



STORMWATER MANAGEMENT FOR OWNERS AND PROPERTY MANAGERS

AQUALIS Stormwater Management is a full service post-construction stormwater management company. We take care of all of our clients' stormwater management needs. Our services include Inspection, Maintenance, Repair, Emergency Response and Consulting. Learn more at aqualisco.com.

OUR MISSION

Inspire change by preserving and protecting our most precious natural resource: water

AQUALIS
STORMWATER MANAGEMENT



Comprehensive Post-Construction Stormwater Management includes ALL services to ensure compliance with Federal, State and Local stormwater regulations.

Owners and Property Managers are legally responsible for ensuring that stormwater facilities installed on their property are properly maintained and continually function as they were designed. In many instances, owners and property managers hire specialists to perform these services. This whitepaper provides the basics of stormwater management, typical types of stormwater facilities (commonly called “SCMs”), and the components of a successful stormwater management program.

What is Stormwater?

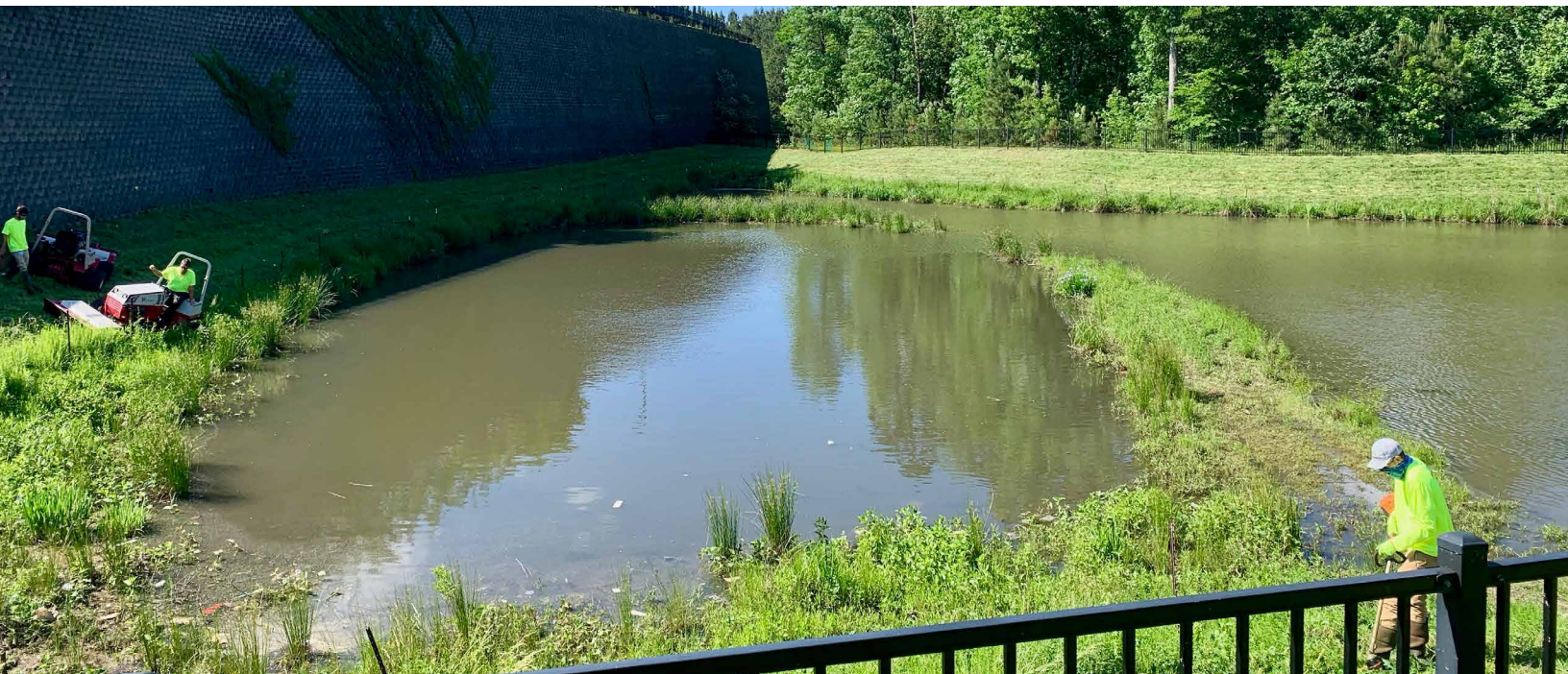
Stormwater originates from a precipitation event and travels multiple pathways before entering into ground and surface waters. An increase in land development results in increases in paved or impermeable, areas and ultimately decreases infiltration. Infiltration is the process by which water on the ground surface enters the soil. When infiltration is limited or prevented, surface runoff is increased and can have detrimental effects downstream. Higher volumes of surface runoff can result in downstream flooding and greater stress on streams and rivers. Surface runoff is also a means of pollutant transport.

Runoff management, more commonly known as Stormwater Management, focuses on the development of control measures designed to lessen the negative impacts related to increased runoff volumes.

Brief History of Stormwater Management

Stormwater Management has evolved over the last several decades due to increased land development and legislation brought on, in part, by growing awareness regarding the importance of clean water and concern for the environment (See *Laws & Regulations page* at www.aqualisco.com for more information regarding Stormwater Regulations).

For many years, Stormwater Management was primarily focused on facilitating water into a pipe and away from a site as quickly as possible. In recent years, increasingly negative impacts downstream on developed areas and the environment have introduced a need for improved techniques for the management of runoff. Best Management Practices, or Stormwater Control Measures, have been implemented to treat and control runoff from a developed site.





What is an SCM ?

Stormwater Control Measures (SCMs), also commonly referred to as Best Management Practices (SCMs), are engineered systems designed to limit the damaging effects of stormwater runoff that results from increased land development. SCMs are designed to maintain or improve the pre-developed conditions for water quality and quantity downstream of a property. An SCM is designed to improve water quality, reduce downstream flooding and erosion, and promote groundwater recharge. Many SCMs can also be an aesthetic asset to a property. In order to provide quality and quantity benefits to a watershed, a system is engineered to perform based on the needs of the site or watershed.

There are multiple types of SCMs implemented to satisfy the needs of a site. The most common and current practices are as follows:

- Bioretention / Rain Gardens
- Sand filters
- Constructed wetlands
- Wet Detention Basin
- Dry Detention Basin
- Grassed Swale
- Infiltration Basin
- Permeable Pavement
- Level Spreader
- Proprietary Systems / Manufactured SCMs



Bioretention Cell

A Bioretention Cell (BC) is an engineered system typically designed with beneficial plants and an engineered media designed to assist in pollutant removal by filtering solids suspended in the stormwater while promoting nutrient uptake. BCs are designed with a volume capacity and discharges are often controlled by an underdrain or weir structure. BCs are commonly found throughout commercial properties and can add aesthetic improvements to a site in addition to water quality and quantity benefits.

Rain Gardens are a similar application to BCs but typically are not engineered systems and often used as a smaller-scale, non-commercial practice.



Sand Filter

A Sand Filter (SF) is a system that facilitates the passage of stormwater through a sand medium designed to assist in pollutant removal by filtering suspended solids, oils and debris. SFs are designed to handle a certain input volume based on the upstream watershed.



Constructed Wetland

A Constructed Wetland is a vegetated system designed with beneficial plants for increased nutrient removal and is designed to hold a permanent volume of water with an additional storage capacity during and immediately following a rain event. Discharges from constructed wetlands are controlled by an engineered outlet device.



Wet Detention Basin (Retention Pond)

A Wet Detention Basin is a vegetated system designed to hold a permanent volume of water at all times with an additional storage capacity during and immediately following a rain event. Discharges from this type of basin are controlled by an engineered outlet device. Wet Detention Basins are also commonly known as a Wet Pond or Retention Pond.



Dry Detention Basin (Detention Pond)

A Dry Detention Basin is a vegetated system designed to hold a temporary volume of water during and immediately following a rain event with discharges controlled by an engineered outlet device. Also commonly known as a Dry Pond or a Detention Pond.



Grassed Swale

A Grassed Swale is a vegetated channel designed to convey runoff while promoting infiltration. Swales are designed with a quantity element, or holding capacity, in addition to a quality aspect.



Infiltration Basin

An Infiltration Basin is a vegetated system designed with highly permeable soils that facilitates infiltration and groundwater recharge. Infiltration Basins are designed with a quantity element, or holding capacity.



Permeable (Pervious) Pavement

Permeable Pavement is a pervious product installed to allow infiltration and reduce surface runoff. These can reduce the area of impervious surface on a parking lot while retaining the number of available parking spaces.



Level Spreader

A Level Spreader is a device installed at a pipe or channel outfall that reduces the energy level in high-velocity, channelized flow by converting it into sheet flow. Level spreaders can be constructed out of various materials to achieve engineered standards. Stormwater runoff is conveyed to a blind swale, and as the blind swale fills, flow diffuses along the length of the level spreader. Infiltration of stormwater and removal of particulate pollutants are expected as runoff flows through the riparian buffer or vegetative filter strip on the downslope of the level spreader.



Manufactured (Underground) System (example, Stormfilter Vault)

A manufactured underground system is a product often retrofitted into a storm sewer system with storage and pollutant removal capabilities. They are commonly used when space is at a premium (and where aboveground BMP's may therefore be too costly). These systems are also commonly known as Proprietary Systems.



Water Quality vs. Water Quantity

Water Quality measures chemical, biological, and physical composition. Runoff carries with it contaminants from the surfaces over which it passes. Pollutants are dissolved or suspended in surface runoff and transported from a site to downstream waterways, adversely impacting the ecosystem and posing a threat to human health. Pollutants include pathogens, organics, nutrient loads, and heavy metals. SCMs are designed with a natural treatment element in order to improve the quality of water before it leaves a site. This occurs through the settling of sediment and other contaminants and promotes biological and nutrient uptake by surrounding vegetation.

Water Quantity refers to the volume of water leaving a site during and after a storm event. Increased volumes of surface runoff can result in flooding, erosion, sedimentation, and loss of habitat. SCMs provide temporary storage for a designed volume of water during and following a storm event. SCMs are designed to release stormwater at a rate that is close to or equal to the pre-developed conditions of the site, thus limiting downstream detriment. Infiltration and groundwater recharge is also promoted by these systems. Groundwater recharge is important in the prevention of droughts and has important biological benefits.

Comprehensive Post-Construction Stormwater Management

Depending on the area of a constructed site, a permanent SCM may be required to manage the stormwater runoff from a property. Once a site is stabilized and moves to a post-construction state, a Stormwater Management plan is necessary for maintaining the function and expanding the life of the system. In many cases, an Operations & Maintenance (O&M) Agreement is developed between the property owner and the regulatory body with certain criteria that must be met with respect to the maintenance of a stormwater system. (It is these agreements that can then be contracted to stormwater specialists such as AQUALIS). The quality of stormwater entering the waters of the state relies heavily on the proper operation and maintenance of permanent best management practices.

Comprehensive Post-Construction Stormwater Management can be divided into the following four elements, all of which work together in a properly implemented Stormwater Management plan.

Inspection	Assessment (initial and annual) of the condition of a system by a qualified Inspector
Maintenance	Regularly scheduled preventative actions to maintain compliance, aesthetics, and function of a system
Repair	Restoration or rehabilitation to correct a deficient or failed system
Consulting	Maximizing the lifespan and value of a system
Spill Prevention and Emergency Response	Ensuring that no harmful or hazardous materials enter the stormwater system



Inspection

Understanding the system and determining its current condition

Once the stormwater systems has been constructed, initial and annual questions to be answered by the property owner or manager:

- Is the site required to submit an annual inspection of the stormwater system?
- What qualifications are required of the inspector?
- When was the last inspection performed on the Stormwater System?
- Who performed the inspection?
- Is the Stormwater System currently inspected? If so, how frequently?
- Does the municipality perform annual inspections to the Stormwater System?

A qualified inspector should perform all SCM inspections. All inspection activities should be documented, and any deficient items should be corrected based on the recommendations of the inspector. Annual stormwater inspections are often required by a municipality and may require the inspector to have special qualifications. Even if the system is not required to submit an annual stormwater inspection, stormwater management facilities must be periodically inspected to ensure that they function as designed. The inspection will determine the appropriate maintenance that is required for the facility.

It is imperative that an inspector utilizes the appropriate type of equipment in order to ensure the safety and allow the inspection to be performed as efficiently as possible. Below is a list of the equipment that may be necessary to perform an inspection of a Stormwater Management Facilities:

- Protective clothing and boots
- Safety equipment (vest, hard hat, confined space entry equipment)
- Communication equipment
- Operation and Maintenance Manual for the site including stormwater management facility plans
- Stormwater Facility Maintenance Inspection Forms
- Manhole Lid Tool
- Shovel
- Camera

In addition to proper equipment, the inspector should keep safety considerations at the forefront of all inspection procedures. Likely hazards should be anticipated and avoided. Never enter a confined space (outlet structure, manhole, etc.) without proper training or equipment. A confined space should never be entered without at least one additional person present.



Maintenance

A customized program to meet the needs of the system and prevent further damage

Stormwater assets must be properly maintained to ensure that they operate correctly and provide the water quality treatment for which they were designed. Routine maintenance performed on a frequently scheduled basis will prevent costly rehabilitative repairs that results when facilities are not adequately maintained.

The majority of stormwater management work consists of scheduled vegetative management and trash and debris pickups for stormwater management facilities. This work includes the removal of debris/material that may be clogging the outlet structure, and also includes activities such as weed control, mosquito treatment, and algae treatment. These activities will normally be performed numerous times during the year.

It is important that the appropriate maintenance plan is implemented in order to promote an aesthetically pleasing and functional stormwater system for an extended lifetime. The following questions should be considered when implementing a stormwater maintenance plan:

- *What are the needs of the Stormwater System on site?*
- *Are there any maintenance requirements based on the location of the system?*
- *What is the property owner's budget allocated toward maintenance?*

Maintenance is typically the responsibility of the property owner. The municipality in which the SCM is located often requires maintenance. If there is a maintenance agreement with the local government, this information should be gathered to ensure full compliance.

Maintenance is essential to the function of each Stormwater System, and there are many advantages to implementing a maintenance program. A few advantages of a Stormwater maintenance program include:

- Ensuring the SCM is functioning as designed
- Maintaining the aesthetic value of the asset
- Limiting the amount and size of repairs within the lifetime of the SCM
- Complying with local regulation
- Minimizing environmental risks and accompanying liability to the owner and/or property manager

The most effective way to maintain your water quality facility is to proactively prevent the pollutants from entering the facility. Common pollutants include sediment, trash & debris, chemicals, dog wastes, runoff from stored materials, illicit discharges into the storm drainage system and many others.

A thorough maintenance program will include measures to address these contaminants and will save money and time in the long term. Key points to consider in your maintenance program include:

- Educate residents or employees to be aware of how their actions impact water quality and how they can help reduce maintenance costs
- Keep properties, streets and gutters, and parking lots free of trash, debris, and landscape clippings
- Ensure the proper disposal of hazardous wastes and chemicals
- Plan lawn care to minimize the use of chemicals and pesticides
- Be conscious of the threat of spills and plan/react accordingly
- Sweep paved surfaces and dispose of materials in proper locations
- Re-vegetate disturbed and bare areas to maintain vegetative stabilization
- Maintain mulch beds to prevent washouts from landscaped gardens
- Clean out the upstream components of the storm drainage system, including inlets, storm sewers and outfalls
- Cautiously and consciously stage materials (including landscaping materials) utilizing best management practices in order to prevent products from entering storm drains

Stormwater maintenance personnel must be qualified to properly maintain stormwater management facilities. Inadequately trained personnel can cause additional problems resulting in additional maintenance costs with the potential for overlooking critical deficiencies with the overall operations of the facility.

Please see ***“MAINTAINING underground and above ground stormwater systems”*** for more information on Stormwater Maintenance.

Repair

Correcting deficiencies to ensure a functional and maintainable system

Repairs may be required at a stormwater facility based on multiple factors. A few contributing factors may include neglect, improper preventative maintenance, age, accident, or defect.

- *Did an inspection determine repair activities to be necessary?*
- *What is the extent/severity of the deficiency?*
- *Can a repair be avoided by implementation of a maintenance plan?*
- *What is the property owner's budget allocated for repairs?*
- *What options are available for restoring the system?*

Restoration Repair

Restoration work consists of a variety of isolated or small-scale maintenance and work needed to address operational problems. Restoration can vary from treatment of invasive plants to erosion repair. Stormwater restoration repairs typically require licensing and extensive knowledge, and often requires the use of small construction equipment.

Rehabilitation Repair

Rehabilitation work consists of large-scale maintenance and major improvements needed to address failures within the stormwater management facilities.

This work may require an engineering design with construction plans to be prepared for review and approval. This work may also require more specialized maintenance equipment, surveying, construction permits or assistance through private contractors and consultants.

From the above discussion of various stormwater control measures, please review typical deficiencies/repairs per type of SCM:



Bioretention Cell or Rain Garden

- Clogged and poorly draining media
- Dead or dying beneficial plants
- Invasive/nuisance vegetation present
- Blockage at inlets to bioretention bed
- Damage to clean out pipes or underdrain
- High volumes of trash accumulation

Sand Filter

- Clogged and poorly draining sand/media
- Blockage at inlets or outlets of sand filter

Constructed Wetland

- Invasive/nuisance vegetative dominance
- Dead or dying beneficial plants
- Clogged or poorly draining structures; incorrect water levels
- High volume of mosquitoes
- High volumes of trash accumulation
- Beaver activity

Wet Detention Basin (WDB)

- Mowing needed
- Invasive/nuisance vegetative dominance
- Clogged or poorly draining structures; incorrect water levels
- Erosion and/or poor vegetative coverage
- High sediment volumes in forebay(s) or basin bottom
- High volumes of trash accumulation
- Animal burrows
- Beaver activity

Dry Detention Basin (DDB)

- Mowing needed
- Invasive/nuisance vegetative dominance
- Clogged or poorly draining structures; incorrect water levels
- Erosion and/or poor vegetative coverage
- High sediment volume in forebay(s) or basin bottom
- High volumes of trash accumulation
- Animal burrows
- Beaver activity

Swale

- Mowing needed
- Invasive/nuisance vegetative dominance
- Incorrect water levels
- Erosion and/or poor vegetative coverage
- High volumes of trash accumulation

Infiltration Basin

- Mowing needed
- Invasive/nuisance vegetative dominance
- Clogged and poorly draining soils at basin bottom resulting in incorrect water levels
- Erosion and/or poor vegetative coverage
- High volumes of trash accumulation

Permeable Pavement

- Limited infiltration due to clogging of pores; sweeping needed
- Damage or settling of pavers

Level Spreader

- Excess sediment accumulation from inlet areas
- Level spreader breach or failure
- Erosion or channelization downstream
- Obstruction by vegetative overgrowth

Underground Vault or Proprietary Device

- High sediment accumulation resulting in incorrect water levels
- Trash/debris present

Reviewing typical SCM repairs is translated in Table 1, below.

Table 1:
Common scenarios relative to Stormwater Systems

Stormwater Control Measure (SCM)	Problem Example:	Solution Example:
Bioretention	“There is standing water present several days after a rain event.”	The media is most likely clogged and would require removal and replacement.
Sand Filters	“There is standing water present several days after a rain event.”	The top 3-5 inches of sediment and/or debris accumulation should be removed; if severe clogging of the sand has occurred, the material should be removed and replaced.
Constructed Wetlands	“My wetland is overrun with cattails and I have noticed a lot of mosquitoes in that area.”	Invasive plants can interfere and overtake the beneficial plants within a system; invasive plants provide the perfect habitat for mosquito breeding; selective treatment should be performed by a Licensed Applicator.
Wet/Dry Detention Basins	“There are multiple large areas of bare soil on the slopes of my pond that appear to be washing away.”	The cause of the erosion should be identified and the area(s) should be stabilized with the necessary method (riprap, seed, temporary or permanent erosion control matting).
Grassed Swale	“The pipe at the highest point of my swale is blocked and water is backing up.”	Sediment volumes should be assessed at the pipe and within the bottom of the channel, and excess sediment should be removed in order to reestablish design grades; all areas of exposed soil should be stabilized with the necessary erosion control method.

Stormwater Control Measure (SCM)	Problem Example:	Solution Example:
Level Spreader	“Sediment and trash has built up around the pipe opening and restricting drainage.”	After installation, level spreaders should be maintained regularly, and cleaned out when volumes become excessive.
Permeable Pavement	“There is standing water at the waffle blocks in my parking lot.”	In time, permeable pavement becomes clogged; regular cleaning with a sweeping truck should be performed with a frequency based on the sediment inputs of the watershed.
Manufactured Systems	“A city inspector informed me that my Stormceptor units have excessive sediment and debris.”	Manufactured systems are designed with catchments for sediment, debris and trash; volumes of this material should be monitored and underground systems should be cleaned with a Vacuum Truck Service when deemed necessary.

One takeaway from a Repair discussion is that stormwater systems are designed and implemented with the presumption that proper maintenance activities will be performed. The very best way to avoid stormwater repairs is through regularly scheduled inspections and maintenance programs managed by qualified individuals.



Consulting

Protecting and maximizing the value of your investment in stormwater management

Stormwater Management is a developing field, and changes in regulation are dynamic. One should periodically review all of the rules and regulations coincident with a property and take advantage of all of the benefits of an investment in a stormwater management system. There are many costs, taxes and fees associated with stormwater management programs, and well-managed programs can sometimes receive waivers or credits on these costs. Managing communication with regulatory bodies and understanding (and possibly lowering) fees paid to municipal agencies can greatly impact the owner and property managers overall costs of stormwater management. Please see the *HANDLING a Stormwater Notice of Violation white paper* and Consulting Solutions Page on the AQUALIS website for more information.

Spill Prevention and Emergency Response

Protecting your stormwater system from hazardous spills

By definition, a well-designed stormwater management system collects and manages liquids via an SCM. Therefore, any liquid spill will be quickly transported to the SCM, and upon entering the SCM, can cause damage and environmental risk. A well designed stormwater management program assesses the potential risks of spills for a particular site, prepares a spill prevention plan, and considers in advance how to react to spills via emergency response. Without effective planning and response, the investments in stormwater management can be rendered moot in minutes. As an owner or property manager, consideration of this area in advance of emergencies is critical. Please see the Emergency Response solutions area of aqualisco.com for more information.





With the stormwater regulatory changes of the last decade, owners and property managers of properties with more than one acre roofed or paved have a clear and direct responsibility relative to stormwater management. In addition to this legal responsibility, taking care of the surrounding environment is also the right thing to do and is good for business. However clear and direct the legal responsibility is, the various requirements, rules, regulations, and nuances of this business make it a sometimes arduous and confusing undertaking.

We hope that this whitepaper has provided the reader with an overview of the basics of stormwater management, including the definition of stormwater, the various methods (SCMs) by which stormwater is managed, and what is involved in a complete stormwater management program. We invite you to consider AQUALIS for comprehensive stormwater program management, and we are ready to answer any questions about how to get started. Please visit www.aqualisco.com for more information and request a free consultation.

AQUALIS
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