must have an empty space that can fill with water during the storm. The empty space from the normal water level to the top of the bank slope is known as the *temporary storage capacity*.

Water Quality Protection: Stormwater ponds are designed to permanently retain water in the basin. This volume of water is known as the *permanent pool* or *treatment pool*. In South Carolina, the treatment pool must be the same volume as if 1 inch of rainfall were to fall on the watershed that drains to the pond. The treatment pool is designed to slow the water down and hold it long enough to allow gravity to pull sediments out of the water column and allow sunlight and biochemical processes to break down pollutants before they are released to rivers and beaches. In most cases, the treatment pool has an average depth of 4 to 6 feet, which has been shown to limit submerged vegetation and provide the necessary treatment and sediment capture.



2.2 Common stormwater pond components:

The Basin: Every stormwater pond has an excavated basin with a specific volume. The part of the basin that permanently retains water is known as the *treatment pool*. The empty space above the treatment pool to the top of the bank slopes is known as the *temporary storage*, which fills and drains with each storm event.

Permanent pool - designed to permanently hold at least the first 1 inch of rainfall that falls on the area of the development that drains to the pond. The treatment pool must be large enough to hold water long enough to allow gravity to remove sediment and debris and allow sunlight and biochemical processes to remove other pollutants such as bacteria and nutrients.

Temporary Storage - usually designed to be large enough to accommodate the "25-year storm" (a storm that is likely to occur only once every 25 years). In coastal South Carolina, this means a storm that drops just over 7 inches of rain in 24 hours.

Inlets and Forebays: Stormwater is conveyed from roads, parking areas, roof tops, and lawns through pipes and swales into the pond. The inlets are where stormwater runoff is discharged into the pond. Forebays are areas around inlets where the heaviest sediments settle. Forebays may lie within the basin or may be depressed areas outside of the basin.

Littoral Shelf: The submerged area near the edge of the pond where the sunlight can penetrate through the water to the bottom is the *littoral zone*. In many ponds, this area is a shallow shelf that provides habitat for fish; emergent wetland plants provide water treatment and stabilize the base of the bank slope.

Outlet Control Structure: The most critical component of the pond is the outlet control structure that regulates the water level and maintains the permanent pool. This may be a weir, concrete riser, spillway or inverted pipe. According to design standards, the surface of the permanent pool should return to the level of the bottom of the outlet control structure within 24 hours after the storm.



2.3 Common considerations for all stormwater ponds:

Sedimentation



Because the primary function of a stormwater pond is to trap sediments, functioning ponds are designed to accumulate sediment and debris and need to be dredged. The frequency of dredging is extremely variable and is directly dependent on 1) the amount of exposed soils in the development (i.e., active construction), 2) rate of shoreline erosion, 3) the amount of aquatic plant growth, and 4) the amount of debris released into the drainage system by residents and workers.

Stormwater ponds should be dredged when the permanent pool volume is half-filled with sediment because the pond is no longer effectively removing sediment and pollutants once filled

to that level. For instance, if a stormwater pond was constructed to have an average depth of 6 feet, it will need to be dredged when the average depth reaches 3 feet. The permanent pool volume must be maintained to ensure proper water quality treatment and control of submerged aquatic vegetation. If you suspect that your pond is in need of dredging, contact your county or municipal stormwater division for guidance. Also, you will need to retain the services of an engineer who can assess the need and draw plans for remediation. The stormwater pond's ability to manage nutrients is also limited by accumulation of sediments, so if your pond is consistently eutrophic, dredging should be considered.

Structural Problems

Areas where water energy is concentrated such as swales, inlet pipes, and outfalls sometimes break or fail and need repair. Gulleys may form on bank slopes where swales concentrate surface runoff. Inlet pipes sometimes crack, collapse or slump. Sink holes sometimes develop over areas where buried pipes separate, and cracks form in outfalls as they settle. Sometimes trees, vines, and other woody vegetation overtake inlets and outfalls and needs to be removed. If any of these problems occurs, you should consult with your county or municipal stormwater division. In some instances, they may be able to assist with the problem. If not, your community will need to retain the services of an engineer who can design the necessary repair.



Inspect your system

It is important that all inlets and outlets be inspected regularly to prevent blockages and to check for structural failures. Sink holes and erosion around inlets should be repaired as soon as they are found because they can grow exponentially once started. Large trees and shrubs should not be allowed to grow around inlets and outlets and should be minimized within the basin to allow for maintenance access. On occasion, the outlet pipe can collapse or become clogged below ground. This will cause the pond to drain slowly and have elevated water levels beyond 48 hours after the storm. If you suspect a blockage in your pipes, you should consult with your municipal stormwater division or have an engineer inspect the outlet.

Safety

Safety is an important consideration for any community with a stormwater pond. Among the typical hazards related to stormwater ponds are drowning; entrapment in the confined spaces of inlet/outlet pipes; and slips, trips, and falls on steep embankment slopes or slippery surfaces. Care should be taken to recognize any unique safety concerns raised by each individual pond and have those concerns addressed through sign placement and community awareness education. Communities should be aware of any possible liability issues related to the hazards posed by their stormwater ponds.

2.4 Maintenance Costs

Like anything else, there are costs associated with maintaining a stormwater pond. The property owner or the HOA will need to establish an operation and maintenance (O&M) fund and assess annual fees for maintenance. Typically, fees are established by the developer prior to turning the responsibility of the pond over to the owner. After several years of operation with these set fees, it may be necessary to re-evaluate maintenance costs for the actual operation of the pond after the development is established. The amount of revenue allocated to the O&M fund should be relative to the number and size of the ponds and number of inlets.

O&M funds are necessary to cover the costs of maintenance activities, including: mowing, fish stocking, vegetation planting, nuisance aquatic plant control, algae control, inspections, dredging, repairs, and more. Weiss et al (2005) found that annual O&M costs ranged from 2-10% of the construction cost of the pond itself. The cost of dredging and repairs is highly variable and depends on access, degree of work, disposal of spoils and broken material, permits, and other environmental concerns. It is recommended that communities consult with a licensed civil engineer before seeking bids. The engineer can help design the repair and walk through any permitting that may be necessary.

A phone survey was conducted of pond management companies in the Charleston area to determine local rates of pond management services. The rates provided are variable and are dependent on many factors, such as the amount and species of algae/aquatic weeds, pond depth, ease of access, and aeration systems.

- Algicide application may cost anywhere between \$60/acre and \$200/acre.
- Pesticide application may cost anywhere between \$60/acre and \$650/acre.
- Buffer planting can range in cost from \$4.63/linear foot up to \$80/linear foot if erosion control materials are needed.
- Mechanical removal of aquatic weeds may cost up to \$1,500/day.
- Inlet and outlet structure inspections cost \$465/hour.
- Aeration systems are approximately \$3,500/acre.

Many companies provide pond owners with a free consultation during a site visit to assess pond conditions. It is also possible to contract with a pond management company to pay a flat rate every year, in which case the company will treat and inspect your pond monthly.

Some information on fish stocking rates was also gathered. Current rates for triploid grass carp stocking are \$165/acre, with restocking needed every 3.5 years. Tilapia are stocked at 200-400 fish/acre of pond at \$0.75-\$1 per fish. Tilapia will need to be restocked annually, as they die every year.

Advice for pond managers is to call early in the season and minimize problems and costs by not waiting for the pond to have major problems before seeking assistance.

Case study: Kiawah Island, South Carolina

The Kiawah Island Community Association (KICA) has a designated Lake Management Department responsible for the management and maintenance of the 115 ponds and lakes spread across Kiawah Island. Their maintenance activities include: weekly visual inspection of the pond system, weekly monitoring of water quality, conducting pond edge maintenance of common property "view windows," fish stocking, establishment of beneficial shoreline vegetation, nuisance aquatic plant control, maintenance of an extensive database of pond information, biannual testing of coliform levels, biannual inspection and maintenance of water control structures, annual analysis of fish tissue samples for pesticide and heavy metal contamination, and annual mapping of bottom contours for 20% of the ponds. Figure 2-1 provides a cost break down of these activities. With most communities having fewer ponds than Kiawah Island, their maintenance costs will be less than those on Kiawah Island; however, communities still need to plan for these recurring costs, as well as for repairs and dredging. Over time, KICA has had to dredge their ponds due to sedimentation (Table 2-1) or clogged pipes (Table 2-2).

Note When the developer transfers governance of the community to the property owners' or homeowners' association, the expenses and responsibility of proper stormwater pond management become the obligation of the POA/HOA in nearly every county and municipality in South Carolina.

Method	Volume Removed (yd³)	Cost	Cost / yd³
Heavy equipment	46,000	\$130,000.00	\$2.83
Long-reach excavator	30	\$2,800.00	\$93.33
Long-reach excavator	2,400	\$27,050.00	\$11.27
Vacuum truck	19	\$3,840.00	\$202.11
Vacuum truck	4	\$800.00	\$200.00
Diver operated dredge / poly bags	21	\$7,100.00	\$346.03
Long-reach excavator	10,117	\$272,000.00	\$26.89
Long-reach excavator	360	\$6,656.00	\$18.49
Long-reach excavator	90	\$2,656.00	\$29.51
Long-reach excavator	540	\$14,016.00	\$25.96
Diver operated dredge / poly bags	13	\$10,413.55	\$778.29
Diver operated dredge / poly bags	10	\$8,094.24	\$778.29
Diver operated dredge / poly bags	71	\$24,000.00	\$337.79
Vacuum truck / poly bags	55	\$35,292.50	\$641.68

Table 2-1. Kiawah Island's pond excavation costs from 1993-2011.

Method	Volume Removed (yd³)	Total Sediment Removal Cost	Sediment Removal Cost/yd³	Cost of Sediment Disposal	Total Cost	Total Cost/yd³
Vacuum truck / poly bags	20.00	\$19,060.00	\$953.00		\$19,060.00	\$953.00
Diver operated dredge / poly bags	100.24	\$45,896.00	\$457.86		\$45,896.00	\$457.86
Diver operated dredge / poly bags	48.24	\$28,404.00	\$588.81		\$28,404.00	\$588.81
Diver operated dredge / poly bags	20.12	\$19,248.00	\$956.66	\$1,300.00	\$20,548.00	\$956.66
Diver operated dredge / poly bags	5.00	\$14,480.00	\$2,896.00	\$650.00	\$15,130.00	\$2,896.00
Diver operated dredge / poly bags	40.66	\$43,318.00	\$1,065.37	\$1,040.00	\$44,358.00	\$1,065.37

Table 2-2. Kiawah Island's clogged pipe excavation costs from 2007-2012.

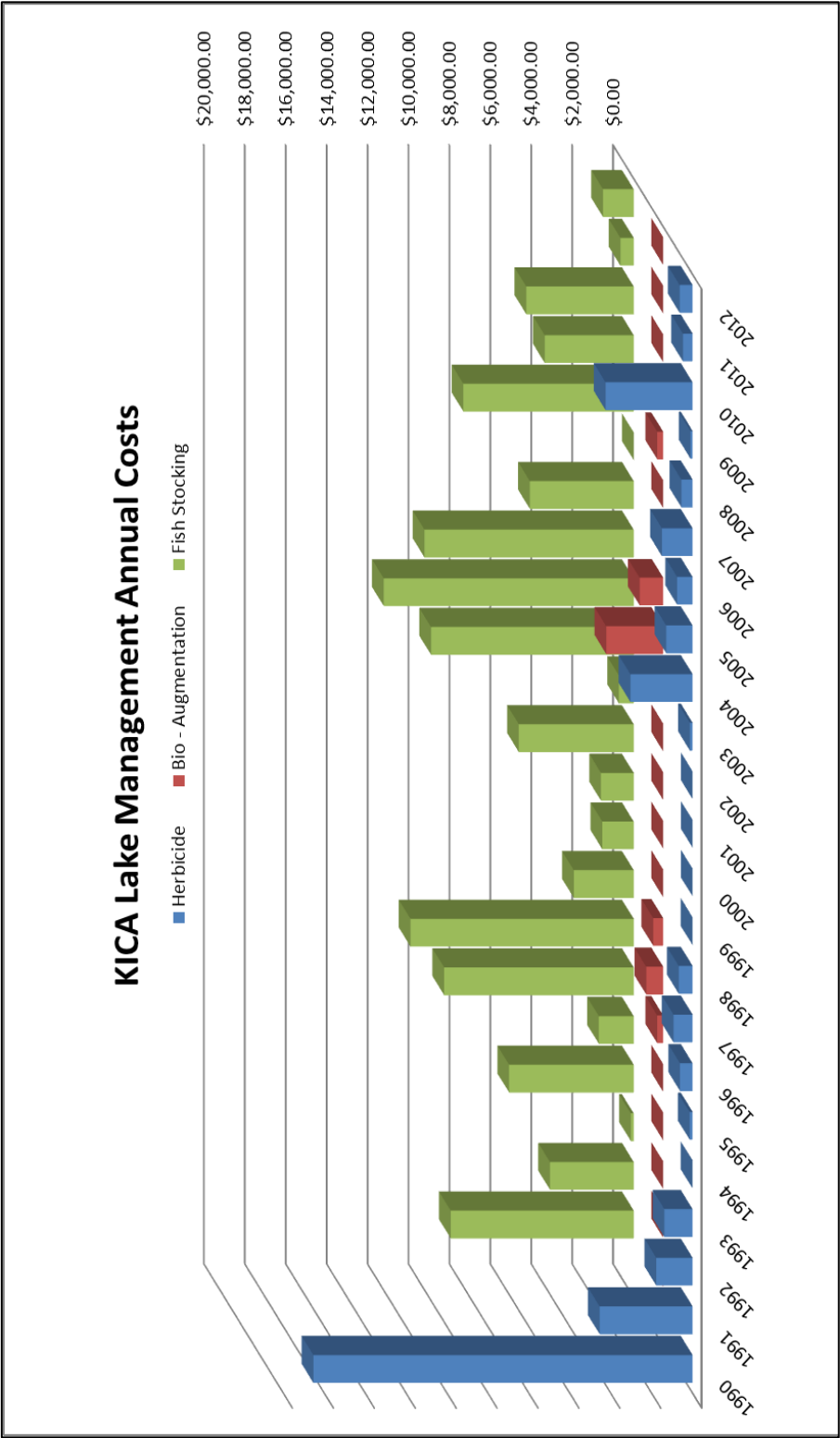


Figure 2-1. Break down of KICA’s pond management costs by activity per year.

3.0 Stormwater Pond Regulations

(Based on available information, May 2013. Users are advised to consult with regulatory authorities as codes and ordinances may have changed since publication.)

With the construction of residential developments comes excess stormwater and sediment runoff. Regulations are imposed on federal, state, and local levels to minimize, or eliminate, the impacts of development on water quality and quantity. These regulations require developers to use a combination of best management practices (BMPs) to effectively manage stormwater runoff. Without these regulations, polluted stormwater runoff would flow into nearby waterways, degrading water quality and flooding downstream areas. The method chosen is dependent upon many factors, including budget, location, zoning, and unique site characteristics. While stormwater ponds are the focus here, there are other BMPs developers can utilize to achieve the same results. Other BMPs include sediment traps, infiltration basins, swales, silt fences, riprap, wind fences, and many more! Not only that, but developers can use a suite of practices to better protect water quality. No matter which BMPs are chosen, developers must remain in compliance with federal, state, and local laws and regulations regarding stormwater and sediment runoff.

There are a number of regulations and local ordinances described below, each addressing different responsible entities. Though regulations may change as a function of county or municipal ordinances, at this point in time very few municipalities and counties in South Carolina assume ownership of stormwater ponds on private property. Therefore, maintenance ensuring function and integrity of this infrastructure to treat water quality and store collected runoff is the responsibility of the pond owner, which may be the property management company, homeowner association, commercial site owner and so forth.

3.1 Federal Regulations

The Federal Water Pollution Control Act (Clean Water Act) provided a regulatory framework for pollutant discharges into water of the United States. If your stormwater ponds are connected to a navigable waterway via their drainage flow, they may fall under the jurisdiction of the United States Army Corps of Engineers (USACE). The Clean Water Act gave the United States Environmental Protection Agency (US EPA) the authority to implement point source pollution control programs, including the National Pollutant Discharge Elimination System (NPDES) and the Total Maximum Daily Load (TMDL) Program.

The South Carolina Department of Health and Environmental Control's (SCDHEC) Bureau of Water is the authorizing agency for NPDES permits in South Carolina. The NPDES program regulates point sources of pollutant discharges into waters of the United States. A point source is a discrete conveyance such as a pipe or man-made ditch. Owners and operators who directly discharge stormwater into waters of the United States are required to obtain a permit from the US EPA or the state, wherein authority has been delegated to the state. Permittees are required to verify compliance with permit conditions by monitoring and maintaining records of their discharge and filing reports. While the NPDES program does not address the use of stormwater ponds, SCDHEC discusses stormwater ponds as a structural control in their "South Carolina DHEC Stormwater Management BMP Field Manual." Wet stormwater detention ponds are used

in general to improve stormwater quality, while dry stormwater detention ponds are used in new and existing residential, commercial and industrial developments where significant increases in runoff are expected to occur as a result of the development. A Pond Maintenance Plan/Agreement is required before approval of a dry detention pond. SCDHEC recommends that maintenance responsibility for a pond be conveyed to a responsible authority by means of a legally binding and enforceable maintenance agreement that is executed as a condition of plan approval.

3.2 State Regulations

In addition to the authority delegated to the state by the CWA (NPDES), South Carolina has enacted several laws and policies regarding stormwater management.

The *Stormwater Management and Sediment Reduction Act* (SMSRA) was enacted by the South Carolina state legislature in 1991 to prohibit anyone from engaging in a land disturbing activity without first submitting a stormwater management and sediment control plan to the appropriate agency (SC DHEC) and obtaining a permit. The Stormwater Management and Sediment Reduction Program administered by SCDHEC provides technical assistance and researches the causes, effects, and hazards of stormwater and sedimentation and methods to control both issues. Civil penalties may be assessed for violations of the SMSRA.

Stormwater Pollution Prevention Plans (SWPPPs) are required by SCDHEC to be included in any application package under the 2012 NPDES General Construction Permit to fulfill compliance requirements of the CWA. SWPPPs are sediment and erosion control plans that describe all of the construction site operator's activities and their efforts to prevent stormwater contamination and control sedimentation and erosion. SWPPPs should address specific site concerns regarding stormwater and sediment. SWPPPs require maintenance agreements when ownership of the BMP is transferred from developers (Primary Permittee) to individual owners/HOAs (Secondary Permittee). It is the responsibility of the Secondary Permittee to ensure proper maintenance of the BMP. Maintenance plans are required to include the maintenance activities to be performed, as well as a schedule for maintenance activities. Failure to properly address concerns can result in heavy fines from the local permitted community, SCDHEC or the US EPA.

The *SCDHEC Standards for Stormwater Management and Sediment Reduction Regulations* provide guidance on the use of stormwater detention ponds as a BMP for mitigating stormwater runoff and sedimentation impacts. Ponds should be designed as both water quality and quantity control structures and utilize an aquatic weed control program. Wet ponds are required to store the first ½" of runoff from the site and release it over a 24-hour period, while dry detention ponds are required to store and release the first 1" of runoff from the site.

3.3 Local Regulations

3.3.1 Berkeley County

Berkeley County is required to obtain an NPDES MS4 permit to discharge stormwater. The MS4 permit requires Berkeley County to develop and implement a Stormwater Management Program

(SWMP) to control the discharge of pollutants from its MS4. The NPDES MS4 permit also requires Berkeley County to encourage, promote, and implement programs and procedures with the intent of reducing or limiting the discharge of pollutants to nearby waterbodies as a result of construction activities.

The Stormwater Management Ordinance of Berkeley County established engineering design standards and procedures for obtaining a construction permit within Berkeley County. Under this ordinance, the County Engineer is authorized to develop all necessary regulations for properly controlling stormwater runoff.

As part of its Stormwater Management Program (SWMP), Berkeley County has developed a Stormwater Design Standards Manual to establish requirements and procedures to control the potential adverse impacts of increased stormwater runoff and related pollutant loads associated with future and existing development. All construction activity disturbing one-half (1/2) acre or more must submit a stormwater management plan and Construction Activity Application to the County Engineer. Projects disturbing less than one-half (1/2) acre are still required to submit a stormwater management plan to the County.

A Covenant for Permanent Maintenance of Stormwater Systems must be filed with the County prior to the approval of a project's stormwater management plan to ensure the County that maintenance activities will be conducted on the stormwater management system by the owner, operator, or a third party. The maintenance plan and schedule must be included in the stormwater management plan for all the activities to be conducted during and after construction for all stormwater system components.

Wet and dry detention ponds are listed as structural control BMPs in the Berkeley County Stormwater Design Standards Manual. Wet ponds are to have a minimum depth of 4 feet to prevent mosquito breeding. Dry detention ponds are to be graded with a minimum 0.5% bottom slope and are not to be used in areas with a high water table. If detention ponds are used as the stormwater BMP on site, a minimum access easement of 20 feet should be provided. The drainage easement for the pond will include the area of the pond plus a minimum of 15 feet around the pond's perimeter for maintenance access beyond the top of the bank. While the County does not accept responsibility for pond maintenance, except when agreed to in writing, the County may utilize the easement for necessary emergency repairs. The County provides a list of maintenance activities that should be performed regarding stormwater detention ponds including weed control and dredging in response to sedimentation.

3.3.2 Charleston County

The Stormwater Management Ordinance established engineering design standards and procedures for obtaining a construction permit within Charleston County. Under this ordinance, the Public Works Director was authorized to develop all necessary regulations for properly controlling stormwater runoff.

Charleston County is required to have an NPDES MS4 permit to discharge stormwater. The MS4 permit requires Charleston County to develop and implement a Stormwater Management Program (SWMP) to control the discharge of pollutants from its MS4. The NPDES MS4 permit

also requires Charleston County to encourage, promote, and implement programs and procedures with the intent of reducing or limiting the discharge of pollutants to nearby waterbodies as a result of construction activities.

The owner of a portion or the entire stormwater system shall be identified before a site construction permit will be issued. Charleston County's Permitting Standards and Procedures Manual states that all BMPs, including stormwater detention ponds, in new and redevelopment residential projects are owned by the owner/operator(s) *of the parcel(s)* or a Home Owners Association (HOA). With ownership comes a requirement to maintain the stormwater system, including all ponds and other BMPs used for controlling runoff quantity and quality. A maintenance plan for all components of the stormwater management system should be developed, detailing control measures to be used during construction and long-term maintenance. The owner/operator or HOA of a stormwater BMP must enter into a permanent maintenance agreement with Charleston County through the issuance of the operating permit. The County provides a list of maintenance activities that should be performed regarding stormwater detention ponds including weed control and dredging in response to sedimentation. The Public Works Director ensures compliance with the permit and may inspect a system to ensure maintenance is being performed in accordance with this permit, either by the owner/operator, an HOA, or a third party.

3.3.3 Dorchester County

Like Berkeley and Charleston counties, Dorchester County is required to have an NPDES MS4 permit to discharge stormwater. The MS4 permit requires Dorchester County to develop and implement a Stormwater Management Program (SWMP) to control the discharge of pollutants from its MS4. The MS4 permit also requires Dorchester County to encourage, promote, and implement programs and procedures with the intent of reducing or limiting the discharge of pollutants to nearby waterbodies as a result of construction activities. Under the SWMP, Dorchester County is to design a set of BMPs to collect, control, treat, and discharge stormwater. All developed land in Dorchester County must maintain pre-development runoff rates for the 2-, 10-, 25-, and 100-year storm events.

All ponds and underground water quality structures in Dorchester County are privately owned and maintained. Dorchester County does not perform maintenance, except in an emergency situation. Emergency access to the stormwater control structure is granted to the County to prevent structural and roadway flooding. Concerns such as algae control, mosquitoes, fish kills, dredging and trash removal must be addressed by the property owner or HOA.

4.0 Aquatic Plants and Weed Control

Aquatic plants are essential for a well-balanced pond and healthy aquatic ecosystem. They provide many important services identified below.

1. oxygenation through photosynthesis
2. food and cover for aquatic animals and wildlife
3. treatment of excess nutrients and other pollutants
4. habitat for beneficial microorganisms
5. shoreline stabilization and erosion prevention
6. shade and temperature control
7. beautification and enhanced land value

On the other hand, too much plant material in and around a stormwater pond can cause significant problems such as sedimentation and filling-in, stagnancy and low oxygen areas, obstructed pipes and outfalls, impediments to maintenance equipment, and overall unsightliness.

What kinds of plants are concerning you?

ALGAE - planktonic

My pond has become very cloudy and green, like pea soup, or has a thin film of bright green or red "scum" floating on the water surface.



ALGAE - filamentous

Filamentous algae form green, "hair-like" strands that grow on the surface of other plants or objects in the water. They do not have roots, leaves or flowers. In large blooms, filamentous algae can break loose and form large floating mats.



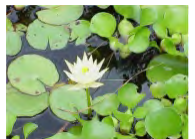
SUBMERGED PLANTS

Unlike filamentous algae, these plants are rooted into the bottom and have roots, stems and leaves. Some are able to break loose from the bottom and survive floating in the water. These plants are often described as "grass-like" or "moss-like." They grow from the bottom up to the surface and often have flowers below or above the water.



FLOATING PLANTS

Floating plants have leaves that lay on the water surface. Some are rooted in the bottom (such as lily pads and lotus) while others are free-floating on the surface (such as duckweed and waterhyacinth).



SHORELINE/EMERGENT PLANTS

These are plants that are rooted in very shallow water and at the water's edge. Some are creeping or "vine-like" and can reach out into the pond (such as alligatorweed and waterprimrose) while others grow vertically (such as cattails and rushes).



4.1 Planktonic Algae - Conditions and Control

Planktonic algae are microscopic plants that live in every drop of pond water. These primitive creatures are extremely important to the aquatic ecosystem because they are the base for the food chain and are largely responsible for the chemistry of the pond. Planktonic algae are important because they produce oxygen and food for the animals that live in the pond. These tiny plants get their nutrients directly from the water, so their growth and reproduction are dependent on the amount of nutrients (i.e., fertilizer) in the water. Because stormwater ponds collect water flowing from yards and roads in the community, they often grow an abundance of algae as a result of the many sources of nutrients in residential and commercial developments.



Is murky green water unhealthy? Should the water be clear?

No, not necessarily. The murkiness is a sign of a growing plankton population which is responding to nutrients that have washed into the pond. This is Nature's way of capturing nutrients that might otherwise contaminate rivers and beaches.

Can too much algae become a problem?

Yes. A severe algal bloom can cause a fish kill because the death and decay of the algae will remove oxygen from the water.

How do I know that I have too much planktonic algae?

Use a white object that will sink and tie it to a string. Mark the string at 18 inches above the object, and lower the object into the pond. If the object is still visible at 18 inches below the surface, the pond does not have too much algae. If the object disappears before 18 inches below the surface, you likely have an algae bloom that is increasing the risk of a fish kill due to low oxygen.

Are there any particularly bad algae?



Yes. One group of algae, known as blue-green algae (cyanobacteria), can produce toxins that can affect the health of fish and animals that come into contact with the water. Cyanobacteria often become problems when the pond receives too much phosphorous, a condition that is most often associated with runoff that contains excessive lawn fertilizers or animal wastes.



Cyanobacteria are normally very bright green and usually form a film on the surface. Most other algae are darker green and do not form surface films. There are some cyanobacteria that do not form surface films.

On occasion, a pond may develop "red algae," which also may be harmful to aquatic animals. "Red algae" are not actually algae, but their growth and control are similar to that of other planktonic algae.

How do I control planktonic algae blooms?

The only ways homeowners can prevent recurring algae blooms are 1) to reduce the nutrients washing into the pond and 2) to use other plants or compounds to absorb nutrients from the water. Licensed applicators can treat algae blooms using properly labeled herbicides, but, unless the nutrients are reduced, the chemical herbicides will provide only temporary control of algae blooms. Also, ponds that are experiencing an algal bloom are more likely to have a fish kill when treated with an herbicide because of the rapid death and decay of the algae, so it is important to provide adequate circulation when ponds develop severe algal blooms. (See section on Circulation/Aeration)

Can homeowners or HOA officers apply aquatic herbicides to stormwater ponds?

No. In most cases stormwater ponds are considered to be community property because multiple property owners abut the pond. The water moves freely from one property to the next and usually the HOA, a delegated community entity, has a maintenance easement. Anyone applying herbicides to the water is liable for damages that may occur from that application. Only pesticide applicators licensed in category 5 (aquatic herbicides) should apply labeled herbicides to stormwater ponds.

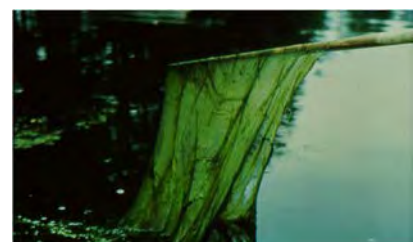
How can homeowners or HOAs prevent and control algae blooms?

1. Soil test before fertilizing to prevent over-fertilizing.
2. Sweep/blow fertilizers off of roads and driveways after spreading to prevent it from washing into storm drains.
3. Decrease or eliminate use of fertilizers on the bank slopes of ponds.
4. Properly discard grass clippings or yard waste.
5. Pick up pet waste and throw it in the trash.
6. Wash cars in on the lawn instead of in the driveway. Normal soaps break down into nutrients that grow algae, so use phosphorus-free soaps.
7. Allow fish, turtles, and waterfowl to find their own food. These animals turn food into fertilizer and are healthier when they feed themselves naturally.
8. Plant wetland plants along the shoreline to filter runoff and absorb nutrients.
9. Place floating wetlands in the pond to extract nutrients directly from the water.
10. Consider circulation systems that increase oxygen conditions in the pond.
11. Consider using aquatic dyes to shade the water and suppress algae growth.



4.2 Filamentous Algae - Conditions and Control

Filamentous algae are colonies of microscopic plants that link together to form threads or mesh-like filaments. These primitive plants normally grow on the surface of hard objects or other substrates under the water. Filamentous algae are important because they produce oxygen and food for the animals that live



in the pond, but they also can cause problems such as clogs and stagnancy. Filamentous algae do not have roots; rather they get their nutrients directly from the water, meaning that their growth and reproduction are dependent on the amount of nutrients (i.e., fertilizer) in the water. Because stormwater ponds collect water flowing from yards and roads in the community, they often grow an abundance of algae as a result of the many sources of nutrients in residential and commercial developments. It is not uncommon for stormwater ponds to develop large floating mats of algae during the warm months of the year in response to fertilization of lawns and collection of animal wastes in the watershed.

Are clumps of filamentous algae unhealthy? Should the water be clear?

No, not necessarily. Most filamentous algae do not produce toxins that are harmful to humans. The algae are growing in response to nutrients that have washed into the pond, so excessive growth of algae may indicate that there are other pollutants in the water. If the source of nutrients is pet or animal waste, it is likely that bacteria and other pathogens are living on the algae mats. Residents should not handle algae harvested from stormwater ponds. If homeowners do handle algae, they should wash their hands thoroughly or use sanitizer. Algal growth serves as nature's way of capturing nutrients and contaminants that otherwise would be carried downstream to impair rivers and beaches, so having some algae in a stormwater pond helps the pond do what it is designed to do, capture contaminants and protect water quality. The clumps are unsightly, but they are not themselves a threat to your health.



Can too much algae become a problem?

Yes. When mats of filamentous algae grow to the extent that they cover large areas of the pond surface, they limit the exchange of oxygen between the water and the atmosphere, and they prevent photosynthesis from producing oxygen in the water. As a result, ponds that are largely covered in algal mats are more likely to have fish kills due to lack of oxygen. Also, large algal mats can contribute to areas of stagnancy and noxious odors, clog outfalls, and contribute to localized flooding. Lastly, excessive algae growth contributes to increased sedimentation and filling-in of the basin.

Should I try to eliminate all algae? How much is too much?

No. Homeowners and HOAs should tolerate some algae during the warmer months (June - September) of the year because it is a natural part of the aquatic ecosystem and the annual cycle of plant growth. On the other hand, ponds that have algae covering more than 20% of the surface are more likely to develop stagnancy, noxious odors and fish kills, so it is recommended that filamentous algae be controlled to prevent it from covering more than 20% of the pond surface. During droughts when water levels are very low, it is not advised to treat ponds for excessive algae because of the increased threat of water quality impairment and a fish kill.

How do I control filamentous algae?

Use Integrated Pest Management...

1. Prevention: The only way to prevent chronic regrowth of algal mats is to reduce the nutrients washing into the pond (see section below).

2. Physical controls: Mechanical/manual harvesting and raking can provide immediate short-term control but are not feasible long-term maintenance strategies. Applying aquatic dyes prevents sunlight from penetrating to the plants and slows the rate of growth. Aquatic dyes must be applied early in the season and reapplied regularly throughout the growing season to be effective.
3. Biological controls: Blue Tilapia (*Oreochromis aureus*) is a fish that eats filamentous algae and provides good control through the growing season. Tilapia are tropical fish, which need to be restocked each year due to winter die-back. Triploid Grass Carp do not provide very good control of filamentous algae.
4. Chemical control: Several herbicides are labeled for control of algae in ponds. State law requires that these compounds only be applied to stormwater ponds by licensed applicators. Homeowners and HOA board members should not apply herbicides to stormwater ponds. Ponds that are experiencing excessive algal growth are more likely to have a fish kill when treated with an herbicide because of the rapid death and decay of the algae. Licensed applicators should be able to determine if it is feasible to treat a pond for algae without harming the aquatic environment.
5. Technology: Floating wetlands may be placed in ponds to absorb excess nutrient in the water and reduce algal growth. Floating wetlands use native wetland plants contained in a synthetic matrix that floats to pump nutrients out of the water. Diffusion circulators can assist with managing nutrients in the water and prevent stagnancy, and they do not clog like fountains and irrigation pumps.



How can homeowners or HOAs prevent and control algae blooms?

1. Soil test before fertilizing to prevent over-fertilizing.
2. Sweep/blow fertilizers off of roads and driveways after spreading to prevent it from washing into storm drains.
3. Decrease or eliminate the use of fertilizers on the bank slopes of ponds.
4. Properly dispose of grass clipping and yard waste.
5. Pick up pet waste and throw it in the trash.

6. Wash cars in on the lawn instead of in the driveway. Normal soaps break down into nutrients that grow algae, so use phosphorus-free soaps.
7. Allow fish, turtles, and waterfowl to find their own food. These animals turn food into fertilizer and are healthier when they feed themselves naturally.
8. Plant shoreline wetland plants to filter runoff and absorb nutrients.
9. Install floating wetlands to utilize nutrients from the water.
10. Consider aquatic dyes to suppress algae growth.

4.3 Submerged Aquatic Plants

A number of submerged plants flourish in stormwater ponds in South Carolina because these ponds are typically shallow enough that sunlight can penetrate all the way to the bottom. Stormwater ponds also receive repeated inputs of nutrients through runoff from lawns and roadways each time it rains. The combination of shallow water, sunlight, and nutrients makes for the ideal habitat for submerged vegetation.

Submerged plants provide many ecological services, such as:

1. oxygenation of the water
2. shelter and forage for fish and invertebrates
3. absorption of nutrients and pollutants
4. moderation of water temperature



However, when submerged vegetation grows in excess, it can also cause problems such as:

1. impeded circulation and reduction of the pond's ability to trap pollutants
2. blocked pipes and conveyances
3. vegetative decay and low oxygen which can lead to noxious odors and fish kills
4. increased sedimentation and accelerating the time till the pond will need to be dredged

Should all submerged vegetation be removed from my pond?

No. Submerged vegetation is essential to protecting the ecological integrity of the aquatic environment.

Are there any particular plants that should be removed entirely from stormwater ponds?

Yes. There are a number of submerged plants that are extremely invasive and should be eliminated if possible. These include plants such as Hydrilla, Eurasian Watermilfoil, and Brazilian Elodea. These, along with several other plants, are illegal aquatic plants in South Carolina, making it against the law to possess, sell, or introduce these plants.

How much submerged vegetation is too much?

Submerged vegetation should be restricted to the littoral zone (the shallow areas around the perimeter of the pond) because most cannot grow in depths greater than 4 feet. Submerged vegetation should be managed to prevent it from covering more than 20% of the pond, and it

should be prevented from "topping out" (i.e., reaching the water surface) where possible. Also, submerged plants should be managed around inlets and outfalls to prevent blockages.

What are the best ways to manage submerged vegetation?

Use integrated pest management:

1. Stock the pond with triploid grass carp. Triploid carp will consume most submerged plant types and will provide effective control for anywhere from 5 to 8 years before they need to be restocked. It is recommended that they be stocked at a rate of 20 fish per acre of vegetation if there is already a lot of weed growth. If not, they should be stocked at a rate of 5 to 10 fish per acre of pond to prevent excessive plant growth.
2. Dredge to restore depth. As ponds fill with sediment they develop more submerged weed growth because sunlight is able to reach the bottom. Restoring depth to at least 4 feet will reduce the potential for submerged plant growth. Also, removing dredge spoils will remove the seed bed and root stock in the bottom of the pond that produces new plants. Before dredging, contact your county or municipal stormwater department for guidance. (See section on Construction and Sedimentation)
3. Harvest plants manually or mechanically. Physically removing submerged vegetation with rakes and other tool is effective at reducing plants but not eliminating them. Removing plants by hand works well for maintaining access points and keeping pipes open, but it is too costly and laborious for maintaining the entire pond. There are some mechanical harvesters available for purchase which can make harvesting more economically feasible.
4. Aquatic dyes can reduce the growth rate of submerged plants and work well when used in concert with grass carp. They must be applied before growth begins in the spring and maintained throughout the growing season. They may not be economical if your pond is being flushed regularly from storm events, and they will not work in very shallow ponds.
5. Contract with a lake management company to apply aquatic herbicides. Some submerged plants may elude control by other methods and will require chemical treatment. Aquatic herbicides are helpful tools for managing aquatic weeds, but they must be applied by licensed applicators when applying to stormwater ponds. For a list of applicators, look under "Lake Management" in the phone book or ask for a list of licensed applicators from the SC Aquatic Plant Management Society.
6. Educate your residents. Many invasive plants are introduced by well-meaning residents who toss water garden plants into ponds. Preventing introductions is important for avoiding invasive weed problems. Also, informing home owners that nutrients from their daily activities (fertilizing lawns, car washing in driveways, pet waste, feeding ducks/fish/turtles, etc.) are accelerating submerged weed growth will help reduce plant populations and water pollution in general.



4.4 Floating Plants

South Carolina has a diverse community of plants, which entirely or at least partially float on the water's surface. Although many floating plants are extremely attractive and are a large part of the water gardening industry, they often create serious problems when introduced into stormwater ponds.

Floating plants can be divided into three categories:

1. **Free Floating** - These plants float freely on the water surface. The entire plant is suspended on the water, allowing the plant to be moved around the pond by wind and water currents. Plants such as duckweed, mosquito fern, waterhyacinth, and watermeal are free floating.
2. **Submersed Floating**- These plants are anchored by roots to the bottom of the pond, but their leaves and flowers grow to and float on the water surface. Plants such as waterlilies, lotus, watershield, and spatterdock are floating-leaved plants.
3. **Trailing Floating** - These plants are rooted into the shallow areas nearest the bank and have a "trailing" or "creeping" growth habit which allows them to form floating mats that extend out over the water surface. Plants such as waterprimrose, alligatorweed, pennywort (dollarweed), parrot-feather, and smartweed form trailing floating mats.

Are floating plants good to have in stormwater ponds?

Generally, no. The primary purpose of a stormwater pond is to manage stormwater runoff to prevent flooding and reduce pollutant loading to rivers and beaches. Floating plants have great potential to interfere with how a stormwater pond manages runoff. Free-floating plants are a significant threat because of their mobility. They can and will move to the outfall and clog the structure, which is responsible for regulating water level in the pond. A clogged outfall will force water to back-up through the system and cause flooding around and above the pond. Submersed floating-leaved plants interfere with the flow of water through the pond and can create areas of accelerated sedimentation and stagnancy. These plants impede flow and may reduce the pond's ability to trap and treat pollutants, increasing the likelihood that pollutants will be discharged to receiving rivers and beaches. Trailing floating plants also have the potential to impede flow and contribute to rapid sedimentation, but trailing floating plants do provide one benefit. They can protect shorelines from erosion and stabilize banks. For this reason it is recommended that trailing floating plants be limited to the shoreline but not removed entirely, except for the highly invasive species such as alligatorweed and water primrose. All floating plants have the potential to create a barrier on the water surface that prevents oxygen exchange with the atmosphere and photosynthesis in the water; therefore, uncontrolled growth of floating plants will reduce oxygen in the water and increase the potential for a fish kill. It is recommended that floating plants be prevented from covering more than 20% of the pond surface.

Should I plant floating plants in my pond?

No. Aside from the problems previously mentioned for stormwater ponds, it must be noted that most floating plants have very fast reproductive rates. What may seem harmless this year could get out of hand very quickly and cost your community a lot of money to fix. Also, many floating

plants are considered illegal aquatic plants in South Carolina and transportation or sale of these plants is a violation of state law (see SC DNR Aquatic Nuisance Species program).

How do I control floating plants in my pond?

This depends on the species of plant. Small free floating plants such as duckweed, watermeal, and mosquito fern can be controlled by stocking the pond with tilapia at a rate of 400 fish per acre. They are very difficult to control by mechanical or manual harvesting. Larger free-floating plants such as waterhyacinth and waterlettuce can be harvested, but are not eaten by tilapia or triploid grass carp. Submersed floating-leaved and trailing floating plants are not controlled well by harvesting or fish. They must be controlled using properly labeled herbicides applied by a licensed applicator. Several herbicides are useful for controlling floating plants and, if applied according to the label, will not impair the aquatic environment. If herbicides are necessary to control floating plants in stormwater ponds, the community must contract with a licensed applicator to apply the herbicides. Residents and HOA Board Members should never apply herbicides to stormwater ponds.

4.5 Plants That Grow Along the Shoreline

Shorelines are home to a unique community of plants, because they are essentially narrow wetlands. Plants that thrive at the water's edge must be able to grow in soils that are permanently saturated and have to survive extended periods underwater. These limiting conditions prevent most of the typical landscape plants from growing well in this zone. As a result, the majority of plants that naturally grow at the water's edge are unfamiliar to most homeowners, and often acquire the label "weed". This is unfortunate because the benefits of cultivating these native plants largely outweigh the negatives, especially along the banks of stormwater ponds. Considering the benefits, it is recommended that wetland plants be protected around stormwater pond shorelines.



Shoreline plants help to:

1. prevent erosion and stabilize the bank;
2. remove nutrients that contribute to algae growth;
3. filter debris and pollutants;
4. provide cover and forage for fish, frogs, and song birds;
5. shade the water; and
6. baffle wind and wave energy.

Is turf grass a good shoreline plant?



No! Turf grass is not a wetland plant, and it does not grow well at the water's edge. Turf does well on the top of the bank slope. Although turf grass will

survive at the water's edge, its roots do not penetrate deep into saturated soils, and it is more prone to disease where it stays too moist. Over time, the shallow roots of turf will be undercut by erosion, and the bank will slump. Also, turf grass does very little to filter runoff and protect water quality. On the contrary, the fertilizers and pesticides used to keep turf healthy pose a significant threat to water quality and are not recommended on the bank slopes of stormwater ponds. Also, the repeated broadcasting of grass clippings into the water each time the bank is mowed will contribute nutrients to the water and exacerbate algae growth.

If turf doesn't work, what plants are recommended?

A variety of native wetland plants with deep, robust root systems are suited for pond shorelines. It is recommended that plants with a vertical growth habit be used rather than plants with a "creeping" or "trailing" growth habit to reduce the potential for spread into the pond and clogging pipes. Vertical shoreline plants are usually restricted to the shoreline because they typically cannot grow in water deeper than 12 inches and cannot spread up the bank beyond where the soils remain wet. There are a number of very attractive flowering plants that are quite easy to grow in this zone, including several irises, lillies, rushes, and other perennial flowering plants. For more information and a plant list, see the shorescaping fact sheet in Appendix A and online at <http://www.clemson.edu/extension/hgic/water/index.html>.

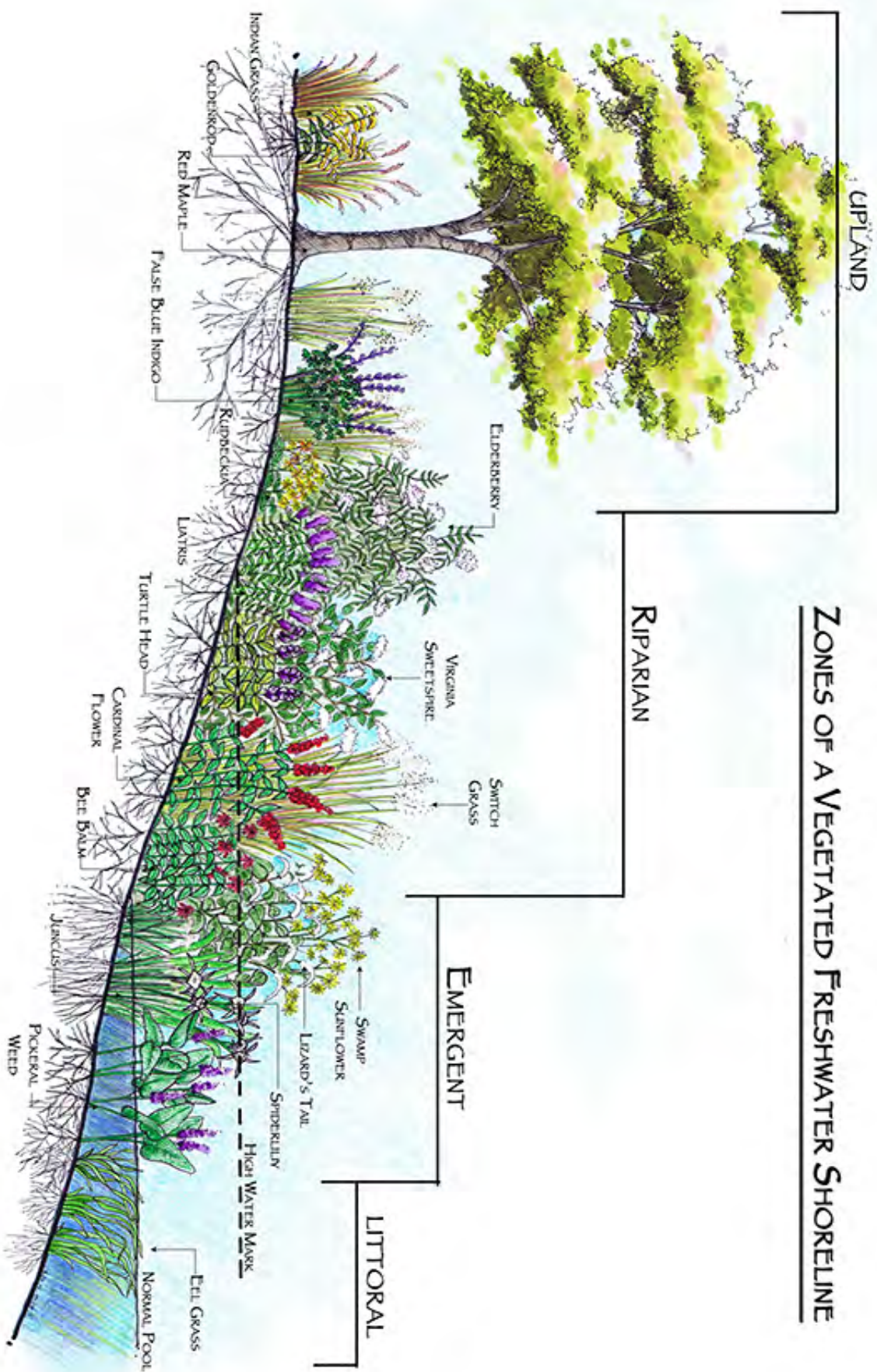
Are there any plants that I should avoid along my shoreline?

Yes. Turf grass should be avoided along shorelines, as it does not prevent erosion or filter nutrients. The basin of a stormwater pond needs to be open and free of large obstructions; therefore, trees and large shrubs should not be allowed to grow on the bank slope or at the water's edge because they can obstruct maintenance equipment and reduce storage capacity in the basin. Also, deciduous trees drop leaves each fall, which can accelerate sedimentation in the pond. As mentioned above, trailing plants that grow horizontally have the potential to grow large mats that extend over the water surface, impede flow and circulation, and can clog pipes and outfalls. It is not recommended that plants such as alligatorweed, waterprimrose, parrotfeather, or pennywort, which grow laterally over the water be allowed to form large mats that extend from the shore. Many homeowners find cattails to be undesirable because they grow tall, obstruct views, and spread rapidly. For this reason, you may choose to eliminate cattails; however, cattails provide excellent erosion control and absorb nutrients efficiently. Finally, there are several plants that grow in ponds that are considered illegal plants in South Carolina because they are invasive exotics that impair freshwater systems. Plants that are on the illegal plants list should never be introduced into stormwater ponds.

Will I attract snakes and other nuisance wildlife if wetland plants grow on my shoreline?

Shoreline vegetation provides food and cover for aquatic animals, so it is likely that frogs, fish, songbirds, and wading birds will inhabit shorelines that have a diversity of native plants. It is difficult to make the shoreline suitable for these attractive animals without also attracting their predators, so a pond bank that has a large number of frogs and birds will occasionally attract a snake that feeds on those animals. However, this is of limited concern around stormwater ponds, because the shoreline plants form a very narrow band around the pond due to the steep slope of the bank. In the event that a snake is sighted, it should be viewed as a positive indication that the plants are functioning as intended and are minimizing pollution, stabilizing the bank, and providing cover for desirable animals. It should be noted that the majority of snakes in South

Carolina are non-venomous. Shoreline plants may also help deter some nuisance wildlife. Ducks and geese find it difficult to traverse a shoreline with the vertical emergent plants. Also, muskrats have a more difficult time digging burrows in well-vegetated pond banks.



Zones

The Littoral Zone – the area below the water line that is too deep for emergent plants but still shallow enough that sunlight can penetrate through the water to the bottom. The littoral zone usually is 1 to 4 feet deep but may be deeper if the water is very clear. Many aquatic plants that grow in the littoral zone can be invasive, especially in shallow stormwater ponds, so it is important to manage submersed and floating-leaved vegetation to prevent clogged outfalls and fish kills.

Plants for the Littoral Zone:

Coontail *Ceratophyllum demersum*

Tape-grass *Vallisneria spiralis*

The Emergent Zone – the part of the bank slope that lies below the water line but is shallow enough to allow emergent aquatic plants to root in the submerged soil and grow upward above the water's surface. The emergent zone is usually less than 12 inches deep. Avoid emergent plants that have a "creeping" lateral growth habit such as water primrose and alligatorweed. Vertical plants are easier to manage in the emergent zone.

Plants for the Emergent Zone:

Pickerelweed *Pontederia cordata*

Arrowheads *Sagittaria latifolia*, *S. lancifolia*

Arrow Arum *Peltandra virginica*

Lizard's Tail *Saururus cernuus*

Alligator Flag *Thalia geniculata**

Golden Canna *Canna flaccida**

White Star Sedge *Dichromena colorata**

The Riparian Zone – the part of the bank slope that lies above the water surface but where the soil remains permanently wet and saturated. The riparian zone often is inundated with water when pond levels rise during storms. Plants that thrive in this zone need moist soils and can withstand extended periods submerged under water but prefer to grow at or just above the water line.

Plants for the Riparian Zone:

Soft Rush *Juncus effusus**

Bulrush *Scirpus spp.**

Louisiana Iris *Iris (hexagonae group)*

Blue/Yellow Flag *Iris virginica*, *I. pseudocoris*

Spider Lily *Hymenocallis palmeri*

Mallow Hibiscus *Hibiscus moscheutos**

Swamp Sunflower *Helianthus angustifolius**

Cardinal Flower *Lobelia cardinalis*

Bog Lily *Crinum americanum*
River Oats *Chasmanthium latifolium**

White-top Sedge *Dichromena colorata**
Lizard's Tail *Saururus cernuus**

The Upland Zone – the part of the bank slope above the riparian zone where soils do not stay permanently moist. This zone often is very dry because the slope forces water to runoff rather than seep into the ground. Upland zones with very steep slopes will need plants that are very drought tolerant. In most cases, the ornamental plants that are commonly used in the home landscape are useful in this zone. Residents that live next to stormwater ponds in residential neighborhoods should avoid planting trees and large shrubs on the bank slopes. Perennials and grasses are best in this zone.

Plants for the Upland Zone:

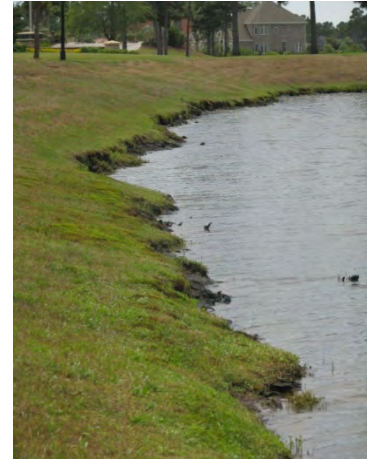
Native Grasses* (Weeping Love Grass, Big Bluestem, Muhly Grass, Switchgrass, Indian Grass)
Native Perennials (Butterfly Weed, False Indigo*, Tickseeds, Coneflower*, Hardy Ageratum, Blazing Star, Verbena*, Goldenrod)
Other Perennials (Sunflower Heliopsis, Daylily*, Bearded Iris*, Red Hot Poker, Lantana*, Lavender*, Creeping Phlox, Salvia, Stonecrop, Purple Heart)

**Special note* Many ponds have large populations of ducks and geese which can damage shoreline plants by trampling and grazing. Plants marked with an asterisk (*) are known to be resistant to waterfowl damage.*

For more information on shoreline plants, see Clemson's HGIC H2Ownership Shorescaping fact sheet in Appendix A.

5.0 Shoreline Erosion

Shorelines of stormwater ponds are prone to erosion because there are many forces working to undermine the stability of the bank. In many communities, property lines and HOA easements are drawn relative to the pond shore. The loss of shoreline is the same as moving the easement toward the primary structure and reduction of useable real estate. Also, most communities consider it the responsibility of the waterfront property owner to manage their respective pond bank, so stopping shoreline erosion is up to the homeowner but may be restricted by the HOA bylaws. This means that the HOA has to determine what shoreline management strategies it will allow to enable the homeowner to prevent erosion of their property.



What causes shoreline erosion?

The most significant erosional force at the shoreline is also the most subtle. The simple lapping of ripples and loosening of saturated soils pulls soil particles apart just below the water surface; therefore, much of the bank erosion is occurring below the water level where it goes unseen until the exposed part of the bank slumps. Stormwater ponds are also designed to fill and drain with each storm event. The repeated rise and fall of water creates currents that pull soils away from the bank. Of course, water enters stormwater ponds through pipes that convey water from the paved surfaces in the community. The inlets where these pipes discharge into the pond are subjected to concentrated flow that can erode deep gulleys and holes and affect the adjacent banks. Finally, many ponds are designed to receive surface flow from grassy swales between houses. These swales receive water from the gutter downspouts and direct it over the lawn to the pond or to the street. These shallow swales concentrate sheet flow, which can create gulleys and depressions as the water flows down the pond bank slope.



Why are our banks eroding faster than the neighboring community?

Bank Slope: The slope of the bank is the single most important factor that determines rate of erosion. Steep banks with slopes greater than 3 to 1 (3 feet of run for every foot in height) are almost certain to erode and undercut over time if they are not stabilized.

Soil Type: The consistency of the soil also determines rate of erosion. Sandy soils have less structural integrity than soils made of clay. In the coastal plain (where the vast majority of South Carolina's stormwater ponds are located), soils consist of little or no natural rock and are often considered highly erodible.

Fountains: Surface fountains agitate the water surface, creating more wave action. In most cases wave action dissipates before it reaches the bank, but ponds with large fountains or fountains that are located near the shore are likely to experience accelerated shoreline erosion.

Nuisance Wildlife: Animals also cause erosion, especially when large numbers are confined to small ponds. Concentrations of ducks and geese are the most common destabilizers of pond banks because they eat shoreline vegetation and trample the bank. They also churn sediments near the bank as they sift for invertebrates in the mud. Another problematic animal is the muskrat because they burrow into the bank to make their dens, and they consume shoreline vegetation. Dens can collapse unexpectedly and create large holes in the bank slope.

Lack of Protection: The most common way to manage shorelines in stormwater ponds is with turf grass that is mowed to the water's edge. This strategy provides very little structural integrity to the bank. Turf grass is not an aquatic plant, and its roots do not grow well in saturated soils. Turf grass will not send roots down below the water surface where the most significant erosion is taking place. As a result, pond banks with grass mowed to the edge are almost certain to undercut with time.

What can I do to stop shoreline erosion?

Although there is very little a community can do to change the bank slope or soil types around their ponds, there are significant improvements that a community can make to deal with the fountains, nuisance wildlife, and lack of protection that are accelerating shoreline erosion.

Fountains: Stopping erosion caused by fountains is simple. Either move fountains to the center of the pond away from banks or consider replacing the fountains with other circulation systems (see section on Aeration and Circulation Systems). Diffuser systems do not agitate the water surface as much as fountains.

Nuisance Wildlife: Unfortunately, dealing with nuisance wildlife that are causing bank erosion is not as simple as fountains. Stormwater ponds are suitable habitats for ducks and geese when residents are feeding the birds. When residents stop feeding ducks and geese, there normally are not enough food resources in residential communities to sustain large flocks of waterfowl, so the birds eventually move on. If waterfowl are persistent even if the community curtails all feeding, then it may be necessary to contact a nuisance wildlife control operator to have the birds trapped and removed (see section on Controlling Waterfowl). The only way to control muskrats in stormwater ponds is to have them trapped. Because muskrats are a fur bearing species, only licensed persons can trap and transport them (see section on Controlling Beavers and Muskrats).

Protect the Shoreline: Pond shorelines can be stabilized using two general strategies: 1) emergent wetland plants or 2) artificial materials (such as rip-rap or bulkheads). Each has its advantages and disadvantages, which the community should consider carefully.



How do I use plants to stabilize my pond bank?

Do not use turf grass to stabilize pond banks. Turf grass has a shallow root network and does not prevent erosion. Wetland plants established on the shoreline are a preferred method for stabilizing pond banks, and they provide many benefits beyond erosion prevention. The deep, robust root systems of these plants bind soils in the area where the majority of erosion is occurring, just below the water surface. Unlike turf grass, these plants thrive in saturated soils. The main advantage of planting

shoreline plants is that they provide other services such as filtering pollutants in runoff, absorbing nutrients that grow algae, trapping sediment and yard debris, deter nuisance wildlife, provide cover and forage for fish and invertebrates, and dampen wind and wave energy. For guidance on which plants to use for stormwater pond banks, consult the Shorescaping fact sheet.

Why not use bulkheads to stop erosion?

Bulkheads provide excellent erosion control if they are installed properly. The toe of a bulkhead needs to extend down into the pond bottom, the sides should be built with wing protection, and the top of the bulkhead needs to be anchored into the slope with a dead-man anchor. Without these measures, bulkheads are likely to breach and fall into the pond or to be undercut and erode from beneath and around the sides. (For design suggestions, refer to the Army Corps of Engineers Bulkheads & Seawalls). All waterfront owners must be aware that each stormwater pond basin is designed to be a very specific volume to meet storage requirements determined by local regulations according to the size of the pond's watershed. If waterfront owners begin building high bulkheads and back-filling behind them, they are reducing storage in the basin. If bulkheads are not regulated by the HOA and high bulkheads proliferate, then the community may be liable for damages incurred from downstream flooding because the community has chosen to alter the engineer's original design. If the community chooses to allow bulkheads, it must be very careful to preserve the storage capacity of the pond and also not impede flow. This is best done by requiring that bulkheads be no higher than a foot or two above normal pool.

There is an easement around my pond. Does that affect what I can do to the shoreline?

Many communities have established easements around ponds. Most commonly the easement extends up the bank 10 to 15 feet from the normal water line. In some cases this easement is merely for maintenance, and what goes on in the easement is determined by the HOA's bylaws. In other instances, the pond is owned/maintained by a municipality rather than an HOA, so it is important for homeowners to know the rules about activities in the easement and who has authority over those activities. Activities such as planting plants or building bulkheads may be restricted by the terms of the easement, and homeowners may be liable for damages and repairs for illicit activities in the easement. Nevertheless, the terms of easements can be changed if the community feels the need to do so. For HOAs, this may mean amending the bylaws.

6.0 Nuisance Wildlife in Stormwater Ponds

South Carolina's surface waters are home to a great diversity of wild animals. Many of these animals are considered desirable and even have become icons of the beauty of South Carolina's wetlands. In fact, the opportunity to see animals such as herons and egrets, frogs and fish, turtles and alligators, and beavers and otters on a regular basis plays a significant role in why many residents choose to call South Carolina home.

Stormwater ponds, although highly engineered and very different from South Carolina's natural waterways, do attract a number of wild animals. Some of the wild visitors to stormwater ponds are considered by homeowners to be desirable, while others are thought of as nuisances. This webpage addresses some of the common "pest" animals in order to provide control recommendations but also to dispel many of the misconceptions made about your pond's wild residents.

6.1 Managing Waterfowl in Stormwater Ponds

Although migratory by nature, ducks, geese, and swans often choose to reside in residential stormwater ponds year-round because there are few predatory threats and they can find suitable habitat. As a result, populations of these birds can grow to the extent that they begin to cause significant property damage and become a health concern for themselves, for residents in the community, and for swimmers, surfers, and fishermen using rivers and beaches downstream.

Are there benefits to having waterfowl in a stormwater pond?

Very few. The most significant benefit is aesthetic and a matter of opinion. Having at least some ducks, geese, or swans in a pond does make the pond seem more natural and appealing. Also, waterfowl can be very playful and an enjoyment to watch. Otherwise, waterfowl do not provide any real management services such as controlling weeds or managing pollution. Quite the contrary, concentrated populations of these birds can cause serious property damage and water quality problems in stormwater ponds.



What is so bad about waterfowl in stormwater ponds?

Large aggregations of waterfowl cause significant damage to stormwater ponds. Large groups of ducks, geese, and swans can:

1. erode shorelines by trampling and feeding on shoreline plants,
2. destroy lawns and gardens,
3. introduce invasive weeds that are stuck to their feathers and carried in their digestive tracts,
4. deposit large volumes of feces (excrement) that increase algae and weed growth and introduce disease causing pathogens into the water that threaten the health of residents, pets, and the birds themselves,

5. make water muddy and cloudy as they sift through the mud for invertebrates,
6. become aggressive with children and pets, and
7. create unsightly conditions when they molt (shed feathers) and leave feces and feathers in yards, on porches, and on driveways and roads.

How many ducks/geese is too many for a pond?



Two birds per acre of pond is a manageable number that will not result in significant property damage or water quality impairments. This number should be considered as an average because ducks are highly mobile and migratory. At certain times of the day, ducks in the community may aggregate in one area or another, and at certain times of the year (mainly the winter months) migratory birds may temporarily reside in a community's ponds. At other times, ecological pressure (competition and predation) will force the birds to disperse and move on.

How can we reduce the number of waterfowl in our ponds?

Stop feeding them! Although stormwater ponds provide suitable open space and water for ducks and geese, they do not usually provide adequate food. Waterfowl require a diversity of plants and invertebrates for healthy growth, and stormwater ponds do not normally have the appropriate food base to sustain large groups of waterfowl. The primary reason waterfowl aggregate in stormwater ponds is that their diet is being supplemented by humans. Before any other strategy can be employed, a community that is trying to reduce waterfowl numbers *MUST* curtail all feeding of birds; otherwise, other efforts will be futile.

Deterrents: There are numerous products on the market that will upset the behavior of waterfowl and encourage them to move elsewhere. These include decoys of predators and dead birds, noise making devices, motion-sensing sprinklers, flashing lights, trip wires, chemical repellents, and more. These devices are useful in small scales, but may not produce the desired level of control for the entire pond or throughout the community. ***special note - Read the directions on these products carefully. The manufacturer may provide hints for increasing the effectiveness of the product, such as moving predator decoys each week to ensure that the birds do not get used to a static decoy.***

Trapping: In some instances stopping feeding and deterrents are not encouraging the birds to find a new home. If this is the case, the community may need to have the birds removed by a professional. The community should contact a licensed nuisance wildlife control operator to have the birds trapped or dispatched. Even though these birds may seem domesticated, they are still considered by the federal government and the State to be protected migratory animals, and residents may be in violation of the law if they trap or dispatch birds out of season and without license. A licensed nuisance wildlife control operator can work with the state to acquire any necessary permits for the removal of large groups of nuisance waterfowl. Consult the SC Department of Natural Resources list of Nuisance Wildlife Control Operators [for a professional near you.](#)

Are there any laws about having or stocking ponds with waterfowl?

Yes, but they are determined at the local level. Some counties and municipalities have

ordinances that prohibit feeding waterfowl or creating other conditions that result in the aggregation of waterfowl in stormwater ponds. These ordinances vary from county to county and city to city, so it is important for your community to check with the local government to find out if there are restrictions on feeding waterfowl. Some municipalities and counties have no such ordinances. Some HOAs have taken the next step and made feeding waterfowl a violation punishable by a fine, so check your HOA's bylaws as well.

6.2 Managing Turtles in Stormwater Ponds

Turtles are prolific throughout South Carolina's wetlands, and several species are well adapted to live in stormwater ponds. In fact, it is almost inevitable that once a pond is dug, that at least a couple of turtles will find it to be a suitable home. For many residents, this is an attractive thought, but others may not be too enthusiastic about having a large number of turtles around the pond.

Do turtles cause problems in stormwater ponds?

Not normally. On rare occasion, a resident may report seeing a turtle bite the foot of a duck, and in large numbers, turtles can cause muddy water conditions as they stir-up bottom sediment. Otherwise, turtles do not pose a significant threat to the management of stormwater ponds, although large populations of turtles can damage or destroy floating vegetated island plants.

Do turtles pose a health threat?

Maybe. The most significant problem with large numbers of turtles around stormwater ponds happens when humans handle turtles. Turtles can carry *Salmonella*, an infectious bacterium, and contact with a turtle can result in *Salmonellosis*. *Salmonella* can reside on the surface of a turtle but must be ingested to infect humans. The most common method of transfer occurs with people handle turtles and then eat without washing their hands. It is recommended that residents not handle turtles. If they do, then they should thoroughly wash their hands immediately.

How do we reduce the number of turtles in our pond?

Stop feeding them! Stormwater ponds do not normally have enough food resources to sustain large numbers of turtles. Where they are not being fed, turtles usually number fewer than 5 individuals per acre. Where they are fed, they may number in the dozens per acre. If feeding is stopped, the turtles will disperse to find other food resources and usually do not need to be trapped and relocated.

6.3 Controlling Snakes around Stormwater Ponds

In South Carolina, encounters with snakes are common and the vast majority of them go without incident. Of the 42 species of snakes that live in South Carolina, only 6 are venomous, and only two of these consistently live near water, the copperhead and the cottonmouth (a.k.a. watermoccasin). Several non-venomous species live near water, and to the untrained eye they resemble their venomous relatives. Both the venomous and non-venomous "aquatic" snakes are using the same food resources: fish, bird nests, ducklings, frogs, small mammals and insects. Combine food, water, and cover, and the habitat may be suitable for water-loving snakes.

How can venomous snakes be distinguished from the non-venomous snakes?

Both species of "aquatic" venomous snakes are pit vipers, meaning that they have small pits in front of their eyes. They also have stocky bodies, triangular heads, and elongated pupils like cat eyes. Their non-venomous relatives are longer and leaner, have rounded heads, no pits, and round pupils like human eyes. It is not advised that inexperienced residents get close enough to snakes to determine presence of these characteristics.

Do snakes cause management problems for stormwater ponds?

Other than frightening residents, snakes do not negatively affect how the pond functions or the ecology of the aquatic ecosystem. In fact, snakes may help manage the pond by keeping frog, duck and insect populations in check. They also indicate that your pond is biologically productive and is producing the resources the snake needs to survive.

How can I control snakes around my pond?

Snakes have a place in the environment and should be avoided rather than removed. On the other hand, if a particular snake is occupying a space to be used by a resident (porch, lawn, dock, etc.) then the resident may choose to have the animal removed. Unless the homeowner is familiar with snakes and can determine venomous from non-venomous species, then the waterfront owner should contact a licensed nuisance wildlife control operator to have the animal trapped and removed by a trained professional.

Are there any deterrents to repel snakes?

Yes. Several repellents are labeled to deter snakes, but these products produce inconsistent results. Several environmental factors (temperature, time of day, duration since last application, humidity/precipitation) affect the effectiveness of these compounds. Moth balls (naphthalene) are not a recommended snake deterrent.

Should I remove shoreline plants to reduce cover for snakes and their prey?

Reducing cover will reduce the likelihood of a snake encounter, but it may result in more significant and costly problems than the snake. Shoreline plants should be protected right at the water's edge in order to prevent erosion and limit pollution in the pond. Above the immediate shoreline on the bank slope, homeowners may choose to reduce cover by mowing regularly, but plants at the water's edge should be protected. Trees and shrubs should be minimized on the bank slope. (See section on Shoreline Plants)

For more detailed information on the biology and identification of snakes of South Carolina, the publication, *Snakes of Georgia and South Carolina*, is available for purchase at your county's Extension office or from Clemson's PSA Publishing website.

6.4 Fish and Invertebrates

Fish and invertebrates are not normally considered to be nuisance organisms in ponds except for a select few species. Considering that fish and invertebrates are some of the most species rich of all of the groups of animals, there is no way that this page can cover the biology and control of all of these animals. It must be noted, however, that most fish and invertebrates are either beneficial or benign to stormwater ponds or are not adapted to survive well in these artificial

aquatic environments. That being said, there are a few fish and invertebrates that may become nuisances if released into a stormwater pond. They are discussed here briefly.

What fish can be a nuisance in stormwater ponds?

The most problematic fish in stormwater ponds is the Common Carp or Israeli Carp. The common carp (*Cyprinus carpio*) is sometimes mistakenly stocked in ponds to control aquatic weeds or as an ornamental fish. Unlike the sterile grass carp, these fish can reproduce quickly in small ponds and affect water quality and the health of other fishes. The most significant problem common carp cause is muddy water. They have a tendency to root in the bottom and stir bottom sediments as they bed and feed. This can be a problem for stormwater ponds whose purpose it is to trap sediments coming from the development. Muddy water may affect fish health in the pond and may result in water quality impairments downstream. It is recommended that common carp be completely removed from stormwater ponds.

Other introduced fish may become problems as well. **No aquarium animals should ever be released into stormwater ponds!** Oscars, pacus, suckers, goldfish, koi, golden shiners, and many other fish have the potential to cause significant problems in ponds and receiving waters downstream. **Special note** Two fish have received special attention recently because of their potential to become invasive in South Carolina public waters. The northern snakehead and silver carp (a.k.a. Asian carp) are causing significant problems in other states but have not been introduced into South Carolina yet. Do not allow your stormwater pond to be their point of entry.

Stormwater ponds should be stocked with fish to help maintain biological services and the ecological balance of the pond. The only fish that should be stocked in stormwater ponds are bream (bluegill/redbreast), largemouth bass, triploid grass carp, and tilapia. See section on Fish Stocking and Harvesting.

How are nuisance fish controlled?

The only absolute control for common carp and other nuisance fish in stormwater ponds is to drain the pond and harvest the fish. Though this may seem drastic and invasive, this will protect the ecological integrity of the pond in the long run. Other fishes (bream, bass, triploid grass carp) can be restocked and will rebound rapidly once the nuisance fish are removed.

What invertebrates cause problems in stormwater ponds?

There had been little concern over invasive invertebrates in stormwater ponds, until the Island Apple Snail was released into a stormwater pond near Myrtle Beach, SC where it quickly spread to neighboring ponds and into the Intracoastal Waterway. The island apple snail (*Pomacea insularum*) has the potential to decimate native plants, displace native snails and other molluscs, and has the potential to transfer meningitis. Its introduction has drawn attention to the threat of other freshwater invertebrates, which may be moved via the aquarium trade and mistakenly released into a pond by a well-meaning but misguided resident. Other freshwater invertebrates such as zebra mussels are not established in South Carolina yet, but have officials on the lookout.

How are invasive invertebrates controlled in stormwater ponds?

If you suspect that you have an invasive invertebrate such as island apple snails or zebra mussels,

contact either your local wildlife office of the SC Department of Natural Resources or the SC DNR Aquatic Nuisance Species Program. They may be able to assist you with control.

Wildlife Section Offices of the SC DNR

- Charleston (843) 953-5291
- Clemson (864) 654-1671
- Columbia (803) 734-3886
- Florence (843) 661-4766

Are there any nuisance insects to worry about?

Sort of but not with stormwater ponds. Residents are often concerned about mosquitoes and other insects that emerge from ponds. Stormwater ponds are not normally suitable breeding habitats for mosquitoes. The ponds are too deep, the water surface has too much motion, and there are too many predators (fish and other insects) for mosquitoes to effectively breed in ponds. The only time when ponds become suitable mosquito habitat is when they become overrun with vegetation that covers the surface. The plants make small pockets and microhabitats suitable for development of mosquito larvae. Often residents will complain about a massive emergent of mosquito-like flies that do not bite, but they get into the house or cover the lights and siding. These insects are most likely the Midges (Chironomidae), which are small flies that look like mosquitoes with the naked eye but do not bite. Midges do thrive in stormwater ponds and often have mass emergences, especially in late spring and early summer. The good news is that they usually are short lived and do not cause any property damage or pose a health risk at all. If midges get into your house, it is best to control them with a vacuum cleaner with an extendable hose.

How can our community control mosquitoes?

The mosquitoes that are most problematic in neighborhoods with stormwater ponds are usually coming from other water sources than the ponds. Clogged gutters, bird baths, drip trays under potted plants, buckets and toys that collect rain water are common breeding habitats for mosquitoes. Also, a few mosquitoes reproduce in isolated pools in the marshes and forests. The best way for home owners to manage mosquitoes is to 1) reduce mosquito breeding sites by emptying containers that collect rain water and 2) protect themselves using repellents and long clothing. For more information on dealing with mosquitoes, consult your local mosquito control program or the Department of Health and Environmental Control.

6.5 Beavers, Muskrats, and Otters

Beavers, Muskrats, and Otters are aquatic mammals whose ranges cover most or all of South Carolina, so there is potential for almost any pond in the state to harbor these fur-bearing animals. Although interesting to watch, these animals can be problematic when they move into stormwater ponds. It is important to be able to identify each animal to determine the potential for damage, because these three mammals have different behaviors and cause different kinds of damage. Early morning hours are the most likely time to catch a sighting of these animals. Otherwise they may be identified by evidence of their activity.

How can these animals be distinguished from one another?

Beavers (*Castor canadensis*) are the largest of the three species (40 to 60 lbs) and also are the slowest swimmers. They have large, leathery, paddle-like tails that they use in several ways, the most indicative of which is slapping the water surface when disturbed. All toes are webbed which can be evident in tracks around the pond. Beaver are probably best identified by the work they do and the damage they cause. Beavers often girdle trees and shrubs around the pond, they block pipes and the outfall with sticks, logs, and mud, and they construct wood and earthen dens or burrows into the bank. It is recommended that beavers be removed from stormwater ponds because of the property damage they cause, the potential for flooding, and the destabilization of the bank.

Muskrats (*Ondatra zibethicus*) are the smallest of the three species (2 to 4 lbs) and are moderate swimmers. They are distinguishable from beavers by their smaller size and the characteristics of the tail and feet. Muskrats have a tail that is flattened vertically (the opposite of the beaver) and is longer and more "rat-like." Their feet have skin folds between the toes but not the extensive webbing that beavers have. Muskrats are not as damaging as beavers because they do not block pipes and outfalls with sticks and mud. Muskrats may girdle trees and shrubs and eat other landscape plants, but their most significant damage is caused by the burrows they build in the bank slope. These burrows can undermine bank stability and are especially problematic for ponds that are held in place by earthen dams. The burrows can breach the dam causing washouts, water loss, and downstream flooding. It is recommended that muskrats be removed from stormwater ponds.

River Otters (*Lontra canadensis*) are easily distinguished from beavers and muskrats by several characteristics. Otters are longer and leaner, they are agile, fast swimmers, and they have long, round tails that are covered in fur. They have sharp, predatory teeth. Otters are more vocal than beavers and muskrats, letting out the occasional yelp or bark. Otters also can be identified by the evidence they leave behind. Otters tend to enter and leave ponds in the same place, which over time creates a worn area known as an otter slide. Otters also tend to dine on the fish they have caught on the bank in the same area, so there may be an area beside the pond that is riddled with fish bones and scales. River otters do not pose a significant threat to property, pets or humans. The most significant problem they cause is consumption of fish. If your community has stocked triploid grass carp, otters may remove them from the pond. Many residents regard otters as desirable animals because of their playfulness and curiosity. It is recommended that they community determine for itself, if otters are to be allowed to remain in the pond. Aside from depleting fish populations, they are unlikely to cause other problems.

How are these animals controlled?

South Carolina regards all of these animals as furbearing species, which are protected under state law. A license is required to trap, dispatch, and transport these animals. Contact your local wildlife office of the SC Department of Natural Resources for guidance on removing these animals. Also, you may contact a licensed Nuisance Wildlife Control Operator to have them trapped and removed for a fee. Consult the Nuisance Wildlife Control Operators list to find an operator near you.

6.6 Alligators

The American alligator (*Alligator mississippiensis*) is an iconic species for wetlands of the southern United States. It is an apex predator that has long held the awe and respect of people who have had the opportunity to see it in its natural setting. It also is one of a few wild animals that has been condemned as a man-eater. As a result, alligators carry a stigma that generates fear and angst among many residents, especially when these animals venture into residential ponds. Alligator populations are rebounding from their once threatened status. Their expanding populations are venturing into new habitats, and some alligators have found their ways into stormwater ponds. This is to be expected because stormwater ponds provide suitable habitat for alligators.

Alligators are opportunistic carnivores, taking advantage of available food resources. In stormwater ponds this predominantly means fish, turtles, and waterfowl. Alligators are typically shy and avoid humans and pets. In some cases, large alligators (>6ft in length) may become curious about small pets and children especially if residents are feeding them. Small alligators (<6ft in length) do not constitute a major threat, and in some cases actually may be helpful to leave in the pond because they will deter ducks, geese, muskrats, and beavers and cull unhealthy fish and turtles.

Alligators are a protected game species in South Carolina, and only individuals issued a permit are allowed to harvest them. If your community has deemed an alligator to be a significant nuisance, you should contact your local DNR office to acquire a permit.

Please read the following statement taken from the SC Dept. of Natural Resources DNR News, 17 July 2009.

"It is up to the landowner's discretion to determine if the alligator is considered enough of a problem to warrant the removal of the animal. Except in cases involving rare or endangered species, control of nuisance wildlife and animal damage is the responsibility of the individual property owner. DNR maintains a list of wildlife control operators that provides wildlife control services, and like most businesses, does charge a fee for this service. The amount charged is negotiable between the customer and the wildlife control operator, and will often depend on the distance traveled, number of trips required, time expended, and/or number of animals removed. The alligator permit is issued to the landowner and they can remove the alligator themselves, or have someone else such as a friend or neighbor do the work as a no-cost alternative to hiring a wildlife control operator. A list of wildlife control operators that have indicated that they will remove alligators for a fee is included with all alligator permits."

Call the following numbers if you have a nuisance alligator during normal business hours:

- (843) 953-9856 (in Charleston)—Berkeley, Charleston and Dorchester counties
- (843) 546-8119 (in Georgetown)—Darlington, Dillon, Clarendon, Florence, Georgetown, Horry, Kershaw, Lee, Marion, Marlboro, Sumter and Williamsburg counties

- (803) 734-3898 (in Columbia)—Aiken, Allendale, Bamberg, Barnwell, Calhoun, Lexington, Orangeburg, and Richland counties
- (843) 844-8957 (in Green Pond)—Beaufort, Colleton, Hampton and Jasper counties

6.7 Frogs and Salamanders

Frogs and salamanders are common in the wetlands of South Carolina and may find your community's stormwater ponds to be a suitable place to reside and reproduce. Following rainstorms and in summer evenings, the stormwater pond may light up with a chorus of frogs that may number in the hundreds or even thousands. While many residents find these amphibians to be attractive, other members of the community may become annoyed by the noise or the feces they may deposit on the siding of the home. Others still may be concerned that these animals are poisonous and a threat to pets and children.

Are amphibians bad?

No. Amphibians, frogs or salamanders, do not pose a significant management problem for ponds. In fact, their presence should be valued. Frogs and salamanders are often referred to as "environmental indicators" because they are sensitive to pollution in the environment. Being that they spend part of their lives in the water, frogs and salamanders are dependent on having good water quality. As water quality deteriorates, so do their populations. If your pond has a loud chorus of frogs, that should be taken as a sign that the quality of the water is at least good enough to sustain them. Because they are more sensitive to pollution than humans or even fish, the presence of large numbers of frogs indicates that the aquatic ecosystem of the pond is not impaired by pollution that could affect human health. Also, frogs are voracious predators of insects, so they provide a natural control for nuisance insect populations.

Do amphibians cause any problems?

Tree frogs are notorious for leaving feces on siding, especially around lights at night where they are catching insects. Likewise, toads will do the same on the ground on the porch or deck below outside lights. This problem is easily remedied with a hose or pressure washer, except with stucco siding, which may require some extra care. Also, some salamanders and toads do excrete mild toxins from their skin. The toxins are not significant enough to affect human health, but it is advised that residents avoid handling these animals. If they are handled, residents should wash their hands thoroughly. Dogs that pick-up toads in their mouths may develop foamy saliva in response to a mild toxin that is secreted from glands behind their eyes. This is a temporary condition that does not cause long-term damage to the dog.

Are there any ways to deter or control frogs?

Not really. There are no pesticides or repellents labeled for use against amphibians. The best way to reduce staining of the deck or siding is to turn the outside lights off during the time of highest insect activity, which is between 30 minutes before dark and 30 minutes after dark. Turning the lights off during this time will reduce the number of flying insects that are attracted to your home and reduce the potential for attracting frogs too.

7.0 Water Quality in Stormwater Ponds

Stormwater ponds are designed to receive runoff from the surrounding development in part to manage the pollutants that may be contained in that runoff. Fertilizing lawns, pet waste, washing cars, painting, pressure washing, construction, automotive maintenance, pesticides, feeding wildlife, and many other homeowner activities contribute to runoff pollution, so there is tremendous potential for pollutants to enter stormwater ponds. In commercial watersheds, other sources of pollution are present, such as unprotected grease bins at restaurants, leaking dumpsters that are not covered, automotive fluids at maintenance shops, and so forth. Considering all of these potential pollution sources, it is difficult to determine what is or is not in stormwater pond water or the sediments in the bottom of the pond, but it is very likely that all stormwater ponds contain at least some pollution.

Are there any signs that indicate that a pond is polluted?

Nutrients from fertilizers and animal wastes produce the visual cues that are easiest to recognize. They grow algae. This growth may be evident through changes in water color such as cloudy, pea soup water or as floating mats of filamentous algae. (See section on Aquatic Weed Control) Rainwater is naturally low in nutrients. It is only when rain water picks up nutrients from roads and lawns that it builds-up enough nutrients to grow large blooms or mats of algae; therefore, stormwater ponds develop algae growth mainly in response to the fertilizers and wastes that residents are depositing on lawns and paved surfaces. Considering that animal waste is not only a source of nutrients but also a source of pathogens and bacteria, it can be assumed that ponds that have significant algae growth are likely to have high levels of fecal bacteria and other disease causing organisms.



A fish kill also is a striking indicator of poor water quality, but the actual cause of a fish kill may be difficult to determine. Fish kills in stormwater ponds usually result from low oxygen events (largely associated with algae blooms or turnovers), but they also may be caused by pesticides, toxins, parasites, or natural causes. (See section on Fish Kill & Fish Health)

Another visual indicator of poor water quality is the formation of suds or films on the water surface or plumes of odd colored water. Oils and other insoluble compounds usually rise and form skims or sheens on the water surface. Plumes of colored water may be a result of painting or pressure washing activity. Suds or soapy water may indicate the discharge of detergents into the drainage system. Evidence of this sort indicates that an illicit material has been discharged into a storm drain or directly into the pond. (See section on Muddy Water, Surface Films, Foam, and Slime)

What can we do if we see an illicit discharge into our pond or storm drains?

Most of the municipalities and counties in South Carolina are required to respond to reports of illicit discharges. Many have established a hotline for such calls. If you see substances being dumped into your



storm drains or ponds, you can report that activity to your local public works or stormwater department. Also, the SC Department of Health and Environmental Control will respond to such reports. This is usually handled through the SC DHEC Environmental Quality Control offices. Homeowners associations also can develop their own bylaws that penalize residents who discharge illicit materials into ponds or storm drains.

What can we do about non-point pollutants that are not discharged directly into drains or ponds?

Non-point pollution is the collection of pollutants that are deposited on the land in the community and are not the result of a direct discharge into a drain or pond. This includes fertilizers from lawns, pet waste, residual pesticides, yard debris, etc. These pollution sources are best minimized by educating the community about the effects of stormwater pollution. Teaching neighbors that washing the car in the driveway is the same as pouring soap suds in the pond, and failing to sweep fertilizer granules off the road after application is the same as throwing handfuls directly into the pond is the only way to prevent these pollutants from entering the storm drainage system. Signage around ponds, community websites and newsletters, assemblies and meetings, and other media outlets are good ways to inform residents about stormwater pollution. For articles and tools to help inform residents about non-point pollution, visit Clemson's Carolina Clear Program website.



8.0 Muddy Water, Surface Films, Foam and Slimes

Ponds sometimes develop puzzling conditions. Muddy water, surface films, foam and slimes may develop seemingly without cause, but these conditions are the result of physical, biological, or chemical factors or some combination of these factors. This page discusses some of these conditions and the factors that cause them to develop in stormwater ponds.

Muddy Water

Several factors cause stormwater ponds to become muddy. The most common factor is erosion of soils either from runoff of exposed soils in the community or from unstable pond banks that are scoured by wave energy. It is to be expected that while a development is still under construction, its ponds are likely to be muddy. Also, ponds that do not have a vegetated border are likely to be muddy, especially after windstorms. The other most common cause of muddy water in stormwater ponds is biological, the result of fish, turtles, or waterfowl. Common carp (not triploid grass carp) are a significant threat to water clarity because they stir bottom sediments as they feed. Sometimes the spawning of bass causes muddy water in early spring (March-April) as they bed. Likewise, bedding of bream may result in muddy water during the summer months. Ducks, and to a lesser degree geese, also muddy pond water as they sift through sediments for invertebrates and uproot submerged vegetation. Ponds with more than two ducks per acre are more likely to develop muddy water. Rapid changes in water chemistry, though not the most common cause, may result in muddy water. Ponds may become muddy with a rapid change in pH, which may occur as a result of a pollutant that has washed into the pond or the rapid development of an algal bloom. Turbidity and muddy water also may coincide with a turnover event as the rapid mixing of water resuspends sediment. In ponds that are supplemented with well water, turbidity may result from a change in the water source.



How can muddy water be cleared?

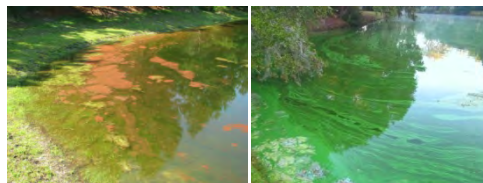
Muddy water in stormwater ponds is usually a temporary condition. Once construction is complete, grass and vegetation prevents erosion on the lots and along the pond banks, and stormwater ponds usually clear. At certain times of the year, they may develop muddy water, but the condition usually is short-lived because sediments either settle out or are flushed from the system during the next storm. Eliminating waterfowl is important with ponds that have large populations of ducks. (See section on Controlling Waterfowl) Stabilizing the banks with vegetation also is very important for preventing muddy water. If a pond remains muddy long after construction is complete, the community may need to consult with an engineering firm about a filtration system to remove suspended sediment or an additive that will flocculate clay particles out of the water. Homeowners or HOA members should not apply any additives to stormwater ponds without consulting the local municipality and the site engineer. It is not recommended to add straw or hay to stormwater ponds to remove suspended sediment because

the loose straw can clog the outlet and decay of the straw material can cause water quality problems.

Surface Films and Sheens

Surface films result when insoluble substances enter the pond. These substances come from a variety of physical, chemical, or biological sources.

1) Pollen and atmospheric dust are common causes of surface films. As trees and other plants flower in the spring, the resulting pollen can coat not only the pond, but just about every other surface in the neighborhood. Spring showers wash pollen into ponds where it floats and forms a yellow-green surface film. The condition may recur in the fall.



2) Films also are formed by the growth of certain kinds of blue-green algae (see section on Planktonic Algae). Films formed by blue-green algae are usually bright green and form swirls and bands as they move over the pond with the wind. On rare occasion, the pond may develop a bright red or blood red film which is the result of the growth of "red algae."

3) Hydrocarbons and oils are usually the other source of surface films in ponds. Oils are produced naturally by the decay of leaves, algae and organic matter, but these oils behave differently from cooking oil or motor oil. To determine if the oil sheen you see on your pond is from a natural organic source, poke it with a stick. If it is from the decay of leaves and other organics, it will most likely crack and shatter like a thin layer of glass and will not reform as the stick is removed. If it reforms or does not shatter, it is likely from automotive or cooking oils that have washed into the pond.

4) Finally, surface films may be the result of insoluble compounds in the soil. Soil-based films usually accompany muddy water and will dissipate as the muddy water clears.

How are surface films removed from ponds?

Very little can be done to remove a surface film from a stormwater pond once it has spread across the pond. If it is biological in origin (pollen or algae), it usually will dissipate or biodegrade on its own within a couple of weeks. If the film is the result of soils and muddy water, the problem may persist until erosion can be stopped or the source of the muddy water is eliminated. Oil films can be managed and involve a two-step process. First, oils can be removed from the pond surface using oil absorbing socks and booms. If the inlet where the oil is entering the pond can be identified, it should be protected by floating booms that will quarantine the oil before it disperses across the pond. Second, the source of the oil must be eliminated. This means that the catch basins need to be inspected for evidence of oil dumping into storm drains, or the streets and driveways need to be inspected for evidence of an oil spill. If a spill or illicit discharge is identified, the community may choose to hire a mobile pressure washer who can clean the surface AND reclaim the wash water that contains the oil so that it does not wash to the storm drain or to the pond.

Foam

Foams that form on the surface of stormwater ponds may be the result of illicit discharges of soap and detergents (see image on the left). They also can be formed naturally, usually in association with



algae blooms. Plant cells contain natural surfactants that change water surface tension. After an algae bloom occurs and the algae begin to die, their cells rupture and release these natural surfactants into the water. Add some current or wave action to this mixture and this water can begin to form a froth or foam (see image on the right). This is the most common reason for the formation of "sea foam" at the beach.

How can I tell the difference between foams from detergents and natural foams?

The two sources usually can be determined by closer inspection of the foam. Soaps and detergents usually contain substances called brighteners, which help the detergent keep a bright white color and prevent staining. Soap- formed foam will retain its bright white color for many days regardless of the color or clarity of the water. Natural foams, on the other hand, are formed by organics that rapidly biodegrade. For this reason, natural foams usually begin to turn brown within hours of being formed. Another way to tell them apart is to look at the individual bubbles in the foam. Soaps



are more efficient surfactants so they can create larger bubbles, so bubbles in soapy foams often are large and of variable size. Natural foams cannot create large bubbles easily, so they tend to have small bubbles that are more uniform in size. Last, soapy foams are able to disperse easily, so they often spread out from their source. Natural foams do not disperse as well, so they tend to stay close to the source.



Slimes

Slimes are usually the result of biological activity in the pond. They often are formed by the growth of algae or microbes at the water's edge or on the bottom in the shallow areas of the pond. These types of slimes are most often green or black, and are familiar to most residents. In some ponds, residents may complain about the development of an orange-brown gelatinous substance on the bottom near the shoreline (see picture to the right). The substance is clumpy and breaks apart easily. This substance being described is most likely colonies of iron-loving bacteria (*Acidithiobacillus ferrooxidans*) that are taking advantage of oxidized iron in the water (see image on the right). The gelatinous colonies of iron-loving bacteria most commonly form in ponds that are being supplemented with well water that is high in iron, a common condition in South Carolina well water. Iron-loving bacteria may affect pH in a pond, but they are not known to be toxic and should not be expected to cause impairments in ponds. The only way to eliminate these bacterial colonies is to reduce iron content in the pond by turning off the well.



9.0 Fish Kills and Fish Health

Fish in ponds can die from several causes. See the sections below to learn what may be causing your fish health problems.

Large fish are dying but not many small fish, or fish of all sizes and species are dying

Large fish are more susceptible to low oxygen conditions and turnovers than small fish. When a turnover or low oxygen event occurs, the large fish come to the surface and begin to die before the small fish. As the low oxygen event worsens, the small fish come to the surface and may be seen gasping and ventilating in the thin layer of water on the surface. Low oxygen events most frequently occur just before sunrise, because oxygen levels are at their lowest at this time of day. Photosynthesis is not occurring because there is not sunlight, meanwhile plankton and microbes in the water are still respiring and consuming oxygen. As a result, oxygen levels decline through the night, and the first signs of a low oxygen event are usually seen in the early morning. By afternoon, photosynthesis may have put enough oxygen in the water to satisfy the needs of the fish. **Low oxygen is the most likely reason for fish kills in stormwater ponds.** Oxygen related fish kills are most common after dense algae blooms in the summer or in the fall when storms and windy days cause rapid "turn-overs."

How do I stop fish from dying from a low oxygen event?

Circulate the water. Circulating the water prevents the pond from stratifying (establishing a thermocline) and forming a layer of low oxygen water on the bottom. For guidance, see section on Aeration & Circulation. It must be emphasized that stormwater ponds are not designed to be ideal fish habitat. They are designed to manage stormwater, and the fact that they can harbor fish is a secondary benefit.

Only small fish are dying but no large fish

Small fish are more susceptible to toxins than big fish. Assuming that the pond has both small juvenile and large mature fish, a fish kill that only affects the juveniles often indicates that some form of toxin is in the water. Toxins may result from improper application of a pesticide, the release of an illicit discharge (such as a solvent or automotive fluid) into the storm drain system, or a blue-green (cyanobacteria) or red algae bloom. Cyanobacteria blooms are usually apparent because the water becomes cloudy and green like pea soup or develops a bright green or red surface film. (See section on Planktonic Algae)



How do I deal with toxins in my pond?

Despite the source, it is nearly impossible to remove a toxin from the water once it has been introduced. The trick to managing toxin related fish kills is to prevent the toxin from being introduced into the system mainly by informing residents about proper fertilizer and pesticide use and proper disposal of household chemicals and automotive fluids. Stormwater ponds are largely dependent on the quality of the runoff that is flowing from roads and lawns in the neighborhood. Communities should be vigilant about illicit discharges into storm drains and

ponds and report egregious offenses to the local stormwater or public works department. Assuming that the mature fish did not die, the fish population should rebound after the toxin has left the system. In some cases the pond may need to be restocked.

I see fish of only one species dying, or fish look diseased or with parasites

Differential death of only one species of fish may be the result of an environmental condition such as low oxygen or a disease or parasite. Some fish species are more susceptible to low oxygen than others. In mild low oxygen events, a few individuals from a single species may die without any other fish demonstrating symptoms, but the event is usually short-lived and the dead individuals are the largest of that species. When disease or parasites are the cause, death usually occurs sporadically over a long period of time and affects all age groups of the species. A few fish die one day, a few more days later, and, over the course of a month or two, many death events may occur. Unlike low oxygen kills, death by disease or parasite usually is accompanied by other symptoms such as bulging eyes, discoloration of the skin or gills, evidence of small wounds or necrosis, external parasites clinging to the skin or gills, and so on. Fish diseases and parasites are not normally a significant cause of death in stormwater ponds, partially because fish rarely reach dense populations in these systems and the water is being exchanged regularly with each passing storm. If you are suspicious that fish in your pond are suffering from a disease or parasite, contact your Extension office or local fisheries office with the SC Department of Natural Resources for guidance.

SC DNR Fisheries Section Offices

- Charleston (843) 953-5291
- Clemson (864) 654-1671
- Columbia (803) 734-3886
- Florence (843) 661-4766

I see fish with wounds and scars

Fish often fall prey to predators and even may cannibalize their own kind. Some fish are fortunate enough to escape attack but remain scarred from the encounter. The most common predators that scar fish in stormwater ponds are ospreys, seagulls, herons, egrets, cormorants and anhingas, alligators, turtles and otters. These animals sometimes remove scales, cause scratches and puncture wounds, and trim or shred fins as they attempt to catch fish. Fish also may develop wounds from bedding activity. This is most evident as redness or scars on the lips and bottom of the tail fin.

Springtime Bream Death

In the springtime, a peculiar type of death occurs most often with large bream. In March or early April, residents around ponds may report seeing a few large bream with large, gaping wounds on their sides, but they rarely see more than 10 fish per acre with these symptoms. This type of kill is most likely the result of cannibalism. Over the winter, food resources are limited and the fish become stressed and malnourished. This affects the largest bream the most. As temperatures begin to



warm in the spring, the fish become more active and begin to peck at each other. The pecking combined with malnourishment makes the fish vulnerable to infection and necrosis, which ultimately overcomes them. This type of bream death is more common in ponds that are overcrowded. If you get reports that small numbers of large bream are dying with large wounds, it is likely due to cannibalism. This will pass as the spring progresses and will not have a significant effect on the fish population.

I see mangled fish or skeletons on the bank

Mangled fish and bones on the bank is almost always an indication of an otter. Otters tend to enter and exit ponds in the same place forming a worn-down slide, and they tend to feed on their catch in the same places on the bank. Otters are somewhat messy eaters and leave behind scraps and bones after they have fed. They also have distinctive feces. Otters do not pose a significant threat to fish populations, except where ponds have been stocked with triploid grass carp. Otters may preferentially remove triploid grass carp from stormwater ponds. Otters are a protected fur-bearing species, so check state regulations before trapping them or speaking with a nuisance wildlife control operator. (see section on Beavers, Muskrats, and Otters)

10.0 Stocking and Harvesting Fish in Stormwater Ponds

Many fish species grow well in stormwater ponds, and there are many advantages to stocking fish in these ponds. Fish help to balance the ecology of the pond by serving as top predators, consuming smaller fish and invertebrates, but they also serve as forage for many attractive animals such as wading birds and osprey. Fish are functional reservoirs for nutrients that have washed into the pond and help the pond capture nutrients carried in runoff. Some fish are herbivores and assist with controlling unwanted aquatic plants. Finally, game fishes stocked in stormwater ponds provide recreational fishing for residents in the community. It must be noted that stormwater ponds are not designed to be recreational fishponds and should not be managed in the same ways as recreational fishponds. Fishing is not the primary service provided by stormwater ponds. Although not ideal, a well-managed stormwater pond can be suitable habitat for several species of fish.

What fish should be stocked in stormwater ponds?

The list of appropriate fish is short and is limited to bream, largemouth bass, triploid grass carp, and blue tilapia.

1. **Bream** (*Lepomis* spp.) refers to several species of "pan" fish that feed predominantly on invertebrates and small fish. Bream provide effective control of aquatic insects, and they serve as prey for largemouth bass. Bream should be stocked at a rate of 500 fish per acre. Both bluegill (*Lepomis macrochirus*) and shellcracker bream (*Lepomis microlophus*) are suitable. If both are to be stocked together, they should be stocked at a ratio of 3 bluegill to 1 shellcracker. Bream are best stocked in fall or winter. Other bream species such as green sunfish, pumpkinseed sunfish, and hybrid bream should be avoided.
2. **Largemouth Bass** (*Micropterus salmoides*) are the most sought after freshwater game fish in North America. They feed both on invertebrates and smaller fishes, amphibians and reptiles. In ponds, bream serve as the primary forage for largemouth bass. Given that the pond has an adequate bream population, largemouth should be stocked at a rate of 50 fish per acre in the early spring. A healthy ratio of bream to bass is 10:1.
3. **Triploid Grass Carp** (*Ctenopharyngodon idella*) provide excellent multi-year control of most species of submerged plants. It is recommended that triploid grass carp be stocked at a rate of 20 fish per acre of vegetation when ponds have heavy weed problems. Ponds that have not yet formed large weed populations may be stocked with 5 to 10 fish per acre to prevent weed growth. Grass carp are best stocked in the spring but may also be stocked in the fall.
4. **Blue Tilapia** (*Oreochromis aureus*) provide aquatic weed control, serve as additional forage for bass, and provide sport fishing for anglers. Unlike triploid grass carp, blue tilapias provide good control of filamentous algae as well as other submerged vegetation. On some occasions when stocked at the maximum rate, blue tilapia will control small floating plants such as duckweed and watermeal. It is recommended that tilapia be

stocked in mid to late spring (once water temps are consistently above 60 degrees) at a rate of 200 to 400 fish per acre of pond surface, depending the level of weed growth. Tilapias are tropical fish that do not normally survive South Carolina winters and need to be restocked each year. On occasion, tilapia have been observed surviving through mild winters when water temps remain above 55 degrees F.

Are there any fish that should not be stocked in stormwater ponds?

Fish other than bream, bass, triploid grass carp, and tilapia should not be stocked in stormwater ponds. Catfish, crappie, spotted bass and hybrid bass are predators that compete with largemouth bass and deplete the prey fishes (bream). Shiners, shad, suckers, and common carp cause other problems ranging from muddy water to competition with other fishes. **No aquarium fishes (gold fish, koi, tropical fishes, pacus, oscars, etc.) should ever be released into stormwater ponds** because there is the potential for these fishes to be washed downstream into rivers and lakes where they can cause significant damage to native fisheries. This is the most common way that invasive aquatic animals are introduced.

How do I find fish for my pond?

Check with your local farm supply stores because these businesses often sponsor "fish days" when you can order and purchase the fish you need, especially if you are seeking small quantities. Otherwise, consult the Aquaculturist Vendors List maintained by the SC Department of Natural Resources. This list contains all of the licensed aquaculture facilities in the state with their contact information and the species of fish that they sell.

Should I harvest fish from my stormwater pond?

Yes. In order to maintain a good balance of fish, it is recommended that 40 lbs. of bream per acre and 10 lbs. of bass per acre be harvested from the pond annually.

*****BE AWARE***** There is potential for toxins and other pollutants to be accumulated in the tissues of these fish. A primary function of stormwater ponds is to trap and treat pollutants washing from roads and lawns in the community. **It is not advised for residents to eat fish harvested from stormwater ponds.** Composting fish for use in the home garden does not pose a significant threat. If anglers do catch fish, it is strongly advised that they use hand sanitizer or wash their hands thoroughly after fishing because stormwater ponds often have high levels of fecal bacteria and other pathogens that can make anglers sick. For more information on sediment toxicity and bioaccumulation of contaminants in fish tissue, see Drescher et al's State of Knowledge Report: Stormwater Ponds in the Coastal Zone (2007) and Weinstein et al's Chemical and Biological Contamination of Stormwater Detention Pond Sediments in Coastal South Carolina (2008).

I am experiencing a fish kill. Who do I contact to determine the cause?

Stormwater ponds are not designed to be fishponds. Their design and purpose make them prone to turnover events, rapid temperature swings, periods of low water, and poor water quality. These conditions often result in poor fish health and possible fish kills. To determine the cause of your fish kill, refer to the Fish Kill/Fish Health Section of this website or call your local Clemson Extension office or Department of Health and Environmental Control Environmental Quality Control office.

11.0 Fountains and Aeration

Circulating and aerating water in stormwater ponds provides several benefits, which may or may not be fully understood by residents in the community. These benefits are 1) oxygenation of the water and 2) mixing of water to prevent *stratification*. Stratification occurs when the sun heats surface waters while deeper waters remain cool. The warm and cool layers do not mix, and the bottom layers become depleted of oxygen because of organic decomposition, while the surface waters receive oxygen from the atmosphere and photosynthesis of phytoplankton. Stratification is a significant threat to fish health in small ponds because it creates a layer of oxygen-depleted water. Under the right conditions this low oxygen water can mix rapidly with the surface waters and dilute the oxygen, an event commonly referred to as a "turnover." Severe turnovers often result in fish kills because the fish "suffocate" from lack of oxygen. A properly designed circulation system can prevent stratification and turnover events. Circulation systems also can help manage nutrients in the pond by balancing the trophic state and reducing nutrients available to algae and aquatic weeds.

What causes a turnover?

Turnovers occur naturally in the fall of every year. The incremental drop in air temperature slowly decreases surface water temperature and the layers in the pond mix gradually. This gradual mixing rarely causes a fish kill. On the other hand, rapid turnover can cause a fish kill. Rapid turnovers can occur anytime during the warmer months of the year when ponds are stratified and they most often coincide with storm events or windy days. A cold rain or the blowing winds of a storm front can cause rapid mixing and result in a fish kill if the pond is stratified.

How do I prevent a turnover?

1. Proper pond construction is important. The ratio of surface waters (epilimnion) to deep waters (hypolimnion) is a major determining factor for the frequency and severity of turnovers. Small, deep ponds often are more prone to severe turnovers because there is a larger volume of deep, low-oxygen water relative to the amount of oxygenated surface water. Broad, shallow ponds have fewer turnovers because less of the pond's volume is tied up in low oxygen deep water. Most stormwater ponds are shallow (6ft deep or less), but some are deeper. It is important to know not only the locations and depths of the deepest parts of your pond, but also the average depth of the pond.
2. Mechanical circulation can prevent turnovers. The primary purpose of mechanical circulation is not aeration/oxygenation. Its purpose is to prevent stratification. By mixing the water, circulation systems never allow the pond to form layers, thus they never develop a low oxygen layer on the bottom. In this way a circulation system becomes an insurance investment to prevent a fish kill.

What is the best way to circulate the water?

By far, diffuser systems circulate water most efficiently. Diffuser



systems are a lot like airstones in an aquarium. They use an air compressor to pump air into the bottom of the pond. The diffuser breaks the air into tiny bubbles which expand as they rise. The rising of the bubbles pushes water and forms a current that lifts bottom water up to the surface. The resulting current mixes the entire water column and prevents stratification in the pond.

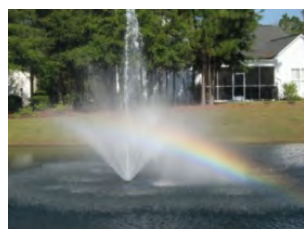
Are there other ways to circulate the water?

Yes. Water pumps such as centrifugal irrigation pumps and sump pumps can be used to push water but they must be designed correctly to work. The trick is to make sure that the pump is creating a current that mixes bottom water with surface water to prevent stratification. Irrigation pumps can be mounted on land as long as they draw water through pipes from near the bottom and shoot it over the surface to create a current. Unlike diffuser systems, which are self-cleaning, water pumps are prone to being clogged with vegetation and debris and require frequent maintenance especially when submerged plant growth is not controlled.

Will circulation systems control aquatic weeds?

No, not necessarily. It is a myth that circulations systems control aquatic weeds except for in the case of some blue-green algae (cyanobacteria). Some cyanobacteria require stagnant waters to grow large blooms. Circulation systems can disrupt some cyanobacteria blooms from growing out of control. Also, in ponds that overloaded with nutrients (eutrophic) and consistently low in oxygen, circulation system may improve water chemistry and make dissolved nutrients unavailable to algae and weeds. By reducing the availability of nutrients, circulation systems potentially can slow but not prevent aquatic weed growth.

What about fountains... Do they work?



Surface fountains are the least efficient ways to aerate ponds, and they do very little to prevent stratification. They do move water, but typically fountains are floating devices that draw surface water into a shallow pump and spray it above the surface. Functionally speaking, they are circulating surface water that is already oxygenated and are not disrupting stratification. As a result, fountains are often deployed more for aesthetic reasons than functional circulation and aeration.

Do I really need a circulation system?

As mentioned previously, most stormwater ponds are shallow basins that do not develop a large volume of low oxygen water in the bottom. On the other hand, some stormwater ponds seem to have chronic problems with fish kills and need a circulation system. Also, stormwater ponds are prone to excessive weed and algae growth. If large masses of these plants are killed using aquatic herbicides, the resulting decay will deplete oxygen and may cause a fish kill. Aeration can help prevent such a fish kill. Finally, if your community has stocked the pond with grass carp or tilapia to control aquatic vegetation, having a circulation system is good protection for that investment. Circulation systems may not be necessary unless your pond develops chronic problems with fish kills or foul odors. It is important for the community to document fish kills so that they can be tracked for frequency and timing. This will help the community when deciding whether or not to invest in a circulation system.

When is the best time to install a circulation system?

It is best to install and start circulation systems before ponds become stratified, which usually means late fall through early spring (April). If your community is considering installing a system in the warm summer months, you should be careful not to cause a man-made turnover when the system is turned on. If the system is installed in the summer it must be started in short increments (10 minutes per day) over the first two weeks in order to gradually mix the water. Consult with your system manufacturer for start-up recommendations. You may need to test oxygen levels during start-up.

How large does the system need to be?

A general rule is that one diffuser unit can circulate a one to two acre pond, but sizing diffuser systems has a lot to do with surface area, depth, and the shape of the pond. Diffusers are less efficient in shallow ponds because the bubbles travel a shorter distance and create less current, so more diffusers may be needed. Also, ponds with odd shapes, bottlenecks, and narrow canals may need several diffusers to adequately circulate water in each of the sections of the pond. The same goes for fountains and water pumps. For water pumps, it is suggested that 1 horsepower of pump be used for each surface acre of pond. You should always consult with the circulation system manufacturer or professional installer for guidance on sizing and designing your system.

12.0 Low or High Water Levels

Stormwater ponds manage runoff and are designed to rise and fall with each storm event (See section on Construction and Sedimentation for details). Also known as wet detention basins, stormwater ponds are designed to permanently hold water after the storm. This is referred to as the *permanent pool*. Within 24 hours after the storm has passed, the water surface should return to the level of the bottom of the pipe or weir or to the lowest orifice on the riser. This level is known as the *normal level of the permanent pool*. On occasion, water levels in the pond either fall below the normal pool or they fail to return to the normal pool after the storm has passed. This page provides guidance on what to look for if your pond is not returning to the level where it should reside normally.



The Illusion of Low Water

Sometimes older ponds appear to have low water levels, but they may not actually be low. As ponds age, minor erosion of the bank at the level of the normal pool scours the shoreline and gives an indication of where the water surface normally resides. On pond banks where lawns are mowed to the water's edge, this becomes apparent as a shelf or rim of exposed sediment. As time progresses, erosion continues and the shelf and exposed area grows and proceeds up the bank. Meanwhile, the water remains at the same level. This gives the illusion that the water level is low because the edge of the grass is well above the water surface. Waterfront owners that have watched the process over the years are aware of what has happened, but new residents in the community may be tricked by the illusion into thinking that the water level is lower than it should be. In this case, it is not the water level that has dropped, it is the bank that has retreated away from the normal pool through erosion. **The only way to determine if a pond is residing at its normal pool is to check the outfall control structure at least 24 hours after any storm to see if the water is sitting at the bottom of the pipe, weir, or lowest orifice.** If the water level is below the lowest orifice on the outfall, then the pond is not maintaining the normal pool as intended.

Low Water

Low water conditions do occur and are caused by irrigation, evaporation, exfiltration, or a broken outfall control structure.



Irrigation: Some communities choose to draw water from stormwater ponds for irrigation. The assumption is that the ponds are supplied by ground water, and that that source of water is endless. In most cases the levels of stormwater ponds is independent of the ground water table, and maintenance of the permanent pool relies on the frequency of storm events. Without regular storms, irrigating from stormwater ponds will rapidly deplete the permanent pool and drop levels. It is not recommended to allow residents to irrigate with stormwater pond water because

low water levels make the ponds more susceptible to weed growth, fish kills, and water quality impairments. Also, stormwater pond water may contain contaminants that residents should not broadcast over the lawn. Fecal bacteria, pesticides, and toxins may be present in the water. Last and most important, irrigating from ponds greatly limits the community's ability to manage aquatic weeds because many of the most effective aquatic herbicides carry irrigation restrictions. These aquatic herbicides can damage or kill lawns and landscape plants, so irrigating from stormwater ponds binds the hands of lake management professionals and prevents them from using some of the most effective herbicides.

Evaporation and Exfiltration: During dry periods such as extended drought, evaporation and exfiltration may lower the water level below the outfall. Contrary to many beliefs, stormwater ponds may or may not be dug to the level of the water table. In some instances, the ponds were dug into soils that are too porous to hold water. If such soils exist on a site, then stormwater management practices other than wet ponds (pervious paving, bioretention, dry detention, etc.) should be considered.

Failing Outlets: Sometimes outlet control structures fail. Cracks form in the base of risers or weirs or around the connection between the riser and the pipe that leads away from the pond. In ponds that are formed by earthen dams, fissures in the dam or around the outfall pipe may allow water to drain from the pond. Ponds that chronically drain below the outfall should be inspected thoroughly to determine if the outfall or dam is failing.

Should we install a well to maintain pond levels?

Often communities remedy low water levels by having a well dug to supplement the water. This is not recommended for several reasons:

1. Ground water has different chemistry from surface water and may impair water quality in the pond and in receiving rivers and beaches.
2. Pumping water out of the ground to put into surface waters is not an efficient use of water or an effective stormwater management practice. Pumping groundwater into surface ponds actually increases stormwater runoff and affects the hydrology of natural systems downstream.
3. Installation of wells and maintenance of pumps is costly.
4. Ground water is precious, and depletion of ground water reserves creates cones of depression and increases the likelihood of saltwater intrusion, cones of depression, and subsidence of the land.

If your community has halted irrigation withdrawals and ensured the outfall is not failing, yet your ponds fail to retain water, you should consult your municipal stormwater or public works department or civil engineer. There may be options for retrofits or conversions.

High Water

Stormwater ponds are designed to drain and return to normal pool within 24 hours after the storm. If they are not doing so, then there must be a blockage in the outfall control structure. Blockages may result from a collapsed outfall pipe, excessive vegetation, sticks and other yard debris, the activity of a beaver, or a resident who has intentionally placed a board or weir over the outfall to raise the water level. It is extremely important that these blockages be removed and repaired immediately upon being found. They could result in significant flooding around the

pond and in properties upstream. Stormwater ponds are designed to be a specific volume of empty space in order to capture the storm surge. If water levels are raised artificially, storage is lost and flooding is a real possibility.



Appendix A

Shorescaping Fact Sheet

H₂Owneership

answering today's water resource challenges for future generations

Shorescaping Freshwater Shorelines

Benjamin Powell, Natural Resources Agent, Clemson Extension

November 2012

Shorescapes

South Carolina is blessed to have an abundance of water resources in the form of rivers, lakes, ponds and estuaries, and many residents own properties that adjoin these beautiful watercourses. This presents the waterfront owner with a unique opportunity to discover a largely unexplored form of gardening - SHORESCAPING. A shorescape is a landscaped shoreline that uses attractive plants to protect and beautify the waterfront. A well designed shorescape uses native plants to provide a functional solution to problems such as shoreline erosion, poor water quality, invasive weeds, and wildlife management. Also, like a flower bed in the yard, a shorescape that uses a mixture of flowering plants can serve as a waterfront garden that improves the appearance of the shoreline and adds value to the property. Luckily, there are many very attractive plants that are easy to grow, native to South Carolina, and suitable for use in a most shorescapes.

Before Planting

Before planting, you should consider carefully what your designated uses are for the body of water. For instance, residential stormwater ponds and recreational fish ponds need to have open shorelines with few trees so that they can be accessed easily for maintenance and use. On the other end of the spectrum, trees may be necessary for properties along rivers and large reservoirs to withstand the strong erosional forces present in these large systems. Also, the waterfront owner should consider how the waterway is used by neighbors and the community. Plants should not be placed in areas that may restrict recreational use or navigation. In the case of residential ponds, the community relies on the ponds to convey stormwater runoff from the neighborhood through a system of pipes and outfalls. The waterfront owner should be careful not



Shorescaped pond bank in community near Myrtle Beach, SC.

to obstruct these conveyances which, if clogged, could cause flooding. In some cases, it is the responsibility of the home owners association to determine what plants are suitable for stormwater pond banks. For more information about protecting water resources, visit www.clemson.edu/carolinaclear.

Right Plant, Right Place

Knowing what to plant and where to plant them is the greatest challenge for designing a shorescape because the shoreline is an ecotone (an area of transition between two ecosystems). Waterfronts have four distinct zones which characterize the transition from water to land. Each zone is suitable to different plants based on the water needs of each plant. The following section provides descriptions of the planting zones and lists of plants suitable for each zone. When purchasing plants, check the scientific names and match them to the plants on this list. Many plant species share common names, but may differ from those described here.

The Littoral Zone – the area below the water line that is too deep for emergent plants but still shallow enough that sunlight can penetrate through the water to the bottom. The littoral zone usually is 1 to 4 feet deep but may be deeper if the water is very clear. Many aquatic plants that grow in the littoral zone can be invasive, especially in shallow stormwater ponds, so it is important to manage submersed and floating-leaved vegetation to prevent clogged outfalls and fish kills.

Plants for the Littoral Zone:

Coontail
Tape-grass

Ceratophyllum demersum
Vallisneria spiralis

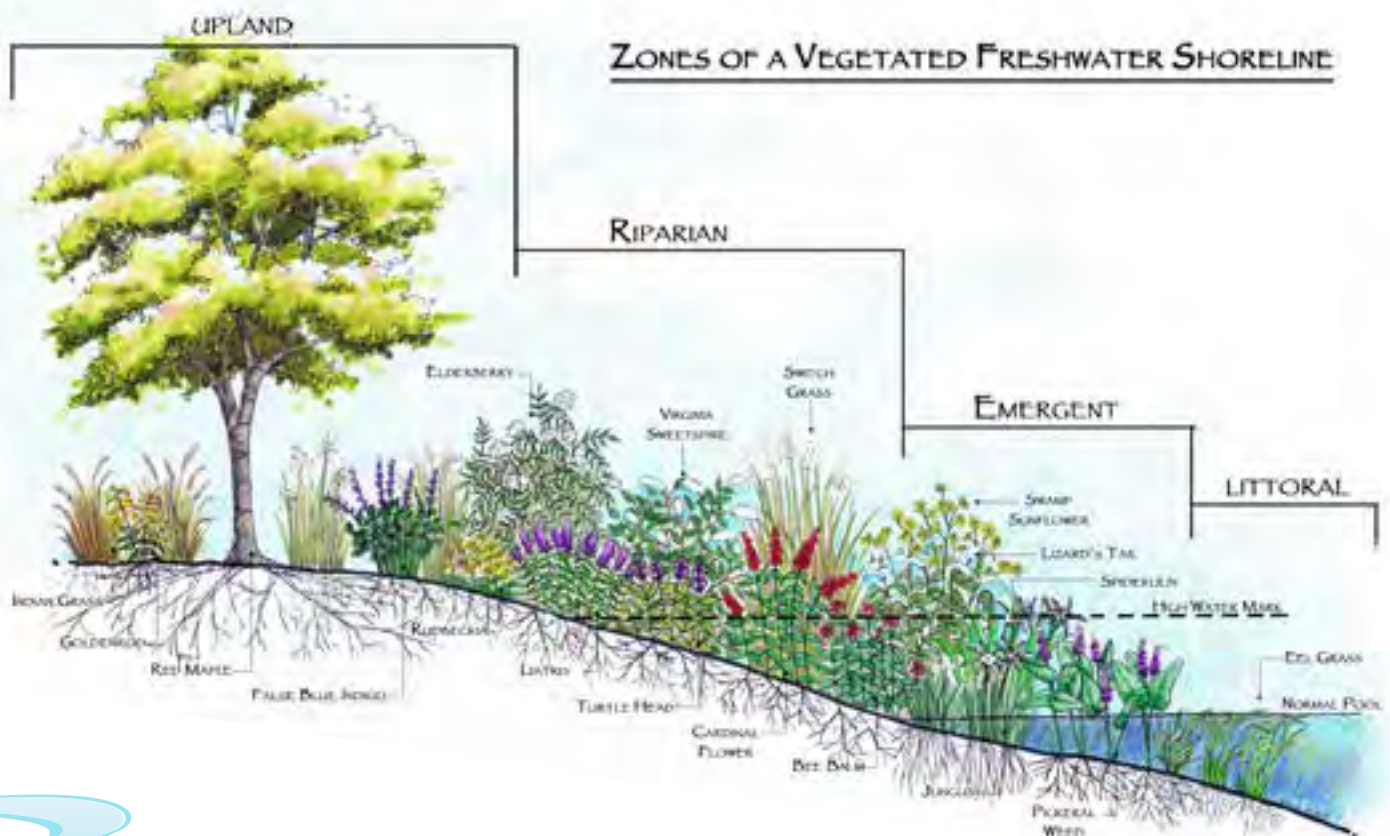
The Emergent Zone – the part of the bank slope that lies below the water line but is shallow enough to allow emergent aquatic plants to root in the submerged soil and grow upward above the water's surface. The emergent zone is usually less than 12 inches deep. Avoid emergent plants that have a “creeping” lateral growth habit such as water primrose and alligatorweed. Vertical plants are easier to manage in the emergent zone.

Plants for the Emergent Zone:

Pickeralweed
Arrowheads
Arrow Arum
Lizard's Tail
Alligator Flag
Golden Canna
White Star Sedge

Pontederia cordata
Sagittaria latifolia, *S. lancifolia*
Peltandra virginica
Sagittaria arifolia
*Thalia geniculata**
*Canna flaccida**
*Dichromena colorata**

Special note Many ponds have large populations of ducks and geese which can damage shoreline plants by trampling and grazing. Plants marked with an asterisk (*) are known to be resistant to waterfowl damage.



The Riparian Zone – the part of the bank slope that lies above the water surface but where the soil remains permanently wet and saturated. The riparian zone often is inundated with water when pond levels rise during storms. Plants that thrive in this zone need moist soils and can withstand extended periods submerged under water but prefer to grow at or just above the water line.

Plants for the Riparian Zone:	Soft Rush	<i>Juncus effusus</i> *
	Bulrush	<i>Scirpus spp.</i> *
	Louisiana Iris	<i>Iris (hexagonae group)</i>
	Blue Flag	<i>Iris virginica</i>
	Spider Lily	<i>Hymenocallis palmeri</i>
	Mallow Hibiscus	<i>Hibiscus moscheutos</i> *
	Swamp Sunflower	<i>Helianthus angustifolius</i> *
	Cardinal Flower	<i>Lobelia cardinalis</i>
	Bog Lily	<i>Crinum americanum</i>
	River Oats	<i>Chasmanthium latifolium</i> *
	White-top Sedge	<i>Dichromena colorata</i> *
	Lizard's Tail	<i>Saururus cernuus</i> *

The Upland Zone – the part of the bank slope above the riparian zone where soils do not stay permanently moist. This zone often is very dry because the slope forces water to runoff rather than seep into the ground. Upland zones with very steep slopes will need plants that are very drought tolerant. In most cases, the ornamental plants that are commonly used in the home landscape are useful in this zone. Residents that live next to stormwater ponds in residential neighborhoods should avoid planting trees and large shrubs on the bank slopes. Perennials and grasses are best in this zone.

Plants for the Upland Zone:	Native Grasses* (Weeping Love Grass, Big Bluestem, Muhly Grass, Switchgrass, Indian Grass)
	Native Perennials (Butterfly Weed, False Indigo*, Tickseeds, Coneflower*, Hardy Ageratum, Blazing Star, Verbena*, Goldenrod)
	Other Perennials (Sunflower Heliopsis, Daylily*, Bearded Iris*, Red Hot Poker, Lantana*, Lavender*, Creeping Phlox, Salvia, Stonecrop, Purple Heart)

Maintaining Your Shorescape

Pesticides and fertilizers should be avoided in a shorescape if possible because of the potential for runoff into the water. Weed control is best done by hand pulling. If herbicides are necessary, it is best to use herbicides that are labeled for aquatic use because they have less potential for causing water quality problems. Undesirable trees, vines, shrubs and tall weeds can be eliminated using a hack and squirt method which involves the application of a systemic herbicide directly to the cut stem of the

undesirable plant. Mulch can be used in the upland zone but may be carried away by high water if it is placed in the riparian zone. Instead, space plants closely so that there is less potential for weeds to invade the shorescape. The crowns of plants in the shorescape need to be cut back and harvested once each year before the spring growing season begins. The mowed or cut plant material should not be left in place or allowed to wash into the water because it may cause water quality problems or block water flow.



Inlet pipes convey stormwater from paved surfaces to the pond.

Shorescapes Around Stormwater Ponds

Stormwater ponds in residential communities present a unique set of conditions that deserve special consideration. Stormwater ponds are designed to be open basins that capture stormwater runoff from roads, rooftops, and yards in the community 1) to moderate the storm surge and prevent flooding and 2) to trap and treat polluted runoff to protect water quality. To that end, stormwater ponds need to be free of obstructions such as large trees and shrubs on the banks and excessive submersed and floating vegetation that takes up space and impedes flow. Special attention also needs to be paid to preventing plants from growing over inlet pipes and outfalls. In addition to these functional concerns, many communities have concerns over the appearance of the pond banks, to the extent that the homeowners association restricts what can be planted on the bank slopes. To balance the functional and aesthetic needs of residential ponds, here is a short list of shoreline plants suitable for stormwater ponds throughout the state along with brief descriptions of each plant.

Shoreline Plants for Stormwater Ponds

Soft Rush - *Juncus effusus*

This extremely hardy perennial is one of the most versatile shoreline plants in North America. It is present in almost every state and is very easy to grow. It is common in almost every drainage basin in South Carolina from small ditches to the banks of large rivers. Its flowers are not exceptionally showy, but it makes up for that with its unique texture and vertical growth. It is perennial but retains its dark green color through most of the year, giving it an almost evergreen nature. It is very effective at reducing pond bank erosion.



Max. Water Depth: 3 inches

Growth Habit: Clumping

Wildlife Value: Moderate

Max. Height: 3-4 feet

Flower: Summer, green to brown

Light Need: Full sun

Arrowhead - *Sagittaria latifolia* & *S. lancifolia*

Also known as Duck Potato, this plant is very common in marshes and tidal wetlands of the coastal plain. It is easily recognized by its flowers and leaf shape. It grows quickly and spreads well in very shallow waters (<6 inches deep). Its cluster of white flowers on a spike is quite attractive, and flowering persists through most of the growing season. Newer cultivars have yellow flowers with burgundy centers.



Max. Water Depth: 12 inches

Growth Habit: Spreading by tubers

Wildlife Value: Very high

Max. Height: 3-4 feet

Flower: Summer, white/pale yellow

Light Need: Full sun

Arrow Arum - *Peltandra virginica*

Also known as the Tuckahoe, this plant is a wetland relative of the Peace Lily. The large arrow-shaped leaf of the Arum provides a safe alternative to elephant ear plants (*Colocasia* spp.) which can be invasive in small ponds. The leaves are large, dark green, glossy and distinctly arrow-shaped. The arrow arum is one of a few wetland plants that are tolerant of shade.

Max. Water Depth: 12 inches
Growth Habit: Slow spreading
Wildlife Value: Moderate

Max. Height: 2-3 feet
Flower: Early Summer, White/pale yellow turning to green
Light Need: Full sun to deep shade



Golden Canna - *Canna flaccida*

This extremely showy plant has been a landscaping favorite for a very long time. The dramatic yellow flowers stand-out and add a brilliant splash of color throughout the summer months. The broad, erect foliage gives a perfect backdrop to accentuate the flowers. This plant grows in clumps, spreads slowly and can be easily contained and managed.

Max. Water Depth: 12 inches
Growth Habit: Spreading by rhizomes
Wildlife Value: Moderate

Max. Height: 3-6 feet
Flower: Summer, brilliant yellow
Light Need: Full sun to part shade

Pickerelweed - *Pontederia cordata*

One of the most common and widespread wetland plants in South Carolina, this plant is arguably the most versatile shoreline plant available to the waterfront owner. The blue to purple flowers are unmatched in beauty and are very attractive to pollinators and hummingbirds. The erect, heart-shaped leaves are dark green and glossy and give the shoreline a very interesting texture. Newer varieties are now available with elongate leaves and white flowers for added variety.

Max. Water Depth: 30 inches
Growth Habit: Spreading by rhizomes
Wildlife Value: Moderate

Max. Height: 3-4 feet
Flower: Summer, blue/white
Light Need: Full sun



Swamp Mallow - *Hibiscus moscheutos*

This plant has the largest flower of any plant in this list and may hold its own as the showiest flower in any yard. Native plants have white/off-white blooms with burgundy centers, but several cultivars are available with varying shades of red and pink. This tall perennial develops woody stems, giving it a shrub-like appearance. This plant is closely related to other showy flowers in the landscape such as the Confederate Rose (*Hibiscus mutabilis*) and Rose of Sharon (*Hibiscus syriacus*).

Max. Water Depth: 6 inches
Growth Habit: Solitary, shrub-like
Wildlife Value: Poor

Max. Height: 7 feet
Flower: Summer, white with crimson center
Light Need: Full sun to part shade

Alligator Flag - *Thalia dealbata*, *T. geniculata*

Alligator Flag is very similar to the Cannas in many ways, but it stands apart by its narrower petioles, taller stature and unique purple flower spikes that extend well above the leaves. This plant works well to provide screening and vertical focal points along the waterfront, and it gives the waterfront a tropical appearance. It tends to grow in clumps and is easily managed.

Max. Water Depth: 36 inches

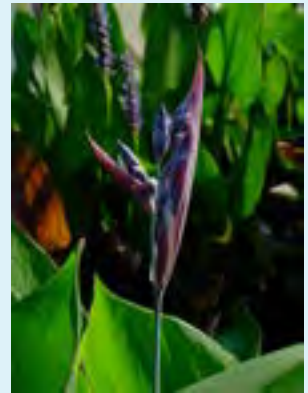
Growth Habit: Spreading by rhizomes

Wildlife Value: Moderate

Max. Height: 6-8 feet

Flower: Summer, purple/dark red

Light Need: Full sun



Swamp Sunflower - *Helianthus angustifolius*

This plant provides a huge splash of color late in the season when many other plants have stopped flowering. It is a very effective attractant for butterflies and often is used in upland gardens, but this plant also thrives in saturated soils and will grow well at the water's edge too. It has narrow leaves that give the shoreline a softer texture than many of the other plants listed here.

Max. Water Depth: 3 inches

Growth Habit: Solitary, shrub-like

Wildlife Value: High

Max. Height: 5-6 feet

Flower: Fall, brilliant yellow

Light Need: Full sun to part shade

Spiderlily - *Hymenocallis spp.*

There are few plants that have flowers as peculiar as the Spider Lilies which makes them stand-out among their fellow wetland plants. In the Catawba River, large shoals are populated by clumps of these plants. In the coastal plain a different species can be found dispersed across tidal freshwater wetlands. This plant spreads slowly and provides interesting variety to the waterfront.

Max. Water Depth: 6 inches

Growth Habit: Clumping

Wildlife Value: Moderate

Max. Height: 2-3 feet

Flower: Summer, white

Light Need: Full sun



Bog Lily - *Crinum americanum*

This plant is often called the southern swamp lily, and it frequently occurs in similar habitats as the Marsh Spider Lily (*Hymenocallis crassifolia*) of the Coastal Plain. Its bloom is not as ornate as the spider lily, but it is fragrant and sweet smelling. Like the spider lily, this plant grows in clumps and does not spread rapidly, but it does work well to provide additional variety to the waterfront.

Max. Water Depth: 3 inches

Growth Habit: Clumping

Wildlife Value: Moderate

Max. Height: 2 feet

Flower: Summer, white/pink, fragrant

Light Need: Full sun

Louisiana Iris - *Iris spp.* (*Hexagonae* group)

These wetland relatives of the Bearded Iris, which is so well known among gardening enthusiasts, give the waterfront owner an opportunity to work with a plant that is more familiar than many of the other plants in this list. The Louisiana Irises actually are a group of five species: *Iris hexagona*, *I. fulva*, *I. brevicaulis*, *I. giganticaerulea*, and *I. nelsonii*. Although there is some variety in bloom color and size, all five species have very similar growth habits.

Max. Water Depth: 3 inches

Growth Habit: Spreading by rhizomes

Wildlife Value: Low

Max. Height: 2-3 feet

Flower: Spring, blue/pink/yellow

Light Need: Full sun



Flag Iris - *Iris virginica*

Blue Flag Iris has become a favorite plant for use in constructed wetlands and rain gardens because of the plant's ability to withstand extended periods of drought while also thriving in saturated soils, once established. Blue Flag has a narrow blue flower and is common in roadside ditches and wetlands in the Atlantic Coastal Plain. Blooms and foliage are attractive additions to the waterfront.

Max. Water Depth: 6 inches

Growth Habit: Spreading by rhizomes

Wildlife Value: Low

Max. Height: 2 feet

Flower: Early summer, blue

Light Need: Full sun to part shade

Lizard's Tail - *Saururus cernuus*

This interesting perennial is a very common inhabitant of the forested swamps in the coastal plain, but it is hardy enough to thrive in even the coldest of South Carolina's climates. Its bottle-brush like flower has a distinctive curl somewhat like the tail of a lizard, hence its common name. Having adapted to life in the forest understory, this wetland plant is one of the few species on this list that is tolerant of low light situations, which makes it suitable for pond banks that remain shaded most of the time.

Max. Water Depth: 8 inches

Growth Habit: Spreading by rhizomes

Wildlife Value: Low

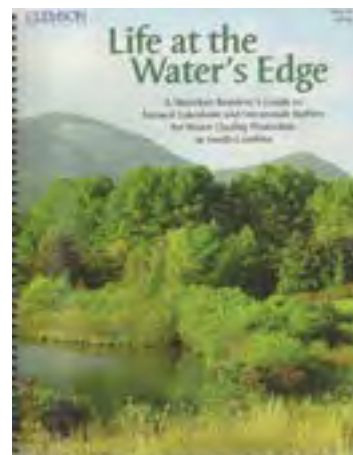
Max. Height: 2-3 feet

Flower: Summer to mid Fall, white

Light Need: Full sun to shade



For more detailed information about designing your waterfront to stop erosion, protect water quality, and beautify your shoreline, consider obtaining a copy of *Life at the Water's Edge*. *Life at the Water's Edge* has 150 pages of detailed information on the benefits and design of landscaped waterfronts. It includes more than 135 color photos and illustrations, a glossary of terms, an appendix of plants mentioned, and a plant list for South Carolina lakeshore and streamside buffers. This book can be purchased at your county Extension office or online from Clemson PSA Publishing at <https://shopping.clemson.edu>.



Content reviewed by Mary Caflisch, Clemson Extension Service; Cathy Reas Foster, Clemson Extension Service; Sarah White, Clemson University; Katie Giacalone, Clemson Carolina Clear.



www.clemson.edu/public/carolinaclear

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Appendix B

Pond Identification Sheet

Stormwater Pond Identification Sheet

Pond ID: _____
(ex. P-01, P-02, etc)

Location: _____
(ex. Intersection of x and y, or at neighborhood entrance, etc...)

Dimensions:
Acreage: _____
Surface Area: _____
Design Volume: _____

Date of Construction: _____

Aeration Device:
Brand/Make/Model number: _____

Access points/Maintenance Rights of Way:

Permitted activities in pond: ex. swimming, fishing...

Prohibited activities in pond: ex. swimming, fishing...

Receiving waterbody: (names of waterways receiving pond overflow)

Roughly sketch your pond and label the locations of the inflow and outflow structures and maintenance rights of way with latitude and longitude coordinates:

Appendix C

Maintenance Log

Stormwater Pond Maintenance Log

Use this sheet to track maintenance concerns and any corrective actions taken.

Pond ID: _____

(Refer to Pond Identification Sheet)

Date: _____

Maintenance Concern:

☐ Algae

☐ Shoreline Erosion

☐ Water Quality

☐ Sedimentation

☐ Nuisance Wildlife (specify):

☐ Low or High Water Levels

☐ Muddy Water

☐ Surface Films and Slimes

☐ Fish Kills

☐ Other (specify):

Event Description: *(What caused you to call for service? Include season, temperature, and other details of when problem originated.)*

Remediation/Maintenance Activity Performed and by Whom:

Cost of Remediation/Maintenance:

Follow Up Services or Recommendations: *(Include name of board member/resident responsible for follow-up)*

Appendix D

Inspection Sheet

Stormwater Pond Semi-Annual Inspection Checklist*

Inspector: _____ Date: _____ Pond Number: _____

Inspection Items:	Checked?	Maintenance Needed?	Comments
	Y/N/NA	Y/N	
Vegetation (§ 4.0)			
1. Are the boundaries of the buffer being observed? <i>(no mowing to the edge, grass $\geq$ 6" tall)</i>			
2. Is your shoreline vegetation dominated by one or a few species?			
3. Is your surface water vegetation dominated by one or a few species?			
4. Is your underwater vegetation dominated by one or a few species?			
5. Is there an excessive amount of algae? <i>(less than 20% surface coverage is ideal)</i>			
Wildlife (§ 6.0)			
1. Are there signs of nuisance wildlife? <i>(Geese droppings, beaver dams, burrows, otter slides)</i>			
2. Are there areas of stagnant water that provide a breeding ground for mosquitoes?			
Water Quality (§ 7.0)			
1. Is there trash/debris in nearby storm drains?			
2. Is there trash/debris in the pond or on the shore?			
3. Does your shoreline show signs of erosion? <i>(undercutting, scouring, or slumping)</i>			
4. Are there signs of sedimentation in the pond? <i>(sediment accumulation in pond, decreased available pond volume)</i>			
Pond Structures (§ 2.0)			
1. Are there obstructions at inlets and outlets? <i>(trash, plant debris, construction materials)</i>			
2. Do inlet or outlet structures show signs of wear? <i>(cracked, corroded, or broken pipes)</i>			
Fountains and Aeration (§ 11.0)			
1. Is the aeration system functioning properly? <i>(water is circulating, diffuser is bubbling)</i>			
2. Have any fish kills been reported? <i>(stratification)</i>			
Access and Safety			
1. Is maintenance access to the pond and aeration system free of obstructions? <i>(no trees, no inaccessible fences or gates)</i>			
2. Are fences, gates, and locks in need of repair? <i>(broken or unlocked locks, gates, or fences)</i>			
3. Are there signs of vandalism/graffiti on or around pond structures?			

*Note: This checklist is presented to provide an example. Stormwater pond inspections may need to be performed more frequently and include other inspection items based on the unique conditions present at your pond. It is also good practice to inspect your pond after major storm events.

Appendix E

Reference Contacts

Agency/Organization Contact List

Agency/Organization	Phone Number	Website(s)
SC Department of Health and Environmental Control (SCDHEC) -plats, stormwater regulations/permits,	(803) 898-3432	http://www.scdhec.gov/
SCDHEC Office of Ocean and Coastal Resource Management -buffers, stormwater pond maintenance, best management practices, water quality	(843) 953-0200	http://www.scdhec.gov/environment/ocrm/
South Carolina Department of Natural Resources (SCDNR) -nuisance wildlife, fish stocking	(843) 953-5291	http://www.dnr.sc.gov/ http://www.dnr.sc.gov/wildlife/control.html
Carolina Clear -stormwater pond general information, workshops	(864) 656-3311	http://www.clemson.edu/public/carolinaclear/
Clemson University Cooperative Extension Services -stormwater ponds, vegetation, soil testing, buffers	(843) 722-5940	Plant Problem Clinic http://www.clemson.edu/public/regulatory/plant_industry/plant_prob_clinic/ Pesticide Applicator Training http://www.clemson.edu/extension/pest_ed/app_training/index.html
South Carolina Native Plants Society -vegetation, buffers		http://scnps.org/ http://scnps.org/education/homeowners/
U.S. Army Corps of Engineers -wetlands	(843) 329-8044	http://www.sac.usace.army.mil/Missions/Regulatory.aspx
South Carolina Sea Grant Consortium -aquatic weed control	(843) 953-2078	http://www.scseagrant.org/
NRCS Soil and Water Conservation District- Berkeley -invasive species, soil quality/health, water quality, wildlife habitat	(843) 719-4146	http://www.nrcs.usda.gov/wps/portal/nrcs/site/sc/home/
NRCS Soil and Water Conservation District- Charleston -invasive species, soil quality/health, water quality, wildlife habitat	(843) 727-4160	http://www.nrcs.usda.gov/wps/portal/nrcs/site/sc/home/
NRCS Soil and Water Conservation District- Dorchester -invasive species, soil quality/health, water quality, wildlife habitat	(843) 563-3218	http://www.nrcs.usda.gov/wps/portal/nrcs/site/sc/home/
NRCS Soil and Water Conservation District- Beaufort -invasive species, soil quality/health, water quality, wildlife habitat, dugout ponds	(843) 522-8100	http://www.nrcs.usda.gov/wps/portal/nrcs/site/sc/home/

Glossary

Algae- microscopic plant-like organisms that contain chlorophyll

Algal bloom- a rapid increase in the population/density of algae in an aquatic system

Bulkhead- a retaining wall along a waterfront to protect against erosion and flooding

Easement- the right held by a person or municipality to use the land of another person, usually as a right of way for utility or maintenance access

Planktonic (algae)- algae that float or drift in a body of water

Filamentous (algae)- algae that link together to form threads and create mats of algae on the water surface

Aeration- the process by which air is circulated through, mixed with, or dissolved in a liquid

Erosion- the wearing away of the land surface (rocks, vegetation, soil) by forces of the wind or water

Sedimentation- the tendency for particles in suspension to settle out of the fluid in which they are suspended (here: soil in stormwater runoff)

Weir- an overflow structure built to regulate water flow

Swales- landscape elements, generally consisting of a moist or marshy depression, designed to remove silt and pollution from surface runoff water

Littoral shelf- shallow areas within a pond that provide emergent aquatic vegetation with the appropriate water depth necessary to survive

Stratification- (here: thermal stratification) the separation of water layers based on their temperature

Impervious- (here: impervious surface) a surface that does not allow penetration or passage through the surface

Runoff- water not absorbed by soil; rainfall that does not soak into the soil, but rather flows on the land surface

Watershed- the land area that drains into a particular lake, river, or ocean

Dredging- an excavation activity carried out underwater with the purpose of gathering sediment from the bottom of the waterbody and disposing of it at a different location

Eutrophic- Having waters rich in nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content

Turnover- an abrupt mixing of the stratified waters in ponds, which can lead to fish kills

Thermocline- the layer of water between the warmer surface waters and the colder deep waters

Epilimnion- the upper water layer of a lake, the layer of water above the thermocline

Hypolimnion- the lower water layer a lake, the layer of water below the thermocline