Chapter 9

BMP INSPECTION AND MAINTENANCE

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1.0. INTRODUCTION

Most of this handbook is devoted to proper design of stormwater management plans, a task that requires a significant investment of effort and expense. Once they are constructed best management practices (BMPs), also known as stormwater control measures (SCMs), are crucial in protecting water quality from the impacts of development projects. However, an essential component of a comprehensive stormwater management program is the ongoing operation and maintenance of the various components of the stormwater drainage, control, and conveyance systems. Failure to provide effective maintenance can reduce the hydraulic capacity and the pollutant removal efficiency of BMPs and conveyance systems. ***BMP maintenance is the purposeful management of a BMP to maintain a desired level of performance and efficiency.***

Typically, we think of structural stormwater BMP operation for optimizing (1) the reduction of runoff volumes/rates via the management of stormwater networks or treatment trains and (2) the removal of pollutants. The site-specific selection of BMPs, their location in the site plan, and their specific design all influence the amount of long-term maintenance that will be required. If designed correctly, BMPs can also be an aesthetic asset to the development. However, no matter how well they are designed and constructed, BMPs will not function correctly nor look attractive unless they are properly maintained. In addition, a lack of BMP maintenance can result in not just missing pollutants which the devices are designed to capture and treat, but generation of additional pollution **(Figures 9.1 and 9.2)**.

Figure 9.1. An unmaintained stormwater conveyance channel now generating sediment to the receiving channel
(Source: CWP, 2009)

We need to think of BMPs as pollution removal devices, just like wastewater treatment plants. As with any infrastructure, deferred maintenance can increase costs and negatively affect receiving waters. Unmaintained BMPs will ultimately fail to perform their design functions and might become a nuisance or pose safety problems. Local governments inherit problems arising from deferred maintenance. Most maintenance problems with BMPs are less costly to correct when they are caught early – as the old adage goes, "an ounce of prevention is worth a pound of cure." Therefore, developing and implementing an effective maintenance program is essential. As well, designers should give considerable thought to future long-term maintenance during the design of site plans and stormwater management practices. The need for on-going maintenance is a fact of life. Most people would never consider spending lots of money to buy a new car and then never change the oil, rotate/align the tires, have the brakes inspected and, as needed, repaired, etc. The same considerations apply to the need to maintain stormwater management BMPs.

Bioretention swale clogged with sediment.


Bioretention area does not drain properly.

Curb inlets to bioretention swale have eroded.


High plant mortality has occurred.

Site runoff bypasses bioretention swale.


Some site runoff bypasses bioretention.

Figure 9.2. Common Issues with Installation of Post-Construction BMPs (Example: Bioretention)
(Source: CWP, 2009)

However, in the world of stormwater management BMPs, that is typically what happens. The field is ripe with studies and stories about the lack of BMP maintenance and quick failure of BMPs (sometimes within as little time as two years). The damage that results is usually difficult to pin down, and so the clean-up is often done at taxpayer expense. In essence, taxpayers are

rewarding poor performance by some property owners, and most don't even realize this is happening.

Increasing focus on mass balances, numeric goal setting, emerging effluent limits and total maximum daily loads (TMDLs) now requires that much more emphasis be placed upon BMP operation and maintenance for permitting and reporting requirements – for example, for the municipal separate storm sewer system (MS4) permits, and as a part of stormwater pollution prevention plan (SWPPP) reporting (Kang et al., 2008). With the increasing municipal oversight and the threat of fines from federal, state and local agencies, BMP owners are likely to become more attentive to routine inspection and maintenance of these devices.

This chapter will discuss the logistical issues associated with inspection and maintenance of post-construction stormwater control measures, as well as provide an overview of some of the tasks associated with maintaining BMPs. Three approaches to maintenance are discussed in detail: (1) limited local government responsibility (maintenance done primarily by landowners), (2) expanded local government responsibility (more sharing of responsibility), and (3) and comprehensive local government responsibility. This chapter also discusses BMP design and construction considerations that affect maintenance and provides tips and sample checklists for conducting inspections. In addition, it presents strategies for public involvement in maintaining BMPs.

In addition, each of the BMP design specifications on the Virginia Stormwater BMP Clearinghouse website includes a discussion of the specific inspection and maintenance activities required to ensure the proper functioning of the BMP. As well, **Appendix 9-B** of this chapter includes examples of BMP Maintenance Agreements, and Appendix **9-C** includes examples of inspection-maintenance checklists for each non-proprietary BMP. **Appendix 9-D** provides guidance regarding how to design and construct BMPs to minimize maintenance needs.

9.1. HISTORY OF STORMWATER MANAGEMENT OPERATIONS & MAINTENANCE

During the 1970s and 1980s, stormwater management consisted of "peak shaving" facilities where peak flow under post-development conditions was reduced to that under pre-development conditions (2-year storm control for receiving channel protection, and up to the 100-year storm for flood protection). These facilities did not require sediment removal maintenance, since the residence time of water within a peak shaving facility was on the order of several hours and there was marginal sediment/pollutant accumulation. Peak shaving facilities were designed to require as little maintenance as possible. However, such facilities still require regular inspection and maintenance of inlet/outlet structures and emergency spillways and routine trash removal, etc.

The introduction of stormwater control measures for water quality control has changed operation and maintenance (O&M) needs. Many pollutants such as metals, bacteria, and nutrients bind to sediment. The treatment mechanism for many BMPs includes or is based primarily on filtering or settling sediment, which results in the need to regularly remove accumulated sediment.

Stormwater BMP maintenance is the responsibility of the developer during the construction period. Following construction, stormwater facilities located on private property are typically the responsibility of the property owner or a neighborhood association. As required by the state regulations, the local stormwater management program often requires a formal maintenance agreement, which specifies a required maintenance schedule and gives the local government the right to enter the private property and conduct inspections and maintenance activities. Historically, maintenance activities are difficult to implement for the reasons outlined in **Table 9.1. Appendix 9-A** provides the results of a 2008 field survey of BMP maintenance.

Table 9.1. Common Maintenance Pitfalls

ISSUE	EXPLANATION
Insufficient funding	At the root of many maintenance problems is the lack of a stable, long-term funding source. Depending on the level of service a community provides, performing BMP inspection and maintenance can be expensive. It is a real challenge for many communities to know what resources are needed to fund maintenance and repairs and to develop a system that provides consistent funding over the long term.
Uncertainty of the physical location of BMPs	In many communities, the location of stormwater BMPs and conveyance infrastructure has not been tracked as they are constructed. Typically, many communities are not aware of the total number of practices within their boundaries, or whether the BMPs approved have actually been constructed.
Inability to track responsible parties	Even if a community (or local government) is able to track the location of a BMP, the land ownership often changes hands, and the community might not know who the current owner is at a given time. Another common problem is that a homeowners association (HOA) can change leadership or dissolve over time, leaving no real mechanism to maintain existing BMPs.
Lack of dedicated inspection staff	Inspecting and maintaining stormwater BMPs is potentially a full-time job, but few communities have a full-time inspector on staff. As a result, repairs are often ordered in response to citizen complaints, rather than as a part of a comprehensive maintenance plan. Thus, many of the practices that are "out of sight" (e.g., underground practices) go without needed maintenance, resulting in a significant loss of pollutant-removal capability.
BMP designs that are not conducive to easy maintenance	Many BMPs have been constructed without design features that reduce the maintenance burden over time. Examples include inadequate maintenance access, insufficient pretreatment, inlets and outlets prone to clogging, and designs that require confined space entry for maintenance. Lack of adequate design for maintenance increases the frequency of needed maintenance activities, and it hampers the ease with which maintenance and inspections can be conducted.
Lack of compliance and enforcement authority/access	Although many communities have maintenance requirements incorporated into a stormwater ordinance, many also lack the real teeth to ensure that maintenance actually happens. Important compliance issues include escalating enforcement procedures (as problems become increasingly severe), maintenance access, and legal authority to inspect and to compel maintenance.
BMP owners unaware of maintenance responsibility	As a property changes hands, maintenance agreements and other documents outlining maintenance needs are easily lost or buried within property deeds. This leaves practice owners unaware of long-term BMP maintenance responsibilities and costs.

Source: CWP 2008

9.2. GETTING STARTED: SCOPING OUT THE MAINTENANCE PROGRAM

A great deal of effort is involved early in the process of developing a stormwater management (SWM) program. Getting appropriate BMPs included on design plans and constructed properly in the field is a major accomplishment, but it is only the beginning of the actual life of the BMPs. Local SWM programs in Virginia have a legal mandate in the Virginia Stormwater Management Law and Regulations to require inspection and maintenance of BMPs (§ 62.1-44.15:27 E 2, Code of Virginia, and §§ 9 VAC 25-870-106 A 5 and 9 VAC 25-870-114 of the Regulations). Therefore maintenance duties must not be neglected. In order to assure effective BMP maintenance, the local program must establish proper legal authority to accomplish the following: (1) assigning maintenance responsibility through legally binding agreements; (2) providing adequate access to BMPs; and (3) enforcing compliance with maintenance requirements.

Typically, we think of the operation of a structural stormwater BMP as optimizing (1) the reduction of runoff volumes/rates via the management of stormwater BMP networks or treatment trains, and (2) the removal of pollutants. BMP maintenance is the purposeful management of a BMP to maintain a desired level of performance and efficiency of its operation. Maintenance consists of short-term (routine or more frequent), long-term (non-routine or less frequent), and major (rare) actions, as depicted in **Figure 9.3**.

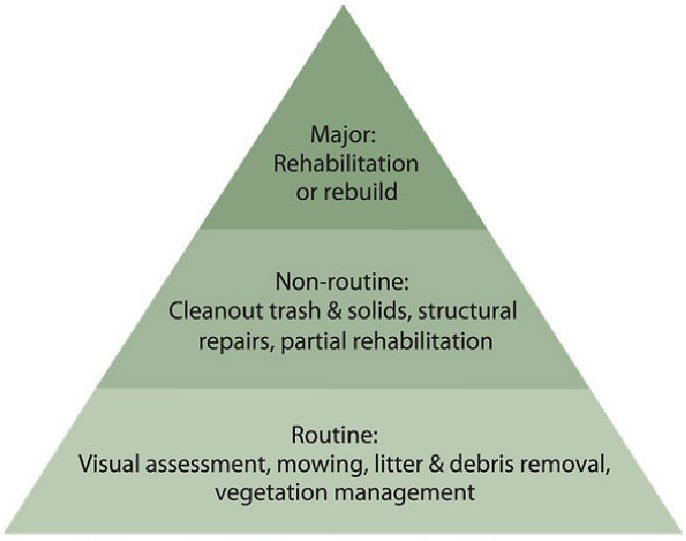

Figure 9.3. BMP Operation & Maintenance Pyramid
Source: *Stormwater*, 2008

Stormwater BMPs have a lifecycle – from their creation (design and construction) through their operative stages (functional or not) – that is largely dictated by operation and maintenance (O&M) actions. Since maintenance involves a significant amount of resources (personnel, equipment, materials, trash/sediment disposal expenses, etc.), the better we understand BMP operation, the more likely we are to maintain optimal performance and improve cost efficiencies (Kang, et al., 2008).

Table 9.2 is a maintenance program service matrix that may help a local program manager scope out the types of maintenance and level of service appropriate for the program.

Table 9.2. Maintenance Program Service Matrix

Program Level of Service	Drainage System Element Included in Maintenance Program	Maintenance Task	Maintenance Response	Inspectors	Inspection Response	Program Feedback Based on Inspections and Maintenance Experience
LOWER	BMPs on public land and within public rights-of-way	Repair immediate threats to public health and safety	React to complaints and emergencies	Rely on owners and HOAs to inspect	Complaint driven	Feedback is anecdotal
⇨	+	+	+			+
⇨	High-priority, high-risk, and/or large BMPs on private land with necessary easements and agreements	Repair structural items: erosion, outfalls, clogged or broken pipes	Establish schedule for mowing and trash/debris removal	Public inspectors send report to responsible party	Every 3 years	Feedback used to modify list of recommended BMPs in design manual based on maintenance burden
⇨	+	+	+			+
⇨	All or most BMPs on private land within easements and covered by deeded maintenance agreement	Also include routine maintenance: mowing, weeding, removal of trash and debris, replacement of vegetation	Conduct maintenance in response to inspection reports, checklists, and performance criteria	Co-inspections with public inspector and responsible party	Annual or semi-annual	
HIGHER	+					
⇨	Completely private BMPs	+		System of certified private inspectors with spot inspections and compliance checks by public agency	More frequent for high-priority BMPs	Feedback used to modify design standards in manual to reduce maintenance burden through initial design
	+	Program includes system to retrofit or reconstruct BMPs				
	All conveyances (pipes, ditches, flood plains)					

System components and maintenance response can increase as programs mature.
The matrix is a tool to set priorities and plan for future program expansions.
(+) means that services are cumulative (level of service includes all previous tasks).

Source: Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program, CWP 2008

The following questions are designed to assist stormwater managers in evaluating their maintenance program responsibilities.

9.2.1. How large is the maintenance task? Developing an Inventory.

It is difficult to develop an effective maintenance program unless an inventory of existing and anticipated future BMPs has been conducted. Without knowledge of the type and locations of stormwater infrastructure components, no comprehensive maintenance plan can be developed.

The following information is necessary in a stormwater management system inventory:

- Facility and conveyance locations;
- Elevations;
- Outfalls;
- Contributing drainage areas;
- Control structures;
- Material types;
- Vegetative species; and
- Any other pertinent information necessary to defining the kind of maintenance required for the facility or conveyance.

An important part of the inventory is assessing the physical and regulatory condition of the system. The physical condition includes the stability and functionality of BMPs and conveyances. The regulatory condition addresses whether BMPs and conveyances are located within easements, have proper maintenance access, and are covered by maintenance agreements or covenants.

This type of information is easily incorporated into a GIS system database. Included in the database can be dates of previous inspections, inspection findings and recommendations, maintenance dates, specific tasks performed, and digital photos of the structure or conveyance. See **Section 9.4.9** for more specific guidance about inventories and tracking systems.

Local programs must also determine what elements of the drainage infrastructure should be included in the maintenance program and who will be responsible for which elements. For example, will the maintenance program be limited to the actual BMPs, or will it also include conveyance systems (pipes and ditches), discharge points, floodplains, and/or stream channels?

9.2.2. Who is responsible for maintenance?

Communities must make decisions concerning the construction, operation and maintenance of the stormwater management infrastructure. For which parts of the stormwater system should the local government be responsible? What services should the local government provide to various parts of a stormwater management system? How do we define exactly what makes up the stormwater management system? And how do we transform our current maintenance policies to a newer definition of responsibility? Deciding who will be responsible for BMP maintenance is an important policy decision, and there are multiple options. This decision may depend on the

status of easements, maintenance agreements, and whether maintenance tasks are aesthetic or structural.

There are two types of maintenance: structural and routine. Structural maintenance consists of repairing plumbing, components, and infrastructure; it is typically costly and requires an enhanced level of expertise. Routine maintenance involves removing accumulated trash and debris and managing vegetative growth (see **Table 9.3**).

Table 9.3. Examples of Structural Routine Maintenance

Structural Maintenance items	Routine Maintenance Items
▸ Clogged or broken Pipes ▸ Missing or broken parts (e.g., valves, seals, manholes) ▸ Cracked concrete ▸ Erosion at outfall or on banks ▸ Sinkhole formation or subsidence within the practice's footprint ▸ Regrading or dredging ▸ Landscaping needs complete refurbishment	▸ Mowing ▸ Removal of small amounts of sediment ▸ Removal of vegetative overgrowth and woody plants ▸ Removal or trash and yard debris ▸ Replacing dead or diseased landscaping ▸ Control of invasive plants

Source: CWP 2008

Unmaintained stormwater facilities will eventually fail operationally. A major contributor to unmaintained facilities is a lack of clear ownership and responsibility. In order for an inspection and maintenance program to be effective, the roles for each responsibility must be clearly defined prior to construction of a system. The lead role in determining what responsibilities belong to whom lies with the local government. Several different approaches are possible and are briefly described below. A community must determine which approach best suits its capabilities, both physically and financially. **Table 9.4** below outlines the characteristics of each approach, as well as typical program budgets and funding mechanisms. Most stormwater programs include features from all three approaches (No. 4, the hybrid approach).

9.2.2.1. Limited local government responsibility

Traditionally, maintenance is the responsibility of the property owner, which in most cases is a private individual, corporation, or homeowners association. However, some communities assume partial or complete responsibility for BMP maintenance. The narrowest approach for communities to take in defining responsibilities for stormwater systems would be for the local government to accept responsibility only for property owned by the community. This would include the right-of-way and any other publicly owned land such as local facilities and parks. With this approach, the community would not be involved with any stormwater systems on private property, except for possible regulatory action. Simple maintenance items such as minor landscaping tasks, litter removal, and mowing can be done by the owner, or can be incorporated in conventional grounds maintenance contracts for the overall property.

Table 9.4. Three Maintenance Program Approaches

Typical Program Characteristics	Typical Annual	Typical Funding

	Maintenance Program Budget Range*	Mechanisms
1. Limited Local Government Responsibility		
• Local government maintains facilities on public land and/or major private facilities within easements, while private parties are responsible for facilities on private property • Most common maintenance approach • Can be cost-effective, but still requires local government budget and staffing	$50K to $300K	Stormwater Utility Capital improvement program General Fund
2. Expanded Local Government Responsibility		
• Local program responsible for more maintenance functions (typically adding the potentially most troublesome at at-risk systems to publicly owned systems)	$100K to $500K	Any of the above plus Stormwater Utility fees
3. Comprehensive Local Government Responsibility		
• Local program responsible for most maintenance functions • Owners may be responsible for routine tasks (mowing, picking up trash, weeding, aesthetics) • Requires highest budget and staff commitment • More common in cities and towns with an established public works function and jurisdiction over roads and drainage	$100K to $1.5M	Stormwater Utility Other utility (e.g., sewer rates, etc.) Transportation maintenance funds General Fund
* Maintenance program budget figures were derived from research on local stormwater programs, primarily Phase II MS4s, conducted in 2005 (CWP, 2006). Because most programs are still in the early stages of program development, these figures represent nominal costs associated with a maintenance program, and do not include other costs, such as the cost of stormwater capital improvement projects. Costs will increase as program responsibilities and accountability increase. Typically, larger municipalities, such as Phase I communities, have much larger maintenance budgets.		

Source: Adapted from CWP 2008

Placing maintenance responsibility in the hands of individual property owners, Homeowner Associations (HOAs) and business owners significantly reduces the costs to the municipality and may be the best option for small communities that cannot afford to allocate staff and crews to maintain BMPs. The local program still must has a significant role under this option however, by educating property owners and HOAs, conducting periodic inspections, tracking maintenance, and initiating enforcement when needed. This approach necessitates that property owners are aware of and routinely budget for the ultimate time and costs of maintenance activities. If the local program fails to fulfill its education and oversight roles, an inadequate level of maintenance is inevitable.

Responsible parties can conduct inspections with in-house personnel (or properly trained HOA volunteers) or by hiring a contractor. This approach still requires the local program staff to conduct spot inspections and to ensure overall compliance. Using this approach, private landowners or HOAs are primarily responsible for routine maintenance and major structural repairs. Public maintenance, where it does occur, is typically limited to facilities on public property.

While this approach may seem most easily defined, there are some drawbacks. Parties who have little knowledge or funding to maintain stormwater systems, own many of the stormwater system

components that are on private land. For example, many residential subdivisions contain a stormwater pond, frequently located on one of the less desirable lots. The homeowners association is typically the owner of such a pond. These groups generally have little understanding of the purpose of the pond and how it operates, and have even less funding available to repair and maintain it. The stormwater pond will typically fall into disrepair and become overgrown with vegetation and lose any viable functionality. Even worse, if left in disrepair for a long enough time, the disrepair may result in a dam failure. Many light commercial stormwater systems also fall into this same state for the same reasons.

If a locality decides to use the approach of limited local government responsibility, the jurisdiction will have to put forth some effort to prevent these drawbacks from occurring. It may be possible for the community to make this approach work with a proactive inspection program to review private systems, and a strong public education program to insure that owners understand their responsibility and perform their required duties. Private owners should also be made aware of the need to plan how they will fund their maintenance programs. For the residential example above, dues to the homeowners association could be earmarked for maintenance and set at a level that will assure that enough funds will be available for potentially expensive dredging or repairs.

9.2.2.2. Expanded local government responsibility

In addition to maintaining and operating publicly owned stormwater systems, the community may determine that it should maintain and operate some of the private portions of the system. This approach could be chosen in an attempt to eliminate the problems mentioned above.

The difficulty with expanding the responsibility of the local government is in determining where to end local responsibility and how to fund the extra responsibilities. These decisions must be made in a fair and equitable manner. One option for this approach would be for the community to accept operation and maintenance responsibilities for all residential stormwater systems, but not for any commercial or industrial systems.

9.2.2.3. Comprehensive local government responsibility

The opposite of a limited approach would be a comprehensive approach, where the community conducts all operation and maintenance activities for stormwater systems within its jurisdictional boundaries. This type of approach may be deemed to be the best approach if the community has serious nonpoint source pollution issues, especially if there is a possibility of regulatory action by the federal or state government. This type of approach would also be well suited to the community that has a stormwater utility in place and/or operates and maintains regional stormwater management systems instead of a myriad of small on-site systems. Because of the inherent problems associated with private maintenance responsibilities, the most efficient organizational structure would be to give the jurisdiction ownership or easement access to the stormwater system. This would place the responsibility for the overall stormwater system with one entity. A comprehensive and cohesive program could be developed and implemented by the jurisdiction for inspection and maintenance.

This approach is not widespread among communities, primarily because of the high costs, extensive staffing requirements, and administrative burden placed on the program. This approach, however, has some advantages. Time-consuming public education and enforcement issues can be avoided, and the local program has more control over when and how maintenance is accomplished. In many cases, municipalities can transition from private maintenance (Approach 1) to local program maintenance (Approach 3) as the program matures. This transition would require the local program to inventory existing BMPs and conveyance systems to determine the immediate maintenance needs.

This option requires the most time, staff, and funding, but it provides local programs with the best control over inspections. An alternative is for the local program to *hire contractors to conduct inspections*. Doing that reduces staff time, but it requires contract management and quality control to ensure that thorough inspections are conducted. Furthermore, local program staff members would still be responsible for compliance and enforcement. In general, the comprehensive approach requires local programs to collect and manage detailed information about each BMP, maintain a team of dedicated staff, and secure funding.

The most difficult aspect of this approach may be how it would be funded. The most logical option for funding would be to adopt a local stormwater utility fee based on the amount of stormwater and pollution contributed by each site.

9.2.2.4. Be Clear about Various Maintenance Responsibilities

Respective maintenance responsibilities must be clearly outlined to achieve program success. One danger of a hybrid system is that maintenance responsibilities may not be systematically assigned and communicated. Local program staff must understand who is responsible for which maintenance tasks and must ensure that private parties understand their roles. The following is a list of methods that can be used to communicate and clarify roles and responsibilities:

Table 9.3 (above) lists tasks necessary to maintain the drainage system, which could be assigned to the local program or private parties for maintenance. Assuming that most or all of the functions in **Table 9.3** must be performed by some party, the following activities may help the local program to delegate responsibilities:

- Make explicit policy decisions based on program goals and the characteristics of the community. Don't assume that all parties will know what they're supposed to do.
- Use a deed of easement or easement agreement to clearly outline rights and responsibilities. See also **Table 9.8** (Considerations for Stormwater Easements).
- Use a maintenance agreement that clearly outlines responsibilities for routine versus structural maintenance.
- Develop a guidebook or other outreach materials geared toward HOAs and responsible parties.
- Explain maintenance responsibilities during co-inspections.
- Include maintenance information on the local program web site.
- Local program staff should monitor all private-party activities to ensure that appropriate inspection and maintenance tasks are performed.

Of the above given approaches to local responsibility, each community must determine the amount of responsibility and effort it is willing to commit in order to provide adequate stormwater management. A local government could choose one of the approaches described above, or could choose some point between. Whichever approach is chosen, the decision must be carefully considered and open for change with time and experience. A stormwater management system should have ownership and maintenance responsibilities clearly defined from the initial stages of design. It should be clear and unequivocal what entity has responsibility for each portion of the system.

9.2.3. Maintenance inspections

An effective inspection program is necessary to ensure a stormwater facility or conveyance remains operational. Inspections should be performed on a regular basis and scheduled based on the type and characteristics of the stormwater control measure. In addition, inspections should occur after major rainfall events for those components deemed to be critically affected by the resulting runoff. Not all inspections can be conducted by direct human observation. For subsurface systems video equipment may be required. There may be cases where other specialized equipment is necessary. The inspection program is tailored to address the operational characteristics of the system.

It is not mandatory that all inspectors be trained engineers, but they should have some knowledge or experience with stormwater systems. Trained stormwater engineers should, however, direct them. Inspections by registered engineers should be performed where routine inspection has revealed a question of structural or hydraulic integrity affecting public safety.

The inspection process should document observations made in the field. Comments should be archived on structural conditions, hydraulic operational conditions, evidence of vandalism, condition of vegetation, occurrence of obstructions, unsafe conditions, and build-up of trash, sediments and pollutants. This is also an efficient way to take water quality measurements required for monitoring programs and to incorporate them into the inspection history. The inspection data should be ideally incorporated into a GIS database, if possible, as it allows spatial identification of where maintenance activities are required or have occurred. Trends may be identified in this way that can assist a community in tracking down specific system components that cause chronic problems.

9.2.4. What "level of service" is desired for the maintenance program?

The level of service defines the frequency and scope of maintenance and the kinds of activities that receive oversight through the maintenance program (see **Table 9.2**). The regulations address this to some degree, but each individual maintenance agreement must specify a schedule of maintenance activities. Schedules will vary somewhat, depending on the size and type of BMP and the associated risks if maintenance does not occur.

In addition to determining the extent of responsibility that a community is willing to assume, a decision must be made about how the stormwater system will serve the community. This

decision determines the *level of service* (LOS) that the system must achieve. The level of service is defined two ways: (1) performance level of service and (2) maintenance level of service.

The susceptibility of a community to flooding or water quality problems due to stormwater can be measured by assessing the performance level of service available. For example, for flooding issues, a level of service can be expressed in terms of the degree of roadway flooding and/or the extent of first floor flooding for a given hypothetical storm event. For some communities, a level of roadway service may be defined as having no less than one open lane on evacuation routes during the largest one-day rain event with a 25-year recurrence interval. LOS definitions vary considerably by community and are defined as a design frequency tied to a specified condition (e.g. the 10-year storm design frequency for culvert overtopping). Compared to a flooding LOS, the concept of a water quality level of service is fairly new. A water quality LOS system might promote land use controls, followed by structural treatment measures, and may penalize untreated discharge from urban areas.

A maintenance level of service is defined by the types of services a community will provide to different parts of the drainage system or by the specific condition of the system. For example, within the right-of-way and in critical areas highly susceptible to flood damages, the maintenance level of service might include periodic inspection, priority cleaning and the highest level of emergency response. In similar right-of-way areas not susceptible to flooding, the level of service for maintenance might be much lower. A community might perform maintenance for residential structural stormwater controls, but only provide inspection and enforcement of maintenance agreements for structural controls located on non-residential parcels.

Maintenance levels of service can also be defined in terms of the condition of the system. Channel mowing may take place when the grass is about 8" high. Or culverts might be cleaned out when they are, on average, 20% blocked with sediment. In these cases inspection of the systems drives work orders rather than flooding complaints.

The extent or responsibility and level of service combine to define the capital project (construction or land acquisition) and operation and maintenance programs. For example, it might be that on private land a local government is only willing, and only has the resources, to perform emergency response services and to give technical advice. But in the high priority public rights-of-way, the local government may be willing to provide a much higher level of service. If a community chooses a low-level stormwater maintenance program with minimal responsibilities, it should anticipate increasing complaints and an unknown but growing backlog of unmet capital construction and remedial maintenance needs. No stormwater management system can function for long without adequate attention. Maintenance avoided is simply maintenance deferred.

9.2.5. Establishing maintenance responsibility and level of service policies

A drainage system, starting from the headwaters and moving downstream toward the mouth, carries incrementally larger and larger flows. The *extent of responsibility* policy seeks to define the dividing point in this dendritic system between local government and private responsibility. The basic components and limits of that responsibility are also defined in extent of service.

The extent of responsibility will almost certainly change over time, both in terms of the local government's policies and the application of those policies. For example, in terms of routine maintenance of the systems, the extent of responsibility may consistently be limited to those components within rights-of-way and easements which allow adequate access to the facilities, but rights-of-way and easements will be added over the years, so the practical extent of responsibility will expand even if the policy does not change.

The extent of responsibility for regulatory activities must go far beyond the rights-of-way and easements to meet the local government's stormwater quantity and quality control responsibilities. Often the community must determine its regulatory extent of responsibility (through its authority for land use control) based on what must, or can, be done on private property in order to protect the general public health, safety, and welfare.

How far into the system should a local government provide service? All of the drainage system can be categorized according to location, conveyance and legal standing:

- In or outside the public right-of-way;
- Does, or does not contain significant public water; and
- Is or is not within a permanent dedicated drainage easement.

Thus, there are typically four "policy" categories of drainage system:

1. Within the right-of-way;
2. Outside the right-of-way, carrying public water and within an easement;
3. Outside the right-of-way, carrying public water but not within an easement; and
4. Totally private systems.

Based on its definition of the system components, the community can determine how it will handle the various portions of the drainage system. Generally:

- The minimal extent of responsibility is within the public right-of-way. Every local government has a public health and safety responsibility to keep its travelways open to traffic and free from dangerous amounts of standing water.
- Often communities also provide maintenance service, of some sort, within permanent drainage easements. This is especially the case when there is both public water and a public interest in keeping a certain drainageway functional.
- Some also have established the policy that they will provide some service to other parts of the drainage system that carry public water (i.e. downstream from the first public street). In other locations, only an inspection and enforcement service is provided outside the right-of-way and easements.
- Most communities will respond to any location whatsoever in an emergency situation.

When developing changes to a maintenance program it is helpful to remember these three basic steps:

1. Define the Program
    - Determine segment category definitions

- Determine level-of-service and policy definitions
- Determine resource demands and available budget
- Develop policies for each segment category

2. Define the System
- Inventory and map the stormwater management system
- Identify the "official" system (right-of-way and key segments outside ROWs)
- Assign segments to the system

3. Initiate Changes
- Begin changes in service
- Expand slowly as experience is gained

9.2.6. Should the local program use in-house resources, a contractor, or both to perform maintenance tasks?

Local program managers who operate large, public facilities may use in-house staff to conduct BMP maintenance in conjunction with operating and managing utilities, buildings, and roads. For many smaller programs, however, employing private contractors is more efficient than hiring new staff and purchasing equipment. Another option is entering into an agreement with a water and sewer utility, Soil and Water Conservation District, neighboring jurisdiction, or transportation agency to share maintenance responsibilities and maximize economies of scale in the use of equipment and personnel. The increased emphasis on stormwater facility maintenance is stimulating the development of new companies focusing on this niche business opportunity to provide such maintenance services (similar to the companies that now provide erosion and sediment control facility installation and maintenance services).

Although non-professionals can undertake many maintenance tasks effectively, a professional should be consulted periodically to ensure that all needs of the BMP facility are met. Elements where the professional judgment of a professional engineer may be needed include structures, outlets, and embankments/dams. As well, the health of vegetation associated with BMPs may require the attention of an appropriate plant professional. Some developing problems may not be obvious to the untrained eye.

In addition, it is advisable to have professionals do the more difficult or specialized work. Filling eroded areas and soil-disturbing activities, such as re-sodding or replanting vegetation, are tasks that are best assigned to a professional landscaping firm. If the work is not done properly the first time, not only will the effort have been wasted, but also the facility may have been damaged by excessive erosion. Grading and sediment removal are best left to professional contractors. Appropriate professionals (e.g. BMP maintenance specialists, professional engineers, aquatic plant specialists, etc.) should be hired for specialized tasks such as inspections of vegetation and structures.

9.2.7. Maintenance scheduling and performance

Maintenance activities can be divided into two types: scheduled and corrective. Scheduled maintenance tasks are those that are typically accomplished on a regular basis and can generally be scheduled without referencing inspection reports. These items consist of such things as vegetation maintenance (such as grass mowing) and trash and debris removal. These tasks are required at well-defined time intervals and can be considered a routine necessity for most, if not all, stormwater structural facilities. A permanent maintenance crew is typically put under a fixed scope of responsibility to address these items.

Corrective tasks consist of items such as sediment removal, stream bank stabilization, and outlet structure repairs that are done on an as-needed basis. These tasks are typically scheduled based on inspection results or in response to complaints. Corrective maintenance sometimes calls for more specialized expertise and equipment than for scheduled tasks. For example, a task such as sediment removal from a stormwater pond requires specialized equipment for which not every jurisdiction is willing to invest. Therefore, as noted above, some maintenance tasks might be effectively handled on a contract basis with an outside entity specializing in that field. In addition, some corrective maintenance may also require a formal design and bid process to accomplish the work.

9.2.8. How will maintenance compliance be tracked, verified, and enforced?

Local stormwater ordinances and program tracking and evaluation systems are key components of a strong program. Certain stormwater plans must have a recorded Maintenance Agreement before the plan is approved. There must also be some type of compliance mechanism to assure that maintenance is actually performed on a regular or as-required basis.

One method for ensuring maintenance is the implementation of a stormwater system operating permit and/or maintenance agreements. This kind of approach would produce information for inclusion in a stormwater inventory database, thus adding to the efficiency of a local maintenance program, as well as providing a funding mechanism through permit fees. Some key aspects of these permits or maintenance agreements is the clear delineation of responsibilities, such as the following:

- Identification of who will perform inspection duties and how often.
- Listed duties that are to be performed by the owner, such as mowing, debris removal, and replanting of vegetation.
- Defined roles for the local government, possibly inspection, and/or modifications to the system such as resizing an orifice.
- Determination of a recourse of action to be taken if the owner does not fulfill their obligations (i.e. repayment to the local government for activities that the owner did not perform).
- Development of a pollution prevention plan by the owner.
- Requirement of a report, possibly annually, that would serve to keep the owner involved and aware of their responsibilities.

For example, a permit or maintenance agreement could specify that the local government accepts responsibility for inspecting and maintaining the stormwater system's structural components, including the periodic removal of debris and accumulated sediments, but that vegetative and aesthetic maintenance would still rest with the private entity.

These Maintenance Agreements can be used to help track maintenance. Checklists based on the Maintenance Agreement can then be used to determine whether performance criteria have been met. Inspection/Maintenance checklists for each of Virginia's approved non-proprietary BMPs are included in **Appendix 9-C** at the end of this chapter. Each checklist, at a minimum, should include the following:

- Date of the inspection and name of the inspector.
- Identification and location of the BMP being inspected
- Condition of each of the BMP components.
- Any maintenance work that was performed (as well as who performed the work).
- Any issues noted for future maintenance (sediment accumulating, vegetation needing pruning or replacement, etc.).

All inspection and maintenance activities should be recorded. Each project should have a maintenance record. Any deficient BMP components noted in the inspection should be corrected, repaired or replaced immediately. These deficiencies can affect the integrity of structures, the pollutant removal efficiency of the BMP, and public safety. Major repairs or maintenance work should include the same level of inspection and documentation as for the original installation. Inspection checklists and record logs should be kept in a known set location. When necessary maintenance is not performed, mechanisms must be in place to enforce compliance.

It is advisable to prepare an annual maintenance report to document maintenance activities. In fact, annual maintenance reports are typically necessary for MS4 programs, since consistent BMP maintenance is a permit condition. Annual reports provide the local program an opportunity to identify important maintenance issues that may need to be checked on during the subsequent year. Ideally, the annual report should provide the following information:

- Observations resulting from inspections:
  - Hydraulic operation of the facility (detention time, evidence or occurrence of overflows);
  - Condition of vegetation in and around the facility;
  - Occurrence of obstructions at the inlet and outlet;
  - Evidence of spills and oil/grease contamination; and
  - Frequency of trash build-up.
- Measured sediment depths (where appropriate);
- Monitoring results, if flow or quality monitoring was undertaken;
- Maintenance activities performed;
- Maintenance activities needed in the coming year; and
- General recommendations for the inspection and maintenance program for the coming year.

9.3. ESTABLISHING AN EFFECTIVE MAINTENANCE PROGRAM

Regardless of who has responsibility for specific program elements, the following are issues and tasks that must be addressed in order to establish an effective local BMP maintenance program.

9.3.1. Develop Program Documents

The program's legal and administrative foundation must be established in the local stormwater management ordinance, design or policy manual, and other forms and applications used to implement the program. A preliminary list of necessary documents is provided in **Table 9.5**.

Table 9.5. Legal and Administrative Foundation for a Maintenance Program

Stormwater Ordinance	Design/Policy Manual	Other Forms and Applications
Requirement for responsible party to maintain BMPs		Maintenance Handbook or guide for responsible parties
Reference to general design standards that include features that reduce maintenance	Detailed maintenance reduction design specifications (on Virginia Stormwater BMP Clearinghouse web site)	
Requirement for a maintenance agreement or covenant recorded with property deed	Standard (template) maintenance agreement(s) (in Appendix 9-B of this chapter)	
Requirement for easements	Standard easement deed and specifications (when required, width, rights of grantor and grantee)	
Maintenance inspection frequency and reporting	Inspection/Maintenance checklists and sample operation and maintenance (O&M) plans (in Appendix 9-C of this chapter)	
Requirement for performance bond to cover initial installation and period of operation (e.g., 2 years)	Performance bond forms	
Compliance and enforcement tools, including injunctions, consent orders, civil penalties, fines, or jail, depending upon the nature of the violation (potential misdemeanor or felony charges); ref § 62.1-44.15:48, Code of Virginia)	Notice of Violation letter template Schedule of civil and/or criminal penalties	Civil penalty "ticket book" for inspectors

Source: Adapted from CWP 2008

9.3.2. Establish Maintenance Policies and Funding

This step requires critical policy-making decisions, which serve as the foundation for program budget and staffing and for determining the appropriate level of service. A typical decision may

include determining who will be responsible for structural versus routine maintenance (see **Table 9.3** above). See **Table 9.2** above for additional level-of-service policy decisions.

In most communities, simple aesthetic and routine tasks, such as mowing and trash removal, are performed by the property owner or responsible party. These activities require equipment and staffing, and they are more challenging for municipalities to undertake on a frequent or routine basis. Assuming the responsibility for such tasks will increase the need for local program staff and additional funding. No matter which maintenance approach is adopted, a reliable source of funding will have to be established to pay for inspection and maintenance expenses.

The expenses associated with maintaining a BMP are highly dependent on the BMP type and its design. However, the most important factor that determines the cost of BMP maintenance is the condition of the drainage area upstream of the BMP. If a drainage area conveys a high load of sediment and other pollutants to a BMP, the cost of maintaining the BMP will increase dramatically. Preventing or minimizing pollution in the drainage area will reduce the cost of BMP maintenance.

If a private landowner or HOA is responsible for some or all BMP maintenance on their property, the owner should establish a funding or savings mechanism should be established and funded regularly with an amount that provides enough money to pay for these maintenance expenses over the lifetime of the BMP. One option is to establish an escrow account, which can be spent solely for sediment removal, vegetative replacement, structural repair, or reconstruction of the BMP(s). In the case of a residential subdivision, the escrow account could be funded by a combination of an initial payment by the developer and subsequent regular contributions by the HOA. For an example of how to legally structure such an account, see the Phase II model stormwater ordinance at the North Carolina DENR-Division of Water Quality's web site, at:

http://h2o.enr.state.nc.us/su/phase_2_mod_ord.htm

Routine maintenance costs are relatively easy to estimate, and include expenses associated with the following activities:

- Conducting BMP inspections at prescribed intervals.
- Maintaining site safety, including any perimeter fencing and other access inhibitors (trash racks or pipe grates).
- Removing trash.
- Removing sediment that has accumulated in any components of the BMP.
- For infiltration systems, maintaining the filtering media and cleaning or replacing it when necessary.
- Restoring soils to assure performance.
- Pruning woody vegetation.
- Replacing dead vegetation.
- Stabilizing eroded side slopes.
- Repairing damaged or eroded outlet devices and conveyance systems.
- Repairing embankments, dams, and channels due to erosion or rodent damage.

Emergency maintenance costs are more difficult to estimate. They depend on the frequency of occurrence and the nature of the problem, which could vary from storm erosion repairs to the complete failure of a structure.

An inventory of BMPs (discussed below) located within the local program jurisdiction is useful in determining the amount of funding that will be needed to implement local BMP inspection and maintenance activities. More and more local governments are considering establishing Stormwater Utilities to generate funding to support administration of their local programs, including long-term inspection and maintenance functions. Stormwater Utilities function in the same way as public utilities responsible for water supply, wastewater treatment, transportation, etc., levying *user fees* to cover the services provided.

9.3.3. Develop Outreach Materials and Programs for Design Consultants, Inspectors and Responsible Parties

One of the most important ways to assure the regular inspection and maintenance of the stormwater infrastructure is through education programs (see **Table 9.6**) for both private owners and the general public. The public can be helpful or detrimental to the success of the community's stormwater management program. Often, property owners are unaware of what a BMP is, how it functions, what is required for maintenance, and how much that will cost.

Table 9.6. Key Stakeholders in Stormwater Maintenance and Selected Strategies

Stakeholder Group	Selected Public Involvement Strategies
Primary Stakeholders	
• Private responsible party or HOA • Public agency inspectors • Public agency maintenance crews	• Co-inspections with responsible party and public inspector • Brochures and mailings to responsible parties • Workshops, certifications, plaques, and other forms of recognition for responsible parties • Adopt-A-BMP programs with training and certification • Workshops for inspectors with field component • Workshops, certification, and recognition for maintenance crews
Other Stakeholders	
• Private sector contractors performing inspections for responsible parties • Private sector contractors performing maintenance tasks for responsible parties • Elected officials • Residents of neighborhoods with BMPs	• Training and certification programs • Periodic updates for elected officials to tout benefits of maintenance program (e.g., cost savings through proactive maintenance) • Hotline for maintenance questions and concerns from the public • General information brochures or Web sites on “what to expect from your neighborhood BMP” • Fact sheet on BMPs, mosquitoes, and West Nile virus

Source: CWP 2008

A good example of the need for public education is residents who use the ditch behind their house to dispose of grass clippings and vegetative debris. This debris can then block a pipe inlet and cause flooding, or cover an infiltration trench and cause excessive runoff. Another common problem is individuals disposing of materials by discharging them into the stormwater drop inlets

and catch basins Citizens need to be informed that sediment, vegetative material and harmful substances such as waste oil should not be dumped into catch basins but must be disposed of properly. In many cases, once the public is informed of the purpose of the system, the need to properly maintain the system, and the potential consequences of misusing and not caring for the system, they are less likely to perform acts that inhibit the system or cause adverse impacts.

An additional benefit of an educated public is the opportunity to have many more "inspectors" (eyes on the ground) who will alert system operators of potential problems prior to catastrophic failure. As part of an effective education component, the public should be informed of signs to be aware of that may indicate serious problems. If a citizen is told that the dry detention pond behind his house should not have standing water at all times or should not fill to the top of the dam after every rain event, he or she would then know to alert the proper authorities and could prevent possible damage to life or property.

In addition to public education for publicly owned or operated systems, education can be very important for privately owned systems. Once stormwater structural controls are installed, the end-user or owner may not be aware of the necessity of the facilities or the consequences of a failed system. As part of the public education, it is vital that private owners be educated to understand and become proactive in the operation and maintenance of their facilities. It is in the best interest of the public to make the owners of private stormwater systems aware of the responsibility that goes with ownership and the effect that failure could have on public health and safety.

When development is proposed for a new site, the following educational outreach efforts should be conducted:

- *During Plan Development*: A municipal staff person should be available to the developer, contractor, or design consultant to assist with development of a maintenance plan for each BMP. At the pre-construction meeting, the parties should review the maintenance plan, maintenance responsibilities, and schedules.
- *During Ongoing Maintenance*: The local government is typically the source of technical assistance to HOAs and businesses after the plan is developed. Technical assistance may include providing lists of local contractors who conduct maintenance or repairs, providing advice regarding a budget for maintenance, providing maintenance handbooks written for citizens, and accompanying owners or contractors during routine and post-repair inspections.

Some related programs (e.g., “Adopt-A-Pond”, etc.) develop citizen-friendly guides, training opportunities, and recognition and awards for participants. In addition to providing educational material, some communities have begun inviting or even requiring homeowners to attend workshops to learn about their buffers, rain gardens and other LID-type practices, to create a long-term connection to the local program and convince them that their efforts benefit everyone (Stormwater, May 2008).

Communities can establish a volunteer program for BMP maintenance by recruiting motivated individuals, service groups, neighborhood associations, and school groups. This approach works well for highly visible BMPs that have safe and easy access. Typically, volunteers perform simple inspections and light maintenance tasks such as trash pickup and weed removal. The

volunteers also report serious problems or more labor-intensive maintenance needs to the local program manager. Certificates of accomplishment, prizes, publicity, or other incentives can be used to recruit volunteers and provide a rewarding experience. Several communities sponsor Adopt-A-Pond programs to provide citizens and responsible parties with guidance and resources for maintaining and improving stormwater ponds. An example of such a program from Hillsborough, Florida, can be found at: http://www.hillsborough.wateratlas.usf.edu
The Adopt-A-Pond program could be broadened to include other types of stormwater BMPs.

9.3.4. Verify Maintenance Provisions during Stormwater Plan Review

The plan review process should ensure that all necessary documents are in place when a project is approved. These include the following:

- Maintenance agreements, including the identity of a responsible party and the applicable parcel(s), which are recorded in the property deed;
- Operation and maintenance (O&M) plans and schedules, which are part of the approved plan and/or maintenance agreement;
- Easements, as needed, which are accurate and shown on the final property plat; and
- Performance bonds, if applicable (see § 62.1-44.15:34, Code of Virginia).

BMP facilities are typically built, owned and maintained by non-governmental entities. To insure proper long-term maintenance, the Virginia Stormwater Management Regulations require that a Maintenance Agreement must accompany the design plans for BMPs (9 VAC 25-870-124 provides some discretion regarding BMPs on small lots). A Maintenance Agreement should include the following:

- The frequency of inspections that are needed (based on the type of BMP proposed).
- The components of the BMP that need to be inspected.
- The types of problems that may be observed with each BMP component.
- The appropriate remedy for any problems that may occur.

The most effective Maintenance Agreement is site-specific for the particular BMPs that are used on the site as well as any conditions that are unique to the site (e.g., the presence of steep slopes that should be inspected for soil stability) and includes a schedule of inspection frequency. Sample Maintenance Agreements are included in **Appendix 9-B** at the end of this chapter.

The Maintenance Agreement should be recorded (i.e., filed with the appropriate Register of Deeds). The responsible party should keep a copy of the Inspection and Maintenance Agreement along with a current set of BMP plans at a known set location.

9.3.5. Secure Easements for New BMPs during Plan Review

BMPs must have access and maintenance easements to provide the legal authority for legal access to the site for inspections, maintenance personnel and equipment. The location and configuration of easements must be established during the design phase and should be clearly shown on the design drawings. The access and maintenance easement must include the entire

footprint of the BMP system plus at least an additional 10 feet around the BMP, to provide enough room to complete maintenance tasks. The BMP system includes the side slopes, forebay, riser structure, BMP device, and basin outlet structure, dam embankment, and emergency spillway.

Access and maintenance easements must be configured to allow for the maintenance tasks that may be needed. If heavy equipment will be necessary to perform maintenance tasks (such as removing sediment from a forebay), typically a roadway with a minimum width of 12 feet should be provided to the BMP. Easements are usually owned and maintained by the owner of the BMP facility, whether an individual, a corporation, or a unit of government. Easements for BMPs that are not publicly maintained should include provisions to permit public inspection and maintenance. Examples of Maintenance Agreements are provided in **Appendix 9-C** at the end of this chapter, including provisions for access and easements.

Easements may be necessary to assure that important components of the stormwater management plan remain in place over time. This is especially true for site planning techniques that provide runoff reduction benefits (e.g., conserving open space, restoring forest cover, etc.) and LID-type practices that may not be obvious BMPs to property owners (e.g., bioretention facilities that often appear to be merely discretionary landscaping). Securing easements after a project is built and after properties are occupied is time-consuming and uncertain. Therefore, program managers should strive to secure easements during the review of stormwater plans. This requires the stormwater reviewer to coordinate with the department or staff person that reviews property plats for the locality. To have legal standing, the easement must be shown on the plat of record.

Programs that promote low-impact development (LID) types of BMPs and dispersed and distributed runoff reduction practices – possibly on individual lots – may have to develop LID-specific easement policies and procedures. There are legal, administrative, and logistical considerations for having easements cover these types of practices, and for the long-term access and maintenance of the practices. The local program may want to consider a "hybrid" approach (see below) for certain categories of BMPs. The following are some considerations for securing stormwater easements:

- Easements should cover:
  - The BMPs.
  - Enough land around the BMPs for construction equipment to enter and maneuver. This includes access to dams, risers, safety benches, forebays, and outlets, as appropriate.
  - For ponds, a setback (e.g., 25 feet) from the flood (100-year) pool area.
  - Access routes for maintenance.
  - According to program policies, conveyances and structures associated with the BMPs.
- For drainage easements, the easement width should increase as the top width of the channel or depth of the pipe increases. For example, the easement width should be progressively increased in increments of 5 feet for pipes at depths of 10, 15, 20 feet, etc.
- Ensure that access routes are of adequate width (minimum of 12 feet) and an acceptable longitudinal slope (no steeper than 15%). Surfacing should be based on the anticipated frequency of use and types of equipment involved. Although gravel may be a suitable

surface, consider pervious surfaces (e.g., reinforced turf or paver blocks) that do not increase the site's impervious cover.
- Make sure easements are recorded on the property plats and in the deeds.
- An easement agreements or deed of easement will help specify the rights and responsibilities of both the easement holder and the owner. For instance, the deed or agreement can spell out that the owner is responsible for mowing and routine maintenance and that fences and other obstructions are not permitted.

9.3.6. Secure Easements and Agreements for Existing BMPs

Depending on the level of service, securing agreements to access and maintain previously installed BMPs may be necessary. Many existing BMPs require costly repairs to restore effective function. It is not uncommon for the local program to assume responsibility for the BMPs only after the private party (1) conducts maintenance of the BMP to a minimum specified performance level and (2) provides legal access and easement documents.

This aspect of the program can be very time-consuming. It requires documenting the condition of BMPs, negotiating with multiple property owners, and involving legal staff and often elected officials. For these reasons, securing easements and agreements for existing BMPs will likely be a phased program. A scoring or ranking system can help a locality set priorities for this task.

9.3.7. Develop Inspection Procedures

Regular inspection and maintenance is an on-going legal requirement after any BMP is constructed, including pre-treatment devices. Regardless of who is ultimately responsible, it will be important for the local program to have consistent inspection policies, procedures and "tools" to guide the inspection process.

Table 9.7 provides recommendations for the frequency of inspections, depending upon the type of BMP involved. Ideally, at least during the first two years of operation, devices that include vegetation and/or permanent pools of water in a highly engineered system require inspection monthly and after large storm events, in order to identify any problems with flow conveyance or vegetative health before they become serious. All other BMPs should be inspected quarterly and after large storm events. Following that initial period, assuming facilities continue to operate without problems and depending upon the type of facility, inspections may be conducted annually or, at the absolute minimum, once every five years.

A greater number of inspections may be required if the BMP is poorly designed or due to other factors, such as upstream development, that may cause operational or maintenance problems. Inspection records should be available upon request. An qualified professional should conduct BMP inspections.

A community should use standard inspection checklists to record the condition of all stormwater BMPs. Using consistent forms makes it easier for communities to track maintenance activities electronically, using either a database or spreadsheet, rather than relying on paper files (discussed further below). Well-designed checklists can be integrated within maintenance

databases to prioritize maintenance, track performance over time, and relate design characteristics to particular problems. **Appendix 9-C** at the end of this chapter provides templates for maintenance checklists based on each type of BMP. Program managers can use these templates to customize their own maintenance checklists.

Table 9.7. Recommended Inspection Frequency for BMPs

Inspection Frequency	BMPs
Monthly and within 24 hours after every water quality storm (greater than 1-inch of rainfall)	Constructed Stormwater Wetlands Wet Ponds Wet Extended Detention Basins Bioretention Cells
Quarterly and within 24 hours after every water quality storm (greater than 1-inch of rainfall)	Level Spreaders Infiltration Devices Filter Practices Dry Extended Detention Basins Permeable Pavement Rain Tanks and Cisterns Vegetated Roofs Filter Strips* Wet and Dry Swales* Grass Channels* Restored Riparian Buffers*
*Although these devices require quarterly inspection, mowing will usually be done at more frequent intervals during the growing season.	

Source: NCDENR, 2007

Program managers may incorrectly assume that nonstructural BMPs, such as vegetated measures, do not require routine inspection and maintenance. In fact, proper maintenance of non-structural BMPs is essential for continued performance. Like structural BMPs, restored natural and riparian areas, disconnected impervious surfaces, grass channels, and similar practices can fail if inspections and monitoring are not routinely conducted.

For example, sediment build-up and debris at BMP inflow points may prevent sheet flow from reaching pervious areas or buffers. Vegetation used to restore natural areas may not have adequate survival rates. Landowner practices and behaviors, such as dumping yard waste and re-routing roof drains, may compromise the function of a nonstructural BMP. For all these reasons, inspection and maintenance procedures should be applied to LID and non-structural practices.

Inspectors should take photographs of all BMPs. In addition, specific critical features or potential problem areas should be photo-documented. For example, a recommended list of photographs for a BMP pond would include the following:

- Vehicle access points
- Overview of areas or related structures surrounding the pond
- Pre-treatment areas
- Wetland planting areas, if applicable
- Inlets

- Overview of principal spillway, upstream and downstream faces of embankments, and the emergency spillway
- Downstream outfall(s) from the BMP
- Before and after photos of any problem areas that must be repaired

9.3.8. Train Inspectors

Training workshops can help standardize the inspection process by reviewing objectives, procedures, and follow-up actions. In addition, peer-to-peer training enhances communication because inspectors can share challenges and problem-solving related to real field experiences. Training tied to inspector certification can also be a motivator to encourage others to participate. To support this scenario, the state or the local program could sponsor inspector training events and maintain lists of locally trained inspectors to promote consistency and quality control. The DEQ will provide Stormwater Management Inspector Training and Certification for local inspectors to become familiar with the unique aspects of SWM BMPs.

Inspector training is essential for a local program that conducts most of its own maintenance operations. Inspectors need to be well versed in the use of the checklists and need to provide feedback to program managers regarding maintenance activities (**Figure 9.4**).

Figure 9.4. Inspector training helps inspectors understand the function and maintenance needs of BMPs (Source: CWP, 2008)

9.3.9. Establish a Tracking System

Regardless of whether the municipality or the property owner is performing the BMP maintenance, tracking maintenance activities is important. Again, accurate tracking of inspection and maintenance activities will enable the local program to generate accurate reports, as needed to meet MS4 permit conditions and Virginia stormwater management regulatory requirements. In order to accurately track BMP maintenance activities, local programs must inventory BMPs, including collecting information on the physical condition of the structures and determining whether the BMPs are within easements (or under fee-simple ownership) and have adequate maintenance access. **Table 9.8** lists typical items that should be included in a BMP inventory.

Table 9.8. BMP Inventory Checklist

Physical Condition	Programmatic Condition
• Type of BMP • BMP Design Features: size of practice, drainage area, treatment area/volume, design storm(s), pipe sizes, etc. • Structural stability of dams/impoundments, if applicable • Integrity of pipes and risers • Condition of emergency spillway or bypass channel • Manholes and inlets in place and locked (if necessary) • Standing water or nuisance conditions • Erosion, sedimentation or sediment build-up • Evidence of sinkhole formation or subsidence within the BMP's footprint or drainage pathways • Evidence of clogging, ponding (infiltration, bioretention, filters, etc.) • Evidence of dumping (trash, yard debris, etc.) • Status of vegetation • Water enters and exits BMP as designed • BMP is built according to design (e.g., dimensions, size, elevations, geometry, etc.)	• Is the BMP within the easement? Are easement dimensions adequate? Any utility easements (that may interfere with BMP function or maintenance)? • Any existing maintenance agreements in force? • Maintenance access is platted and exists in good condition on the ground?

Source: CWP 2008

In large communities, tracking systems are technically advanced and use linked systems comprising geographic information systems (GIS – see **Figure 9.5**), global positioning systems (GPS), hand-held data collectors and related computer databases to track location, ownership, condition, and other BMP characteristics. Automated systems can be established to send notices to property owners when inspections and routine maintenance should be performed, or when an inspection by a municipal staff person reveals specific maintenance needs. However, simpler GIS and hard-copy file formats can also be used. **Table 9.9** lists items that are appropriate for local programs to track.

After changes in property ownership, updating responsible party information is an important, but often difficult, tracking function. Often, no formal mechanisms are in place for notifying local programs when a property with a deeded maintenance agreement is sold. The local program must work with the real estate office or send frequent (annual) notices to responsible parties requesting updated information.

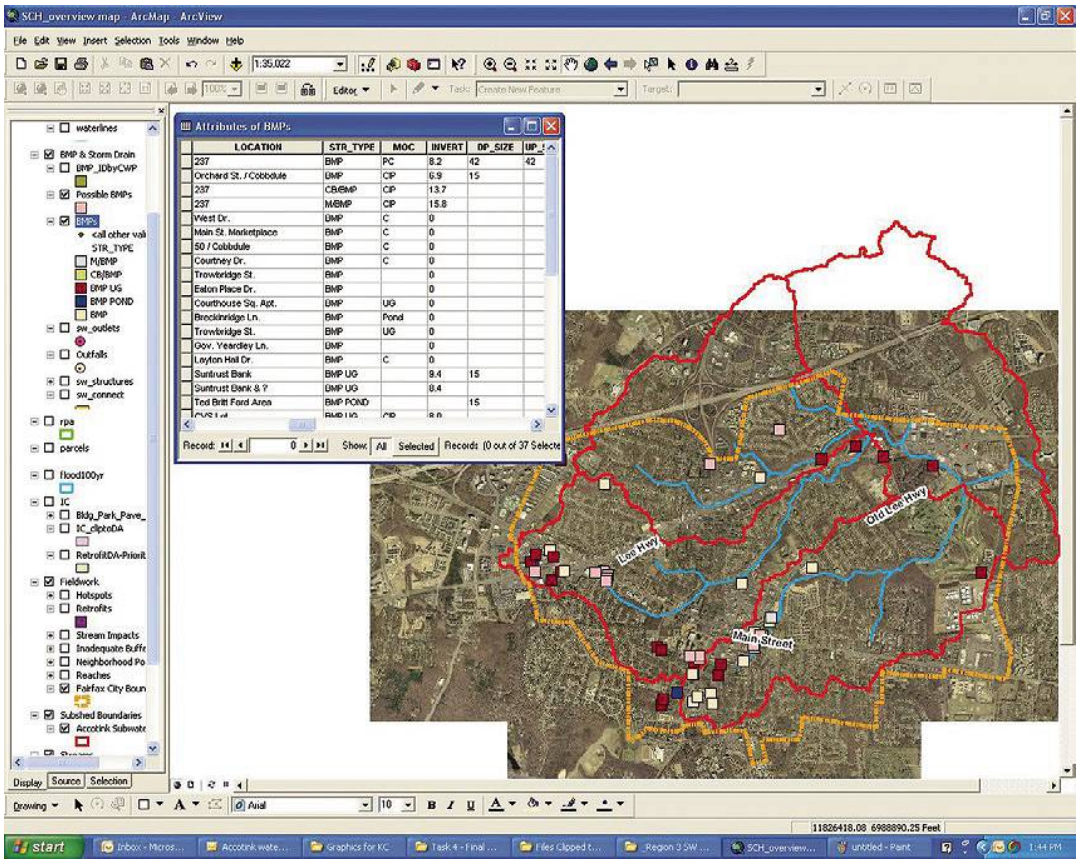

Figure 9.5. Example BMP Computer Tracking System
(Source: CWP 2006; Graphic: Albermarle County, VA)

Another critical task is collecting data about specific maintenance activities and their costs. Tracking systems can monitor costs for performing inspection and maintenance services. These data can assist local programs in estimating future expenses and developing more cost-effective means to accomplish tasks.

Benchmarks must be established for tracking and monitoring BMPs. For example, in ponds and wetlands, sediment markers (graded measuring sticks) placed in forebays or permanent pools can be used to consistently measure the depth of sediment during inspections. Similar markers can be used to ensure that the elevation of the permanent pool remains relatively constant over time. Sediment clean-out markers should also be used in underground vaults and in the sediment chambers of sand filters.

Table 9.9. Tracking Items for a Municipally Operated Maintenance Program

• Inspection dates and reports • BMP locations • General condition of BMPs • BMP features: size of practice, drainage area, treatment volume/design storm, age, pipe sizes, etc. • Photos • Information needed to prioritize maintenance tasks. For instance, the inspection process can categorize BMP maintenance needs as (1) no action, (2) routine maintenance needed, (3) major maintenance needed, or (4) remediation/reconstruction needed. This type of BMP triage system is necessary to allocate available resources. • Maintenance work orders • Maintenance schedules and/or documentation on tasks completed • Costs for various maintenance tasks • Available BMP feedback or evaluation data that can help program managers amend the list of approved BMPs or particular BMP design features • Good retrofit opportunities	 

Source: CWP 2008

9.3.10. Obtain As-Built Plans

After construction is completed, qualified engineers and surveyors should prepare as-built drawings of BMPs for a permanent record of the structures. The as-built plans are a critical element of future inspections. Although the acceptance of as-built plans is primarily a plan reviewer function, construction inspectors can play a key role in confirming the accuracy of as-built plans. They can also add documentation to the file that might be extremely useful for the maintenance inspection staff, who will ultimately inherit inspection responsibilities.

As-built plans should be prepared by qualified engineers and surveyors to verify that post-construction BMPs have been installed according to plans and specifications. Inspection staff should confirm these as-built plans and take photographs of as-built conditions. Doing so will provide useful documentation and help answer questions when future maintenance issues are identified (**Figure 9.6**). This is particularly important for control practices that may change their function during transition from the construction process to the post-construction setting. Examples are sediment basins that become permanent ponds, or sediment traps that are converted to biofilters.

In some programs, the staff that inspects post-construction BMPs during the construction process is the same staff that inspects them afterwards for maintenance purposes. In other cases, different

staff members, facility owners, or responsible private parties actually perform maintenance inspections.

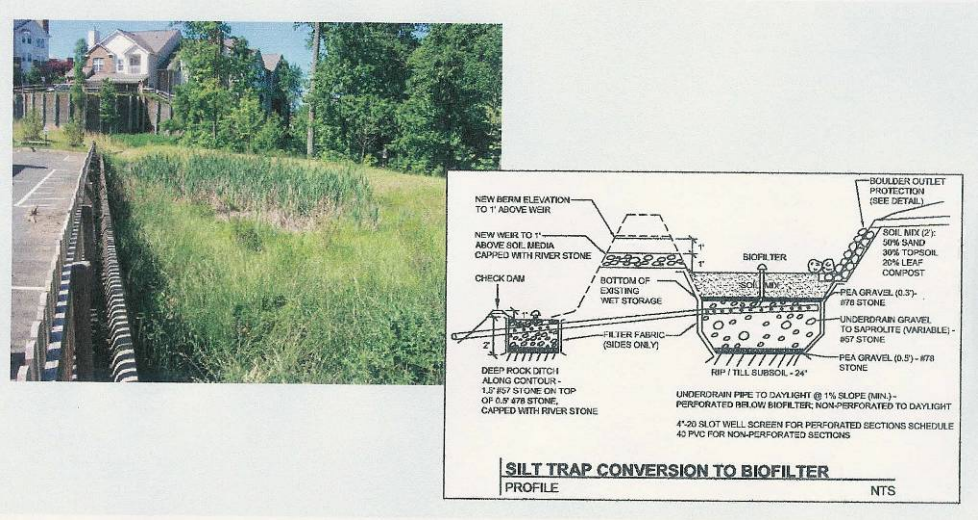

Figure 9.6. Construction inspectors should be involved in confirming as-built plans (Source: CWP 2008)

It is important to note here that the Virginia SWM Regulations do not, at this time, require the submission of as-built plans. However, as noted above, as-built plans are critical for effective long-term BMP maintenance. The SWM Law authorizes local governments to enact provisions of their local programs that are more stringent than those specified in the state regulations. Localities should consider using this authorization to require submission of as-built plans.

9.3.11. Perform and Document Maintenance Activities

Because of the overhead equipment costs and specialized skills needed to conduct the full range of maintenance activities, it is common for all but the largest communities to rely, at least partially, on outside contractors to conduct maintenance and repair activities (**Figure 9.7**). As noted above, one alternative is to form a separate organization, or special "district" (e.g., a Stormwater Utility) that is responsible for all maintenance and inspections. Another option is to assign stormwater maintenance responsibilities to an existing utility, such as a water and sewer authority. Such a utility or district would have a dedicated funding source to ensure longevity.

Inspectors should clearly document items that require repairs. Notations on design plans and physical markers, such as spray painting the key areas of concern, can help maintenance crews locate and correct problems. In addition, the inspector should mark potential corrections and problem areas on a copy of the as-built plan. The marked-up as-built plan should be stored digitally or in a paper file system, for reference. As noted above, photographs should be taken and kept in the record. Such records can be used on the follow-up inspection and will help confirm that maintenance was performed correctly.

Figure 9.7. Municipal staff, contractors, or both can perform maintenance tasks (Source: CWP, 2008)

Neglected repairs, or missing or damaged structures, may pose immediate safety concerns. Examples include a missing manhole cover over a drop inlet, a damaged grate at a large inflow or outfall pipe, or damaged fencing around a pond with steep slopes, which may allow unauthorized and unsafe access. Furthermore, repairs related to dam safety and flooding hazards must be implemented immediately. For example, if a BMP shows signs of embankment failure, or if an inspector is unsure, a qualified engineer should investigate the situation immediately and appropriate corrective actions must be taken. Similarly, cracks in a concrete riser for a pond that drains a large area may pose a safety threat and should be repaired immediately.

9.3.12. Administer Compliance and Enforcement Procedures

The local program is responsible for enforcement actions when maintenance activities are not conducted (see 9 VAC 25-870-116). Language in ordinances should specifically define maintenance enforcement procedures and time lines. Typically, municipalities are responsible for educating property owners about these procedures.

A tiered enforcement procedure is often best. Initially, responsible parties can be notified, either verbally or in writing (essentially given a "warning"), of inspection and maintenance tasks. If needed repairs are not performed accordingly, a more formal notice of violation, which outlines specific tasks and a completion schedule, can be issued. In cases of continued noncompliance or negligence, or where lack of maintenance poses a threat to public health and safety (e.g., a potential dam breach), fines or other penalties may be assessed and issued. **Table 9.10** below summarizes several compliance and enforcement methods that can be used for BMP maintenance.

Table 9.10. Review of Available Compliance Methods

Method	Stage of Compliance	Description
Maintenance Agreement	Recorded at the project review. Used during the life of the BMP as the basis for other enforcement measures.	This agreement is a contract between a local government and a property owner and is designed to guarantee that specific maintenance functions are performed. A maintenance agreement usually specifies that, in cases of noncompliance, the local program is legally authorized to enter the property to make necessary repairs and then assign applicable costs to the owner. Examples of maintenance agreements can be found in **Appendix 9-B** of this chapter.
Performance Bond	Posted at the project review, usually to ensure the proper construction of BMPs and installation of other SWM systems. The bond period can be extended to cover the initial period (e.g., 2 years) of maintenance after construction.	In a typical stormwater management performance bond, a site developer or property owner guarantees that construction of stormwater BMPs will be completed in accordance with the terms of the stormwater ordinance and approved stormwater design plan. Should the site developer or property owner fail to meet the performance measures, the bond ensures that enforcement action and corrective actions can be taken by the jurisdiction at the developer's or property owner's expense.
Notice of Violation (NOV)	This is the first stage of enforcement, following inspection and documentation of non-compliance	As a first step in the compliance process, the owner or responsible party is sent a NOV outlining the nature of the violation, the specific actions needed to come into compliance, a schedule for completing the remedies, and subsequent penalties that can be imposed if the actions are not taken.
Civil Penalty	An escalating level of enforcement if the NOV does not lead to compliance and the bond has already been released	As an incentive for compliance, a municipality is authorized to levy a monetary penalty for noncompliance. This penalty can be a fixed amount, or the amount could increase with the severity of the violation, frequency of occurrence, or length of time passing prior to achieving compliance status.
Criminal Penalty	An alternative to a civil penalty when the remedies listed above are not sufficient	A criminal penalty can be levied for more serious cases in which a party can be considered intentionally or knowingly negligent. Section 10.1-603.14 of the Act establishes the basis for both misdemeanor and felony charges for violations of the Stormwater Management Act and Regulations.
Maintenance Escrow Requirement	This is not common, but it could be an effective tool at the completion of construction	A property owner is required to post a performance bond, cash escrow, letter of credit, or other acceptable form of performance security in an amount that would cover the costs associated with maintenance and repair or replacement in the event of BMP failure (see § 62.1-44.15:34, Code of Virginia).

Source: Adapted from CWP 2008

9.3.13. Periodically Review Regulations and Procedures

Once a community's stormwater management operation and maintenance program has been developed and implemented, it may become apparent that changes or modifications are necessary to make the program more effective. Review of the operation and maintenance program should be scheduled one to two years after implementation. After the initial review, additional reviews may be scheduled in three to five-year intervals. Reviews should include input from staff members who are performing the various activities.

The following are some examples of issues that may arise during the review:

- The system inventory may not be complete or up-to-date.
- Inspection scheduling may need to be revised for more or less frequent inspections for all or only specific types of systems.
- Inspection checklists may need modification.
- Maintenance activities may need to be modified.
- Some systems or system components allowed may need to be deleted based upon experiences.
- Some systems or system components may need to be added based on new techniques or developments.
- Additional equipment may be necessary to perform duties adequately.

9.4. PUBLIC INVOLVEMENT IN THE MAINTENANCE PROGRAM

Educational outreach programs can improve compliance with maintenance requirements. Local governments should consider providing residential or commercial property managers with BMP inspection training and workshops on how to perform basic maintenance. **Table 9.6** above provides a list of typical stakeholders and strategies for involving them in a maintenance program.

A telephone hotline, or a web site with a reporting form, is a good tool for increasing citizen involvement. Using these methods, citizens can notify local program staff about specific maintenance issues or observed violations, request an inspection, or ask technical questions. In response, local programs would have to establish a procedure for addressing these reports or queries quickly. The hotline or web site should be advertised in utility inserts, the government pages of the local telephone phone book, on the municipal web site, and through other communication channels.

9.5. SUMMARY OF BMP OPERATION AND MAINTENANCE TASKS AND ACTIVITIES

9.5.1. Emergency Maintenance

Maintenance after floods and other emergencies requires immediate mobilization. The response can include replanting vegetation and repairing damaged structures. Living systems are likely to need at least minor repairs after emergencies. Following an emergency such as a flood, standing water may pose health risks because of mosquitoes or contact pollutants. Mosquito control and blocking access should be considered if this becomes a problem.

Obstructions and debris deposited during storm events should be removed immediately from all installations. Exceptions include debris that provides habitat and does not damage vegetation nor divert currents to, from, or within the BMP. In fact, because of the high quality habitat that can be found in woody debris, careful repositioning rather than complete removal may be desirable. There may be instances where debris is even added. Such locations should be noted so that the debris is not accidentally removed. Educating adjacent property owners about the habitat benefits of certain kinds of debris and vegetation can decrease requests for removal.

Formation of sinkholes or other evidence of subsidence within an BMP footprint or its drainage pathways indicates failure of the BMP. The practice should be repaired as soon as feasible after the first observation, using appropriate angineering techniques (e.g., VDOT IIM228 – *Sinkholes: Guidelines for the Discharge of Stormwater at Sinkholes; WVDEP, 2004; MDE, 2000; etc.*).

Figure 9.8. BMP Sinkhole Collapse

9.5.2. Routine Debris and Litter Removal

Trash removal is an integral part of BMP maintenance. Generally, a "spring cleanup" is needed to remove trash from all surface BMPs. Subsequently, trash removal is performed as required, based on observations during regular inspections. Special attention should be given to removing floating debris, which can clog the outlet device or riser. Regularly removing debris and litter is well worth the effort and can be expected to help in the following ways:

- Reduces the chance of clogging in outlet structures, trash racks, and other facility components.
- Prevents damage to vegetated areas.
- Reduces mosquito breeding habitats.
- Maintains facility aesthetics.
- Reduces conditions for excessive surface algae.
- Reduces the likelihood of stagnant pool formation.

9.5.3. Stability and Erosion Control

The best way to promote soil stability and erosion control is to maintain a healthy ground cover in and around the BMPs. Areas of bare soil quickly erode, potentially clogging the facility with

sediment and threatening its integrity. Therefore, bare areas must be stabilized as quickly as possible. Newly seeded areas should be protected with mulch and/or an erosion control mat that is securely staked. For BMPs that rely on filtration, such as bioretention facilities, it is critical that adjacent soils do not contaminate the selected filter media during or after construction. If the site is not permanently stabilized with vegetation when the filter media is installed, the best design practice is to specify sod or other robust erosion control practices for all slopes in and immediately around the BMP.

Erosion is quite common in or around the inlets and outlets of BMP facilities and should be repaired as soon as possible. Erosion control efforts should also extend to areas immediately downstream of the BMP.

The roots of woody vegetation (e.g., young trees and shrubs) can cause embankments to be unstable. Consistent mowing of the embankment controls stray seedlings that take root. Growth of trees and shrubs further away from the embankment should not pose a threat to the stability of the embankment and can provide important runoff filtering benefits. Trees and shrubs should *not* be planted within maintenance and access areas.

Animal burrows also diminish the structural integrity of an embankment. Muskrats, in particular, burrow tunnels up to 6 inches in diameter. Efforts should be made to control animal burrowing. Burrows should be filled as soon as possible.

Finally, subsidence can result in sinkholes on embankments or basin and channel bottoms. Subsidence is not soley related to karst areas. *The presence of subsidence or sinkholes anywhere within the BMP perimeter or along the treatment train can short-circuit the stormwater management system, and it should always be considered a criterion of BMP failure that must be addressed and corrected.*

9.5.4. Sediment Removal and Disposal

Sediment gradually accumulates in BMPs and must eventually be removed. However, removal intervals vary so dramatically among facilities that no “rules of thumb” are applicable. The required frequency of sediment removal is dependent on many factors, including the following:

- The type of BMP;
- The design storage volume (e.g., if the active and permanent pool storage is oversized for sediment storage);
- The characteristics of the upstream catchment area (e.g., land use; level of imperviousness; upstream construction activities and effectiveness of sediment and erosion control activities); and
- Municipal practices (e.g., winter weather roadway sanding and salting, etc.) in the contributing drainage area.

Before installing a BMP, the designer should estimate the lifetime sediment accumulation that the BMP will have to accommodate. Several time periods may be considered, representing expected changes in land use in the watershed. To estimate sediment accumulation, an estimate

of the long term sediment load from upstream must be calculated (see an example method in **Appendix 9-E** at the end of this chapter). Then an estimate of the BMP's sediment removal efficiency must be determined. The analysis of watershed sediment loss and BMP efficiency can be expedited by using a sediment delivery computer model.

The frequency of sediment removal is then based on the sediment accumulation rate versus the amount of sediment storage volume that is inherently provided in the BMP without affecting treatment efficiency or stormwater storage volume. Again, the frequency of sediment removal is BMP- and site-specific. It could be as often as every 2 years, or as long as 15-25 years. The volume of sediment that must be removed and disposed of each dredging cycle is the volume calculated above multiplied by any density or dewatering factors, as appropriate.

Wet sediment is more difficult and expensive to remove than dry sediment. Ideally, the entire facility can be drained and allowed to dry sufficiently so that heavy equipment can operate on the bottom. Provisions for draining permanent pools should be incorporated in the design of water impoundments, where feasible. Also, low-flow channels and outlets should be included in all BMPs in order to bypass stormwater flow during maintenance. However, in many impoundments periodic rainfall keeps the sediment soft, preventing access by heavy equipment. In these cases, sediment may have to be removed from the shoreline by using backhoes, grade-alls, or similar equipment.

Underground or proprietary BMPs – such as vaults, chambers, and other structures that require accumulated material to be pumped out – require special consideration. For such facilities, inspection and maintenance staff may be required to have confined-space training to satisfy OSHA safety requirements. Also, some types of proprietary devices require more frequent maintenance in order to perform as designed. Maintenance contracts are essential when such BMPs are specified on plans.

At sites where sediment loads are expected to be high, designers should designate a dewatering and storage area on the site. This area must be located outside of the floodplain. If such a disposal area is not set aside, transportation and landfill tipping fees can greatly increase the cost of the BMP's maintenance, especially if disposal of wet sediment is not allowed in the local landfill. If on-site storage is not feasible, sediment can be used elsewhere after dewatering, unless the material was generated from a stormwater hot spot (e.g., a gasoline station). In this case, a Toxicity Characteristic Leachate Procedure (TCLP) or other analysis should be performed on the removed sediment to determine if it meets the criteria of a hazardous waste, which requires special handling and disposal. If the waste is not a hazardous waste and is going to be managed as a solid waste, other testing may be required by a receiving facility.

Sediment removed from a BMP requires proper disposal, which must be carefully planned. Some pump-outs result in a waste material that is composed of both liquids and solids. Wastewater plants usually do not accept wastewater with solids, and sanitary landfills usually do not accept any liquids or saturated sediments. Therefore, sediment removal activities must result in a waste material that meets the various disposal requirements. State waste disposal requirements should be consulted for information pertaining to the exact parameters and acceptable levels for different disposal options. Generally, sediment removed from BMPs will not be contaminated to

the point that it would be classified as hazardous waste. However, all sediment removed from BMPs should be tested to determine the proper disposal option. Most private laboratories are familiar with waste disposal regulations and can test sediment samples with these in mind. Generally, there are three sediment disposal options:

- **On-Site Disposal.** On-site disposal allows the sediment to be disposed of on any land area that is not regulated (i.e., land other than floodplain, etc.). During the site planning process, when determining land requirements for stormwater control measures, land can be set aside for on-site disposal of sediment removed from the various BMPs during maintenance. The areas that are used for sediment disposal should be landscaped after each sediment removal operation, inorder to stabilize the soil and provide a natural appearance.

- **Off-Site Disposal.** Off-site disposal is often preferred by developers and municipalities. Off-site disposal does not reduce the developable area, landscaping/grading does not have to be performed, and there are no perceived liability/health concerns with respect to the surrounding landowners. Off-site disposal can mean disposal at a sanitary landfill or disposal at another area undergoing filling. The decision of where the material is deposited depends on the quality of the sediments and the availability of and distance to the alternative fill areas.

  Temporary disposal areas are recommended for surface end-of-pipe stormwater management facilities – particularly those that do not have a maintenance by-pass – since this provides a location for the sediment to dry before transporting it off-site. Where temporary sediment disposal areas (i.e., drying areas) are not feasible due to limited availability of land or high cost, the means of dealing with the un-dewatered sediment should be detailed in the SWM plan and and maintenance agreement, which must be approved by the municipality.

- **Hazardous Waste Disposal.** Although sediment removed from BMPs is expected to contain contaminants (metals, bacteria, nutrients), the levels of pollutants involved are typically not sufficient for it to be classified as hazardous waste. Hazardous waste must be deposited at a hazardous waste facility. Transportation costs and disposal fees are expensive for hazardous waste, since licensed haulers must be used to transport the material and the number of accessible hazardous waste receiving facilities may be limited in number or distance.

9.5.5. Maintenance of Mechanical Components

Each type of BMP may have mechanical components that need periodic attention. For example, valves, sluice gates, fence gates, locks, and access hatches must be functional at all times. The routine inspection, exercising, and preventive maintenance for such mechanical components should be included on a routine inspection/maintenance checklist.

9.5.6. Vegetation Maintenance

Vegetation maintenance is an important component of any stormwater maintenance program. The grasses and plants in all BMPs require regular attention, but particularly in vegetative BMPs such as filter strips, dry and wet swales, grass channels, restored riparian buffers, bioretention facilities, and constructed stormwater wetlands. The development of distressed vegetation, bare

spots, and rills indicates that a BMP is not functioning properly. Problems can have many sources, such as the following:

- Excessive sediment accumulation, which can clog the soil pores and produces anaerobic conditions.
- Nutrient deficiencies or imbalances, including pH and potassium.
- Water-logged conditions caused by reduced soil drainage or a high seasonal water table.
- Invasive weeds.

The soil in vegetated areas should be tested every other year and adjustments made to sustain vigorous plant growth with deep, well-developed root systems. Soil aeration is recommended for filter strips and grassed swales where sediment accumulation rates are high. Ideally, vegetative cover should be mown infrequently, providing for the development of thick stands of tall grass and other vegetation. Also, trampling of vegetation by pedestrian traffic should be prevented.

Areas immediately upstream and downstream of some BMP plantings often experience increased erosion. Although properly designed, located, and transitioned installations experience this effect to only a minor degree, all erosion should be repaired immediately to prevent spreading. Live stakes, live fascines, and other soil bioengineering techniques, possibly in combination with 3-D geotextiles, can be applied to erosion in natural drainage ways with minor grading.

Table 9.12 below describes some of the vegetation-specific maintenance activities at various types of BMPs. It is important to note that there are specific requirements related to certain management practices that *must* be followed, such as those performed within buffers. In addition, vegetation should be removed if it poses threats to human safety, buildings, fences, and other important structures. Finally, vegetation maintenance activities naturally change as the vegetation matures after construction.

9.5.6.1 Grass Cutting

Generally, grass-cutting should be limited or eliminated around SWM facilities. Allowing grass to grow tends to enhance water quality and provide other benefits for wet facilities. Short grass around a wet stormwater facility provides an ideal habitat for nuisance species such as geese. Allowing the grass to grow is an effective means of discouraging geese. Grass cutting is one maintenance activity that is undertaken solely to enhance the perceived aesthetics of the facility. The frequency of grass cutting depends on surrounding land uses, local municipal or HOA by-laws, and public or peer pressure. In view of the various influences, grass cutting should be done as infrequently as possible but with sensitivity to the aesthetic concerns of nearby residents.

Grass around wet facilities should not be cut to the edge of the permanent pool. As a safety precaution, cutting should be done parallel to the shoreline with grass clippings being ejected upland, in order to avoid adding organic matter to the pond.

Table 9.11. Vegetation Maintenance for BMPs

ACTIVITY	INSTRUCTIONS
Replacement of Dead Plants	All dead plants should be removed and disposed of. Before vegetation that has failed on a large scale is replaced, the cause of the failure should be investigated. If the cause can be determined, it should be eliminated before vegetation is replaced.
Fertilization	The objective of fertilizing at a BMP is to secure optimum vegetative growth, rather than yield (often the objective with other activities such as farming). Infertile soils should be amended before installation and then fertilized periodically thereafter. Fertilizer can be composed of minerals, organic matter (manure), compost, green crops, or other materials.
Irrigation/ Watering	Watering vegetation is usually necessary during the germination period, as well as occasionally thereafter to preserve the vegetation through drought conditions. This can typically be accomplished by pumping water the BMP pool or from the stream, installing a permanent irrigation system or frost-proof hose bib, or using portable water trucks.
Mulching	Mulch should be used to maintain soil temperature and moisture, as well as to improve site aesthetics. A 1/2-inch layer is typically adequate. Ideally, mulch should be removed before winter to prevent an infestation of rodents.
Weeding	Weeding is often necessary in the first growing season, particularly if herbaceous grasses are out-competing the young woody vegetation. The need for weeding may be largely eliminated by minimizing the amount of seed used for temporary erosion control. Weeding may also be required if, over time, invasive or undesirable species are entering the site and out-competing plants that are specifically desired for the treatment of the stormwater.
Cultivating/ Hoeing	Hoeing is often required to loosen overly-compacted soil and eliminate weeds that compete with the desirable vegetation.
Pruning	Pruning is used to trim plants to a desired shape and remove dead wood. Pruning can force single-shoot shrubs and trees to assume a bushier configuration.
Thinning	Thinning dense brush may be necessary for particular species to thrive, to increase the vigor of individual specimens, to reduce flow obstructions, and to increase the ability of maintenance staff to access the entire BMP. Tall maturing trees typically have no place in a BMP (except for buffers) and should be removed as soon as possible.
Staking	Saplings of tall trees planted in or near the BMP may require staking. Care should be taken not to damage the tree's roots or trunk with stakes or ties. Stakes should be kept in place for 6-18 months, and the condition of the stakes and ties should be checked periodically.
Wound Dressing	Broken or damaged branches and other wounds on trees should be dressed in accordance with recommendations from a trained arborist.
Disease Control	Based on monitoring observations, either insecticides or (preferably) organic means of pest and fungal control should be used.
Protection from Animals and Human Foot Traffic	Fencing and signage should be installed to deter pedestrians and to prevent damage due to trampling. These measures are often most necessary during the early phases of installation but may be required at any time. Measures for controlling human foot traffic include signs, fencing, floating log barriers, impenetrable vegetation, ditches, paths, and piled brush. Wildlife damage is caused by the animals browsing, grazing, and rubbing the plants. However, the use of chemical wildlife repellents should be avoided. Fences and meshes can be used to deter entry to the BMP. Tree tubes can be used to prevent damage to individual specimens.
Mowing	Mowing of perennial herbaceous grasses and wildflowers, especially once seed heads have set, promotes redistribution of seed for this self-sustaining system. However, mowing should be carefully controlled, especially when performed for aesthetics. As adjacent property owners and citizens in general learn more about BMPs, their vision of what is aesthetically pleasing can change. Grasses associated with BMPs, in healthy herbaceous stands, should never be mown more than once each year.

9.5.6.2 Weed Control

Weeds are generally defined as any kind of vegetation which is unwanted in a particular area. In terms of BMPs, weeds are generally invasive species which cannot provide the intended function of the planting strategy, or other non-native species such as purple loosestrife, the spread of which is undesirable. Local weed control rules should be consulted for local requirements. Weed control may be required annually.

Ideally, weeding should be done by hand to prevent the destruction of surrounding vegetation. The use of herbicides and insecticides, which cause water quality problems, should be prohibited near BMPs. The use of fertilizer should also be limited to minimize nutrient loadings to the downstream receiving waters.

9.5.7 Plantings

Upland and flood fringe plantings are generally stable and should not need much maintenance or re-establishment. Shoreline fringe areas are subject to harsher conditions as a result of the frequent wetting and drying associated with this zone. Aquatic plantings are the hardest to establish initially. Typically, vegetation in the aquatic and shoreline fringe zones will require some replanting or enhancement during the first two years of SWM facility operation. Preliminary results of studies of stormwater plantings indicate that a healthy vegetative community will establish if proper conditions are created (although the final set of species may not be those that were originally planted).

Planting methods can be separated into the following three main categories (from terrestrial to aquatic), based on the wetness level and types of vegetation that will grow in these conditions:

- **Upland/Flood Fringe.** The two types of plantings used are herbaceous (ground covers and grasses) and woody vegetation (shrubs and trees). Planting should occur in the spring after groundwater levels have normalized. Ground cover can be installed either by hydroseeding or using a custom seed mix in a nutrient rich medium impregnated in a biodegradable mesh-like blanket. Individual shrubs and trees can be planted manually, with openings made in the mesh blanket for each individual plant, if necessary.

- **Shoreline Fringe (Wet Riparian).** Shoreline fringe vegetation should be planted in mid-May to early June but after water levels have subsided to a stable level. Some form of protection of the seed mixture and soil nutrient medium (if required) should be provided in this dynamic zone of water level fluctuation. In order to establish ground cover in this zone, the biodegradable mesh-like blanket suggested for the upland zone is also highly recommended for this zone. Shrubs and trees can be planted through openings created in the mesh blanket.

- **Aquatic Fringe/Shallow Water.** The establishment of plantings in this zone will require greater material handling and growth monitoring, both in the short-term and over the long-term. Emergent vegetation is easily planted by hand if the substrate is suitable (e.g., ideally, a firm substrate with at least 10% organics by volume). Young shoots (rather than rhizomes or corms) are preferable for planting, since these plants are already growing with an established root structure (for early stability). The plants should be at least 10 cm tall, and planting should occur from late May to early June. Sprigs or plugs are preferable for planting emergent plants, since the root material is already contained in a suitable growth medium.

  Mature growth should be planted to establish submerged rooted plants (including pondweeds), if planted in late spring to early summer when the mature plants can take

advantage of warmer water and sunlight penetration. Plantings in early spring or fall should use vegetative propagules such as turions or rhizome plugs, which can germinate in the spring or over the winter and begin growing in the following growing season.

9.5.8 Maintenance of the Aquatic Environment

An important yet often overlooked aspect of non-routine maintenance of BMPs that have a permanent pool of water is the need to regularly monitor and maintain conditions that promote a healthy aquatic environment. An indicator of excess nutrients (a common problem) is excessive algae growth in the permanent pool of water. In most cases, such problems can be addressed by encouraging the growth of more desirable aquatic and semi-aquatic vegetation in and around the permanent pool. The plants selected should be tolerant of varying water levels and have a high capacity to incorporate the specific nutrients associated with the problem. If algae proliferation is not addressed, algae-laden water will be washed downstream during rain events and may contribute to nuisance odors and pollution stresses in downstream aquatic habitat.

9.5.9 Insect Control

Ponded water can function as a breeding site for mosquitoes and other insects. Mosquito problems can be minimized through proper design and maintenance. The most effective control technique for prevention of mosquito breeding is to ensure that permanent impoundments do not develop stagnant areas. BMPs with permanent pools should include a source of steady dry-weather flow. Promptly removing floatable debris from the drainage path helps eliminate areas where water can collect and then stagnate. In larger basins, fish that feed on mosquito larvae can be stocked. Additionally, splash aerators can be employed to prevent stagnant water. However, aerators require electricity at the site, increases maintenance costs, and must be designed so as to not decrease the settling efficiency of the BMP.

9.5.10 Winter Operation

Infiltration facilities are subject to reductions in capacity due to freezing or saturation of the soil. Surface filters and bioretention areas are generally subject to similar problems. Subsurface filters, while less susceptible than surface filters, may demonstrate poorer performance in the winter due to freezing in underdrain pipes or the filter medium. Filters which use organic media are particularly prone to freezing because they retain water.

There is also an increased likelihood of infiltration facilities and filters clogging during winter operation due to the high sediment loads resulting from road maintenance activities (e.g., sanding and salting). Furthermore, there is an increased risk of groundwater contamination from road salt associated with winter operation of infiltration facilities that receive road runoff.

Where filters and infiltration systems are part of a treatment train, runoff that may be diverted in the winter to by-pass these BMPs but will still pass through some type of downstream controls.

9.5.11 Maintenance of Other Project Features

All other devices and features associated with BMPs should be monitored and maintained appropriately. These additional items could affect the safety or aesthetics of the facility, which can be as important as (if not more important than) the operational efficiency of the facility. Such items might include:

- Fences
- Access roads
- Trails
- Lighting
- Signage (e.g. no trespassing, emergency notification contact information, etc.)
- Nest boxes
- Platforms
- Watering systems

9.5.12 Monitoring

Stormwater monitoring is typically conducted at two levels:

- ***Watershed and Subwatershed Monitoring***. As noted previously, stormwater is best managed within the context of a watershed and subwatershed plan. These plans will normally contain a monitoring component to track implementation of the plan. The monitoring program will typically include administrative monitoring, water chemistry, biological monitoring, flow and erosion monitoring. These monitoring programs are essential to the success of the Plan. Subwatershed monitoring will normally be conducted or administered by the local conservation authority or municipality.

- ***Facility Monitoring***. The consensus of opinion among practitioners is that monitoring for chemistry or biotic parameters cannot be justified for each individual facility, because to have any scientific validity a large and costly sampling program is required. The approaches generally used are (1) physical operation monitoring by the owner or municipality to verify that the facility is operating as designed, and/or (2) detailed monitoring of a typical installation through a research program to evaluate design and performance issues. The designer is advised to consult with authorities regarding site-specific requirements, because some jurisdictions have additional monitoring requirements.

9.6 REFERENCES

Buranen, Margaret. "Rain Gardens Reign." *Stormwater Magazine*. May, 2008. Published by Forester Communications, Santa Barbara, CA.

Center for Watershed Protection (CWP). July, 2008. *Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program.* Ellicott City, MD.

Center for Watershed protection (CWP). 2009. *Technical Report Stormwater BMPs in Virginia's James River Basin: An Assessment of Field Conditions & Programs*. Ellicott City, MD.

Commonwealth of the Northern Mariana Islands and the Territory of Guam (CNMI & Guam). April 2006. *Draft CNMI and Guam Stormwater Management Manual, Vol. II.* Prepared by the Horsley Witten Group, Inc.

Kang, Joo-Hyon, Peter T. Weiss, John S. Gulliver and Bruce C. Wilson. "Maintenance of Stormwater BMPs." *Stormwater Magazine*. November-December 2008. Published by Forester Communications, Santa Barbara, CA.

Minnesota Pollution Control Agency. September, 2006. *Minnesota Stormwater Manual, Ver. 1.1.* St. Paul, MN.

North Carolina Department of Environment and Natural Resources (NCDENR). September, 2007. *Stormwater BMP Manual*. Raleigh, NC.

Northern Virginia Regional Commission. January, 2007. *Maintaining Stormwater Systems: A Guidebook for Private Owners and Operators in Northern Virginia*. Fairfax, VA.

Ontario Ministry of the Environment (OME). March, 2003. *Stormwater Management Planning and Design Manual*.

Rafter, Dan. "The Messy Business of Maintaining BMPs." *Stormwater Magazine*. September, 2007. Published by Forester Communications, Santa Barbara, CA.

Reese, Andrew J., and Henrietta H. Presler. "Municipal Stormwater System Maintenance." *Stormwater Magazine*. September-October, 2005. Published by Forester Communications, Santa Barbara, CA.

Appendix 9-A

RESULTS OF A FIELD SURVEY OF BMPs

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9-A.1.0. INTRODUCTION

In the late summer and fall of 2008, staff of the Center for Watershed Management and partner organizations involved in an *Extreme BMP Makeover* project conducted a targeted field survey of nearly 200 stormwater control facilities in Virginia's James River Basin (CWP, 2009). This study came out of a desire for empirical data on the relationship between BMP design specifications and BMP performance. The survey was comprised of a visual screening for performance indicators, such as signs of by-passing runoff, proper functioning of inlets and outlets, adequate sizing, integrity of filter media and vegetation, and key maintenance and longevity items.

Gaps in data exist, especially for newer BMPs and those for which design standards have been constantly evolving and lack consistency through time and across regions. This is particularly true for bioretention, infiltration, and low-impact development techniques. In an effort to fill such research gaps regarding BMP performance and help improve BMP design specifications, the following types of stormwater facilities were targeted for this study:

- Newer classes of BMPs that are not well represented in published research.
- BMPs for which design specifications have been developing through time and are inconsistent.
- BMPs that have been difficult to monitor (e.g., infiltration)
- BMPs that are becoming increasingly popular and are likely to have more widespread application in the next decade (e.g., bioretention, some underground BMPs).
- Special categories of more conventional BMPs for which the research has raised questions or been incomplete (e.g., multi-cell pond and wetland designs).

Specifically for this field survey, the CWP staff developed a comprehensive BMP evaluation form that that applies to a wide variety of stormwater facility types, from dry swales to wet ponds. The CWP staff and project partners visited a total of 187 BMPs in eight cites and counties in the James River watershed, starting in the Hampton Roads area (coastal plain) and progressing upriver to the Charlottesville area in central Virginia (Piedmont region). Stormwater management and public works staff from each of these municipalities also participated in the surveys, providing insight into the past history of many of the BMPs.

Table 9-A.1 shows the specific categories and numbers of BMPs that are used in the areas where this study was conducted. **Figure 9-A.1** is a set of box and whisker plots that show the range of overall performance scores for each type of BMP, including the following metrics:

- Entire range of scores (thin line)
- 25th and 75th percentile scores (bottom and top of box)
- Median score (line across box)
- Mean (∗)

For some types of BMPs ("Other" and Wet Swales), the data set was too small to generate a box.

Table 9-A.1. Types of BMPs Used in Eleven Communities in James River Watershed

BMP Type	Number	Percent of Total
Wet Pond (WP)	1785	34%
Dry Pond, no water quality treatment (PU)	933	18%
Dry Pond, water quality treatment (PW)	499	10%
Other (OT)	497	9%
Grass Channel (GC)	439	8%
Infiltration (IN)	428	8%
Bioretention (BR)	237	5%
Proprietary Device (PD)	152	3%
Filtering Practice (FP)	106	2%
Underground Structure (UG)	77	1%
Constructed Wetland (CW)	55	1%
Dry (water quality) Swale (DS)	25	less than 1%
Level Spreader (LS)	10	less than 1%
Permeable Pavement (PP)	6	less than 1%
Wet Swale (WS)	2	less than 1%

Source: CWP, 2009

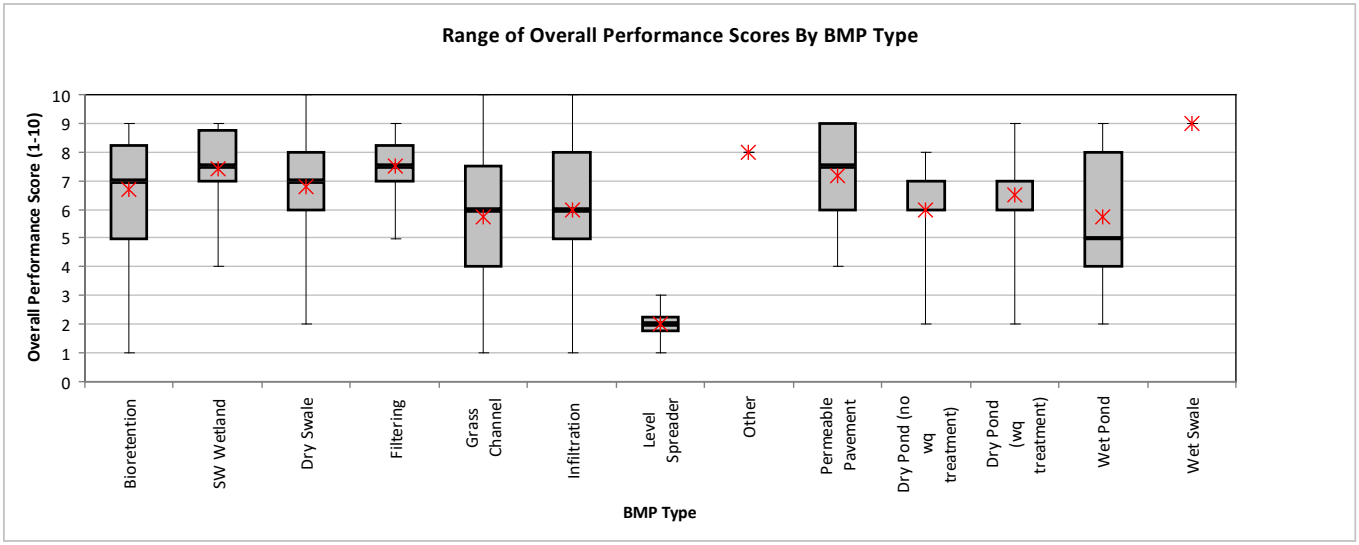

Figure 9-A.1. Box and Whisker Plot for the Range of Overall Performance Scores by BMP Type
(Source: CWP, 2009)

As can be seen in **Figure 9-A.1**, most types of BMPs had mean scores in a range indicating the BMP design is adequate, but the plots for several BMPs indicate performance problems. Wet ponds, dry ponds, infiltration devices, and grass channels had somewhat lower mean scores, and level spreaders generally had significant performance issues.

As might be expected, the ranges of scores are quite large, indicating that each type of practice has some representatives that are failing and others that are performing very well. Some of the practices with the widest ranges of performance scores include bioretention, grass channels, infiltration, permeable pavement, and wet ponds. This may indicate that design, installation, and maintenance guidelines for these practices are not yet well articulated or applied consistently. As one result of this survey, the DEQ is providing much improved BMP specifications on the Virginia Stormwater BMP Clearinghouse web site (http://www.vwrrc.vt.edu/swc/). The following is a summary of some specific BMP performance issues identified by the field survey (examples in **Figure 9-A.2** below):

- ***Ineffective Treatment.*** In many BMPs, the treatment mechanism is not effective due to short-circuiting (e.g., a flow path from inlet to outlet that is too short), no pre-treatment, ineffective treatment mechanisms, incorrect flow paths, and/or water by-passing inlets.
- ***Vegetation.*** Vegetation management is often an issue with BMPs, because the target vegetative community is not known or understood. This can result in excessive vegetation and invasive species, trees on dam embankments, or inadequate vegetation.
- ***Erosion and Deposition.*** Some BMPs were not stable due to erosion of embankments, erosion within the facility itself, or deposition of sediment within the facility.
- ***Awareness of BMP Owners.*** As may be expected, some BMPs had performance problems because the owners are unaware of the BMP or its purpose and functions. Overall, 46% of BMPs were in need of some type of maintenance, and 14% had no access to the BMP to conduct maintenance activities.

The survey determined that problems with BMPs were due to several issues, including incorrect or ineffective design, less than optimum location, improper construction and, of course, lack of proper maintenance.

Accumulation of trash and debris

Clogged pavers and non-infiltrating infiltration bed

Property owners filled in rain garden and replaced it with a sculpture

Sediment forebay filled in and became vegetated

Figure 9-A.2. Examples of Typical BMP Maintenance Problems (Source: CWP, 2009)

Figure 9-A.3 shows the incidence of the most common performance problems.

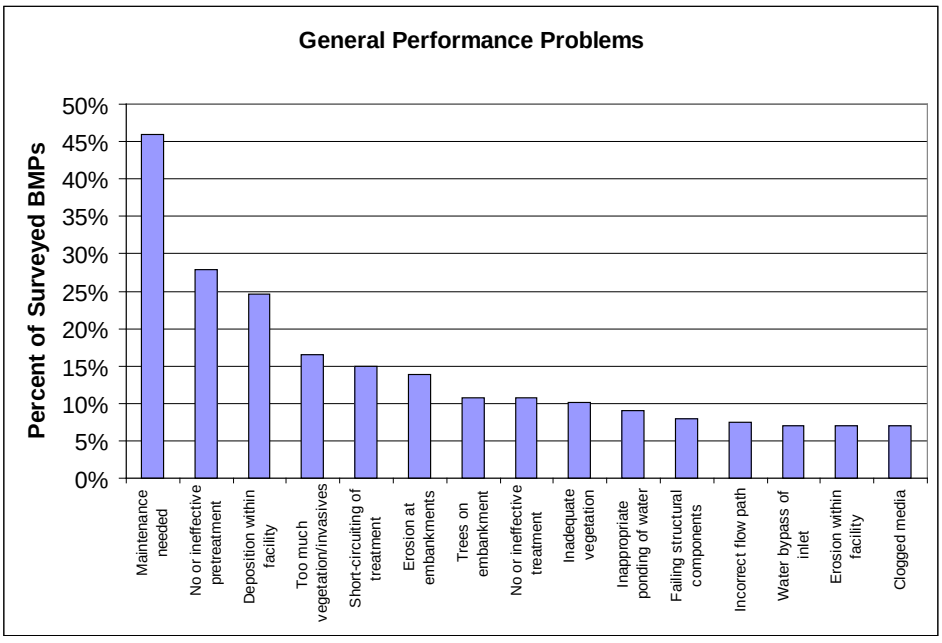

Figure 9-A.3. Incidence of the most common performance problems
(Source: CWP, 2009)

9-A.2.0. REFERENCES

Atlanta Regional Commission (ARC). 2001. *Georgia Stormwater Management Manual*. Prepared by AMEC, the Center for Watershed Protection, Debo and Associates, Jordan Jones and Goulding, and the Atlanta Regional Commission. Atlanta, Georgia.

Center for Watershed protection (CWP). *Technical Report on Stormwater BMPs in Virginia's James River Basin: An Assessment of Field Conditions & Programs*. Ellicott City, MD.

Appendix 9-B

EXAMPLE BMP MAINTENANCE AGREEMENTS

Table of Contents

APPENDIX SECTION HEADINGS

9-B.1.0. STAFFORD COUNTY, VIRGINIA

MAINTENANCE AGREEMENT FOR A STORMWATER MANAGEMENT SYSTEM

This agreement is entered into this _____ day of _____, _____, by and between _____, hereinafter referred to as the "Landowner" and the Board of Supervisors of Stafford County, Virginia, hereinafter referred to as "County".

W I T N E S S E T H

WHEREAS, the Landowner has submitted a development plan for a project known as _____, which includes, among other features, a system that regulates peak rates of discharge and/or quality of runoff water (the term system includes any and all components designed to regulate flow, provide storage for runoff water, remove pollutants from runoff water and increase infiltration of runoff water into the soil); and WHEREAS, the Landowner will install the system in order to comply with one or more of the following laws, regulations and codes:

Act	Regulations Title	
62.1-55.15:24	9 VAC 25-870 et seq.	Stormwater Management
62.1-55.15:67	9 VAC 25-830 et seq.	Chesapeake Bay Preservation Act
62.1-55.15:51	9 VAC 25-840 et seq.	Erosion and Sediment Control

Stafford County Code	Title
21.5	Stormwater Management Ordinance
28-62	Chesapeake Bay Preservation Area Overlay District Ordinance
11	Erosion and Sediment Control Ordinance

and

WHEREAS, this system includes_____
_____
_____; and

WHEREAS, it is in the best interests of both parties and the general public to ensure proper maintenance of the system; and

WHEREAS, a maintenance plan (attachment ___) for the system has been submitted by the Landowner and approved by the County in conjunction with this agreement; and

WHEREAS, both parties desire to ensure sufficient maintenance to maintain the integrity and the proper functioning of the system;

NOW, THEREFORE, for and in consideration of the mutual covenants stated below, the parties agree as follows:

1. The County shall:

   A. Release construction security after as-built plans and other appropriate certifications, showing adequate completion of the system, have been submitted and approved by the County and after an inspection report prepared by County staff recommends approval of the system. The certification shall be made by a Professional Engineer, a qualified Class B surveyor, or a Certified Landscape Architect) and shall certify that the as-built plan represents the actual condition of the structure(s) and shows that all aspects of the structure(s) conform substantially to the approved design plans and the Stafford County Stormwater Management Design Manual. Where the as-built condition varies significantly from the approved design, appropriately revised calculations shall also be provided by the professional certifying the system.

   B. Perform maintenance inspections and provide copies of the maintenance inspection reports to the Landowner. These inspections will be performed at reasonable times (between 8 A.M. and 4:30 P.M., Monday through Friday) and with the Landowner or agent(s) of the Landowner, if available. Periodic inspections may be conducted after storms producing high rates of runoff. Whenever possible, the County shall notify the Landowner prior to entering the property.

2. The Landowner shall:

   A. Construct the system in accordance with approved designs. Provide as-built data and drawings, soil/geotechnical reports, and other certifications requested by the County in order to document compliance with the approved designs and the requirements set forth in Stafford County's Stormwater Management Design Manual.

   B. Provide maintenance which keeps the system in good working order acceptable to the County. Such maintenance shall be provided in perpetuity unless and until both parties formally enter into a revised agreement. Maintenance inspections will be performed within twenty-four (24) hours after each rainfall of one (1) inch or more.

   C. Provide a right of ingress and egress for the County and agents of the County for maintenance inspections and, if deemed by the County to be needed and not adequately done by the Landowner within a reasonable time after due notice, maintenance and repair of the system. Thirty (30) days shall normally be regarded as a reasonable time The Landowner will reimburse the County for maintenance and repair costs within ten (10)

working days after receiving a request for reimbursement. It is expressly understood and agreed that the County is under no obligation to maintain or repair said system, and in no event shall this agreement be construed to impose any such obligation on the County. However, if the County performs or otherwise provides maintenance and/or repair, the landowner will hold harmless and indemnify the county with regard to damage to or destruction of personal or real property.

D. Keep written records of inspections and repairs and provide access to those records to the County upon request.

E. Record this agreement in the land records of Stafford County along with a copy of the approved maintenance plan. The Landowner also stipulates, by this agreement, that final plats for any land on which this system and/or a portion of this system is situated will include a reference to this agreement and to its location (deed book designation, page number, etc.) in the land records of Stafford County.

F. Agree, by this agreement, that the terms of this agreement shall be binding upon the heirs, successors and assigns of the Landowner and that any subsequent owner of the property shall be responsible for the maintenance of the system and shall hold the County harmless from any loss, damage, injury, cost or other claim resulting from the operation of the subject system.

G. Agree, by this agreement, that for any systems to be maintained by a property owners association, deed restrictions and covenants will include membership in a property owners association responsible for providing maintenance of the system.

WITNESS THE FOLLOWING SIGNATURES

DEVELOPER/OWNER: NAME: _____

TITLE: _____

ADDRESS: _____

_____

_____

BY: _____

COMMONWEALTH OF VIRGINIA
COUNTY OF STAFFORD, to wit:

The foregoing agreement was acknowledged before me

this _____ day of _____, _____, by

_____ developer/owner.

My commission expires _____.

_____
Notary Public

WITNESS THE FOLLOWING SIGNATURES

STAFFORD COUNTY BOARD OF SUPERVISORS

By: _____
County Administrator

COMMONWEALTH OF VIRGINIA
COUNTY OF STAFFORD, to wit:

The foregoing agreement was acknowledged before me

this _____ day of _____, _____, by

_____ developer/owner.

My commission expires _____.

_____
Notary Public

Approved as to form: _____
County Attorney

9-B.2.0. SAMPLE MAINTENANCE PLAN FOR SELECTED BMP TYPES

9-B.2.1. Sample Maintenance Plan for Stormwater Detention Ponds

1. Describe the structure and the site it serves. Also describe the design functions. Example: This structure is a stormwater detention pond; it will store water during period of high intensity rainfall. Within a few hours most of the water will drain out of the pond. The development of Sections 1, 2, and 3 of subdivision "XXX" increased the amount of rainfall water which leaves the site because absorbent soil was covered with impervious surfaces such as building and roads. The purpose of this temporary storage is to ensure that the peak rates of flow to the channel below the subdivision were not increased. Such increases cause flooding and channel erosion downstream from the pond. This structure was also designed to be a Best Management Practice. In other words, it was designed to ensure that the amount of phosphorus and other pollutants flowing to the Chesapeake Bay were not increased by construction of Sections 1, 2, and 3 of subdivision "x". This is accomplished by holding some of the water for a longer period of time. The water from this BMP pool will drain out in about 48 hours after the detention pool has drained. The pond has a 36-inch reinforced concrete pipe (RCP), called a "barrel", through the bottom of the pond. In the pond there is a vertical RCP called a "riser." The small 4-inch hole in the bottom of the riser is called a "BMP orifice." The bottom of the 12-inch hole is 4 feet higher than the BMP orifice; the 4 feet of water stored in the bottom of the pond is the "BMP pool." The top of the riser is 7 feet above the bottom of the 12-inch hole. During the 10-year storm the water level would be about 1 foot above the top of the riser and the surface area of the water would be about ½ acre. There is also an emergency spillway on the left(facing downstream) end of the dam; during high intensity storms, water will also flow in this channel.

2. Mowing. All grasses should be mowed at least twice each year. Grasses such as tall fescue should be mowed in early summer after emergence of the heads on cool season grasses. They should be mowed again in the early fall to prevent seeds of annual weeds from maturing. Mowing of legumes such as Sericea lespedeza and crown vetch can be permitted to grow on the dam or in any part of the emergency spillway.

3. Liming and fertilizing. The soil should be sampled according to recommended procedures at least once every 4 years. The sample should be tested at a qualified soil testing laboratory (such as the one at VPI&SU). Lime and fertilizer should be applied in accordance with recommendations based on the tests.

4. Replanting and overseeding. If vegetation covers less than 40% of the soil surface, lime, fertilize and seed in accordance with current recommendations for new seedings. If vegetation covers most than 40% but less than 70% of the soil surface, lime fertilize and overseed in accordance with current recommendations.

5. Removing trash and debris. Trash, litter and vegetation will be removed as needed to prevent obstruction to the flow of water, to prevent movement of trash and litter to downstream properties, to maintain the integrity of the structure, to provide an attractive appearance and to minimize water pollution.

6. Removing sediment. Soil materials (including clay, silt, sand and gravel) will be removed before the detention pool or the BMP pool loses 10% of the designed storage capacity. If forebays are included in the design, sediment should be removed before the forebay loses 10% of the design capacity of the forebay.

7. Sediment disposal. Sediment disposal should be in accordance with current procedures for disposal of sediment. Where it is determined to be necessary or desirable, the sediment will be tested for appropriate pollutants before it is removed from the pond.

8. Repairs, Repair slides, slumps and eroded areas promptly and in a workmanlike manner Trash racks, pipes, headwalls, etc. will be maintained, repaired and/or replaced as needed to maintain the integrity of the structure. Exposed metal surfaces will be painted to minimize damage due to rust.

9. Maintenance inspections. A representative of the owner(s) will inspect each stormwater management structure after each significant rainfall. Once each year a representative of the county will jointly inspect each stormwater management structure. Appropriate action will be taken to ensure appropriate maintenance. All maintenance costs will be borne by the owner(s). Where structures are to be maintained by more than one party, allocation of costs will be in accordance with terms set forth in the maintenance agreement. Keys to locked access points shall be available to Stafford County personnel upon request.

10. Maintenance records. The landowner, or someone designated by the landowner, shall inspect the detention pond within 24 hours after each rainfall event of one inch or more of rain. The owner or the designee shall keep written records of these inspections. The records shall also include maintenance and repairs performed Copies of these records shall be provided to the county upon request.

11. The detention pond shall not be modified in any way without prior approval by Stafford County.

9-B.2.2. Sample Maintenance Plan for Stormwater Retention (Wet) Ponds

1. Also describe the structure and the site it serves. Also describe the design functions and provide information needed for proper maintenance. Example: This structure is a stormwater retention pond; one of its functions is to store additional water during periods of high intensity rainfall. Within a few hours most of this extra water will drain out of the pond. The development of Sections 1, 2, and 3 of subdivision "x" increased the amount of rainfall water which leaves the site because absorbent soil was covered with impervious surfaces such as buildings and roads. The purpose of this temporary storage is to ensure that the peak rates of flow to the channel below the subdivision were not increased. Such increases cause flooding and channel erosion downstream from the pond. This structure was also designed to be a Best Management Practice (BMP). In other words, it was designed to ensure that the amount of phosphorus and other pollutants flowing to the Chesapeake Bay were not increased by construction of Sections 1, 2, and 3 of subdivision "x". This is accomplished by storing a certain volume of water in the permanent pool. The pond has a 36-inch reinforced concrete pipe (RCP), called a "barrel," through the bottom of the pond. In the pond there is a 72-inch vertical RCP called a "riser." During the 10-year storm, the water level would be about 2 feet above the top of the riser and the surface area of the water would be about ¾ acre. There is also an emergency spillway on the left (facing downstream) and of the dam; during high intensity storms water will also flow in this channel. There is also a "forebay" at the inlet end of the pond; this is an area designed to trap coarse sediments before they go into the deeper water where sediment removal is more difficult and expensive. The permanent pool has a surface area of ½ acre (about 22,000 square feet). The volume of water in the permanent pool is 1.3 acre feet (about 490,000 gallons or 4 million pounds) of water. The average depth is about 3 feet; the maximum depth is about 7 feet. The area of land which drains to the pond is 8 acres. This information should be considered when making management decisions with regard to fish, control weeds, etc. This pond should be well suited for warm water fish such as bass; it is not well suited for cold water fish such as trout or land-locked salmon.

2. Mowing. All grasses should be mowed at least twice each year. Grasses such as tall fescue should be mowed in early summer after emergency of the heads on cool season grasses. They should be mowed again in the early fall to prevent seeds of annual weeds from maturing. Mowing of legumes such as Sericea lespedeza and crown vetch can be less frequent. Trees and shrubs should not be permitted to grow on the dam or in any part of the emergency spillway.

3. Liming and fertilizing. The soil should be sampled according to recommended procedures at least once every 4 years. The sample should be tested at a qualified soil testing laboratory (such as the one at VPI&SU). Lime and fertilizer should be applied in accordance with recommendations based on the tests.

4. Replanting and overseeding. If vegetation covers less than 40% of the soil surface, lime, fertilize and seed in accordance with current recommendations for new seedings. If vegetation covers most than 40% but less than 70% of the soil surface, lime fertilize and overseed in accordance with current recommendations.

5. Removing trash and debris. Trash, litter and vegetation will be removed as needed to prevent obstruction to the flow of water, to prevent movement of trash and litter to downstream properties, to maintain the integrity of the structure, to provide an attractive appearance and to minimize water pollution.

6. Removing sediment. Soil materials (including clay, silt, sand and gravel) will be removed from the forebay before 25% of the capacity of the forebay is lost. Sediment will be removed from the rest of the pond before 10% of the designed storage capacity is lost in order to ensure that the pond will adequately function as a BMP. The plan includes information designed to facilitate sediment surveys; this includes a method for locating specific points in the pond and the forebay.

7. Sediment disposal. Sediment disposal should be in accordance with current procedures for disposal of sediment. Where determined to be necessary or desirable, the sediment will be tested for appropriate pollutants before it is removed from the pond.

8. Repairs. Repair slides, slumps and eroded areas promptly and in a workmanlike manner. Trash racks, pipes, headwalls, etc will be maintained, repaired and/or replaced as needed to maintain the integrity of the structure. Exposed metal surfaces will be painted to minimize damage due to rust.

9. Maintenance inspections. A representative of the owner(s) will inspect each stormwater management structure after each significant rainfall. Once each year a representative of the county will jointly inspect each stormwater management structure. Appropriate action will be taken to ensure appropriate maintenance. All maintenance costs will be borne by the owner(s). Where structures are to be maintained by more than one party, allocation of costs will be in accordance with terms set forth in the maintenance agreement. Keys to locked access points shall be available to Stafford County personnel upon request.

10. Maintenance records. The landowner, or someone designated by the landowner, shall keep written records of all inspections, maintenance and repairs performed. Copies of these records shall be provided to the county upon request.

11. The pond shall not be modified in any way without prior approval by Stafford County.

9-B.2.3. Sample Maintenance Plan for Subsurface Stormwater Detention Systems

1. Describe the structure and the site it serves. Also describe the design functions and provide information needed for proper maintenance. Example: This structure will store water during high-intensity rainfall. Most of the water will drain out within a few hours. The development of the Shopping Center "x" increased the amount of rainfall water which leaves the site because absorbent soil was covered by the building and the paved parking lot. The purpose of this temporary storage is to ensure that the peak rates of flow to the channel below the shopping center were not increased. The control structure is a large concrete box with a wall across the middle. There is a 6-inch hole (called an "orifice") in the bottom of the wall. The western end of this box is connected to a concrete pipe 48 inches in diameter and about 300 feet long. When there is more water coming in than the 6-inch hole can carry, the extra water is stored in the western side of the box and in the 48-inch pipe. During very high intensity storms the water flows over the top of the wall (when water flows over the wall, it serves as a "weir). This weir is designed to prevent flooding of the parking lot. The wall on the eastern end of the box is connected to an 18-inch concrete pipe. This carries the water which flowed through the orifice and over the weir to a channel near Parkway "x". Each side of the control box is accessible through a manhole cover. Four more manhole covers also provide access to the storage pipe.

2. Maintenance inspections. A representative of the owner will inspect the control box and the storage pipe after each significant rainfall. If water is standing in both compartments of the control structure more than 5 hours after the rain has stopped, check the outlet end of the 18-inch pipe. If it is not obstructed, check the inlet end in the eastern end of the control structure; it is recommended that no one enters the control structure when water is standing in the structure unless another adult is standing by outside the structure. While not common in storm sewer structures, it is possible that heavier-than-air gases could be trapped above the water; this is not likely if the water has drained out since the heavy air would also drain out through the 18-inch pipe unless the outlet end of the pipe is submerged in water. If only the western compartment contains standing water, the 6-inch hole in the weir/orifice wall is probably plugged. Other than the need to remove trash and debris, this is the maintenance problem that is most likely to occur. Workers can usually clear this opening while in the eastern compartment. Once each year a representative of the owner and a representative of the county will jointly inspect the entire detention system. Appropriate action will be taken to ensure proper maintenance. All maintenance costs will be borne by the owner(s). Keys to locked access points shall be available to Stafford County personnel upon request.

3. Removing trash, debris and sediment. The control structure and the pipe should also be checked during dry weather. Litter and sediment deposits should be removed as needed to prevent obstruction to the flow of water, to prevent movement of trash and debris to downstream properties, to minimize water pollution and to ensure that the system adequately performs the function for which it was constructed.

4. Sediment disposal. Sediment disposal should be in accordance with current procedures for disposal of sediment. Where determined to be necessary or desirable, the sediment will be tested for appropriate pollutants before final disposal.

5. Property maintenance. Grass and other soil covers should be maintained in order to minimize the amount of sediment entering the system. Trash and litter should be collected on a daily basis.

6. Maintenance records. The owner, or someone designated by the owner, shall keep written records of all inspections. The records shall include maintenance and repairs performed. Copies of these records shall be provided to the county upon request.

7. The system shall not be modified in any way without prior approval by Stafford County.

9-B.2.4. Sample Maintenance Plan for Stormwater Infiltration Systems

1. Describe the structure and the site it serves. Also describe the design functions. Example: This stormwater infiltration system will store runoff water for a period of about 48 hours after heavy rainfall. The development of Mini-Mall "x" increased the amount of rainfall water which leaves the site because absorbent soil was covered by the building and the paved parking lot. This increase in impervious area also increased the amount of pollutants carried by runoff water. This structure has two purposes. It is designed to ensure that the peak rates of runoff from the 2-year and 10-year storms were not increased by construction of Mini-Mall "x". It is also designed to ensure that the amount of phosphorus (a "keystone" pollutant) leaving the site in runoff water was not increased by construction of Mini-Mall "x"; this system is a Best Management Practice constructed in compliance with the Chesapeake Bay Preservation Act. This structure is basically a trench filled with gravel. Water is stored in the voids (spaces between the pieces of gravel) until it seeps into the soil under the bottom of the trench. This decreases the amount of runoff and the water is added to other water stored in the ground ("groundwater"). The soil also serves as a filter. When larger storms occur, the overflow will be carried to the road ditch by a broad, shallow channel. The top 12 inches of gravel is underlain by a filter fabric which is wrapped around the rest of the gravel. There are also three observation wells; these are vertical plastic pipes with removable caps. There is a 20-foot wide strip of grass (filter strip) between the pavement and the trench. The purpose of this filter strip is to remove some of the particles which would otherwise plug holes in the gravel and the filter fabric.

2. Maintenance inspections. The observation wells should be checked right after rainfall has stopped or rainfall intensity has slowed down, If the trench is full of water runoff water is getting into the gravel. If the overflow channel carries water during the rainfall and the water level in the trench is relatively low, it is very likely that the holes in the top 12 inches of gravel and/or the holes in the filter fabric have been filled or plugged. When this happens, the top 12 inches of gravel and the filter fabric under the gravel should be replaced with clean materials. These factors will also vary with duration and intensity of rainfall; routine inspections should be done by the same person or persons in order to develop a base of knowledge about the system. The filter strip should also be inspected. Maintain a healthy stand of grass. Cut with lawnmowers at a high setting (grass should be at least 4 inches tall just after mowing) so the remaining grass can function as a filter. This grass should be bagged as it is mowed so that the cuttings will not plug up the holes in the gravel. The observation wells should also be inspected 2 to 3 days after the rain has stopped. If there is water in the bottoms of the wells it is probably time to remove all of the gravel and filter fabric and replace the filter fabric. If the gravel is dirty or dusty it too should be replaced. The system was designed to be several feet above the water table. However, if there is water in the wells 48 hours after rainfall in April and May but not in July and August, the standing water may indicate that the seasonal high water table was higher than anticipated; discuss this with appropriate Stafford County personnel.

3. Removing trash, debris and sediment. The best was to remove sediment is to prevent it from being there. Do not allow areas of soil to be exposed to rain; plant grass or provide other ground cover. During winter, keep application of such things as sand and cinders to a minimum. Litter and sediment deposits should be removed, preferably before they get to the filter strip. If sediment deposits in the filter strip cause water to pond on the pavement, remove the sediment

and the grass. Replace the grass with tall fescue sod or apply lime, fertilizer, seed and mulch and install a temporary silt fence along the edge of the trench. Collect trash and litter on a daily basis.

4. Sediment disposal. Sediment disposal should be in accordance with current procedures for disposal of sediment. Where determined to be necessary or desirable, the sediment will be tested for pollutants before final disposal.

5. Maintenance records. The owner, or someone designated by the owner, shall keep written records of all inspections. The records shall include maintenance and repairs performed. Copies of these records shall be provided to the county upon request.

6. The system shall not be modified in any way without prior approval by Stafford County.

9-B.2.5. Sample Maintenance Plan for Delaware Sand Filters

The system consists of two parallel concrete trenches (long narrow concrete boxes) placed side by side. The wall between the two trenches contains rectangular openings through which water flows from the first trench to the second trench. Water enters the trench nearest the paved area through grates in the cover over the trench. This trench is called a "sedimentation chamber". There is a relatively permanent pool of water in this chamber. This helps to prevent heavier particles from entering the filter chamber. As the depth of sediment increases, the depth of water decreases and the ability of this pool to remove pollutants decreases. This chamber should be cleaned out when the sediment reaches a depth of 4 inches. Cleaning is usually done with tank trucks equipped with vacuum pumps.

The second chamber contains the sand filter and is known as the filter chamber. This chamber has a solid cover since the water must first be treated by the sedimentation chamber. Pollutants (including fine particles and floatable materials such as hydrocarbons) will enter this chamber. Some of the pollutants are trapped on the sand or in the sand. The accumulated pollutants reduce the ability of the water to flow through the sand and the ability of the sand to trap more pollutants. It is therefore necessary to replace the sand occasionally with "ASTM C-33 Concrete Sand"; this sand should be at least 18 inches deep. The sand is underlain by perforated tubes or pipes. The tubes convey the treated water to a flow splitter/clearwell at the outlet end of the system. Each chamber is about 3 ft wide and 36 ft long. There are 14 rectangular openings (16 inches wide and 3 inches high) in the wall between the two chambers. The bottoms of these openings are about 3.75 feet above the floors of the chambers. The water in the sedimentation chamber should drain down to the bottoms of these openings within 24 hours. The water in the filter chamber should drain out completely within 36 hours after the rain has stopped. If drawdown times exceed these guidelines and there are no obstructions in the outlet structure the sand and the geotechnical fabric should be removed and replaced. Check the perforated tubing before replacing the sand. This should normally be done once every 3 to 5 years. If removal is required more frequently, check for erosion in the area that drains to the sand filter. Stabilize eroding areas so that less sediment will flow to the structure.

Perform at least one major inspection each year. Check for missing grates, structural damage, cracks, etc. Keep a log of inspections (date, time, weather, depth of sediment in the sedimentation chamber and depth of water in both chambers, other items noted. etc.). Keep records of all maintenance and repairs. Copies of these records shall be provided to Stafford County upon request.

9-B.2.6. Sample Maintenance Plan for Dry Wells

One or more "dry wells" were installed in order to comply with the Chesapeake Bay Preservation Act and Stafford County's Stormwater Management Ordinance. Runoff from the roof must flow into the dry wells. These dry wells should fill up with water during heavy rainfall. There should be no water standing in the dry wells 48 hours after the rain has stopped. These wells have been designed to hold specific volumes of water until it infiltrates into the soil. If they function properly, the peak rates of runoff leaving the site will be reduced, pollutants will be removed by the filtering action of the soil and underground water supplies will be recharged.

In order for these wells to function properly, the owner is obligated to maintain them. The water should be able to get to the wells. Rainspouts should be kept clean. Remove such things as tree leaves, seeds and roof beads. Screens and wire trash racks can be helpful. The areas where the downspouts enter the plastic pipes should also be kept clean and open; the water should be able to come out here when the well is full. Each dry well has several observation wells (perforated vertical pipes). Each observation well has a removable (preferably lockable) cap. The observation wells should be checked at least once every three months. The check would consist of measuring the depth to water after heavy rainfall (if it is full, the water from the roof is getting into the well) and checking the depth to water two days later (if there is no water, it is infiltrating into the soil) The observation wells which receive water directly from rainspouts also contain cleaning rods. There is a cap (or plate) on the bottom end of each rod. Debris can be removed from an observation well by pulling the rod up and cleaning the cap. The rod should be reinstalled right after the debris has been removed from the cap.

If properly maintained, the maintenance described above may be all that is needed. If the holes in the gravel become filled with dirt and/or other debris, it may be necessary to install new stone and filter fabric in the dry well. If "fines" fill the holes in the fabric to such an extent that water will not filter out within 48 hours, the filter fabric should be replaced.

9-B.3.0. CITY OF VIRGINIA BEACH, VIRGINIA

STORMWATER MANAGEMENT FACILITIES MAINTENANCE AGREEMENT

THIS STORMWATER MANAGEMENT FACILITIES MAINTENANCE AGREEMENT made this _____ day of _____, 20_____, by _____ (the "Covenantor," and for indexing
(individual, partnership, association, corporation, LLC)
purposes "Grantor"); the CITY OF VIRGINIA BEACH, a municipal corporation of the Commonwealth of Virginia, (the "City," and for indexing purposes "Grantee"); _____ (the "Trustee," and for indexing purposes "Grantor"); and _____ (the "Noteholder," and for indexing purposes "Grantor").

W I T N E S S E T H:

WHEREAS, the City is authorized and required to regulate and control the disposition of storm and surface waters within the Stormwater Management District of the City of Virginia Beach as set forth in the City of Virginia Beach Stormwater Management Ordinance effective June 1, 1998, as amended (the "Ordinance"), adopted pursuant to Section 10.1-603.1, *et seq.* of the Code of Virginia of 1950, as amended (the "Act"); and

WHEREAS, the Covenantor is the owner and is seized in fee simple of a certain tract or parcel of land more particularly described on Schedule A attached hereto (the "Property"); and

WHEREAS, Covenantor desire to construct certain improvements on the Property which will alter existing storm and surface water conditions on both the Property and adjacent lands; and

GPIN # _____ Prepared by: _____

WHEREAS, in order to accommodate and regulate these anticipated changes in existing storm and surface water flow conditions, the Covenantor desires to build and maintain at Covenantor's expense a storm and surface water management facility and system (the "Facility and System") more particularly described and shown on plans titled _____ sheets ____ through ____ of _____ prepared by _____ and dated _____, which plans and any amendments thereto, are on file with the Development Services Center of the Planning Department of the City of Virginia Beach, Virginia, and are hereby incorporated by reference (the "Site Plan"); and

WHEREAS, the City has reviewed and approved the Site Plan subject to the execution of this Agreement.

NOW, THEREFORE, in consideration of the benefit received and to be received by the Covenantor, its successors and assigns, as a result of the City's approval of the site Plan, the Covenantor, hereby covenants and agrees with the City as follows:

1. At their sole expense, the Covenantor, its successors and assigns, shall construct and perpetually maintain the Facility and System in strict accordance with the Site Plan and any amendments thereto which have been approved by the City, the Ordinance and the Act.

2. At their sole expense, the Covenantor, its successors and assigns, shall make such changes or modifications to the Facility and System as may be determined as reasonably necessary by the City to ensure that the Facility and System is properly maintained and continues to operate as originally designed and approved.

3. At reasonable times and in a reasonable manner as provided in Section 10.1-603.11 of the Act and Section 12 of the Ordinance, the City , its agents, employees and contractors, shall have the right of ingress and egress over the Property and the right to inspect the Facility and System in order to ensure that the Facility and System is being properly maintained, is continuing to perform in an adequate manner and is in compliance with the Act, the Ordinance and Site Plan and any amendments thereto approved by the City.

4. Should either the Covenantor or its successors and assigns, fail to correct any defects in the Facility and System within the time specified in a written notice from the City that the Covenantor or its successors and assigns has/have failed to maintain the Facility and System in accordance with the approved design standards and/or the Site Plan and in accordance with the law and applicable regulations of the Act and the Ordinance, the City may pursue such remedies as provided by law, including, but not limited to, such civil and criminal remedies set forth in Section 10.1-603.14 of the Act and Sections 12 and 13 of the Ordinance.

5. The Covenantor, its successors and assigns, shall indemnify, hold harmless and defend the City from and against any and all claims, demands, suits, liabilities, losses, damages and payments, including reasonable attorney fees claimed or made against the City that are alleged or proven to result or arise from the Covenantor's, its successors' and/or assigns', construction, operations or maintenance of the Facility and System.

_____
Owner's Initials

6. This Agreement and the covenants and agreements contained herein shall run with the title to the land and whenever the Property shall be held, sold, conveyed or otherwise transferred, it shall be subject to the covenants, stipulations, agreements and provisions of this Agreement which shall apply to, bind and be obligatory upon the Covenantor hereto, its successors and assigns, and shall bind all present and subsequent owners of the Property described herein.

Initially, the Covenantor is solely responsible for the performance of the obligations required hereunder and, to the extent permitted under applicable law, the payment of any and all fees, fines, and penalties associated with such performance or failure to perform under this Agreement. Notwithstanding any provisions of this Agreement to the contrary, upon the recordation of a deed or other instrument of sale, transfer or other conveyance of fee simple title to the Property or any portion thereof (a "Transfer") to a third party (the "Transferee"), the Covenantor shall be released of all of its obligations and responsibilities under this Agreement accruing after the date of such Transfer to the extent such obligations and responsibilities are applicable to that portion of the Property included in such Transfer, but such release shall be expressly conditioned upon the Transferee assuming such obligations and responsibilities by recorded written agreement for the benefit of the City. Such written agreement may be included in the Transfer deed or instrument, provided that the Transferee joins in the execution of such deed or instrument. A certified copy of such deed, instrument or agreement shall be provided to the City. The provisions of the preceding three sentences shall be applicable to the original Covenantor and any successor Transferee who has assumed the obligations and responsibilities of the Covenantor under this Agreement as provided above.

7. Nothing herein shall be construed to prohibit a transfer by the Covenantor to subsequent owners and assigns.

8. The provisions of this Agreement shall be severable and if any phrase, clause, sentence or provision is declared unconstitutional, or the applicability thereof to the Covenantor, its successors and assigns, is held invalid, the remainder of the Covenant shall not be affected thereby. This Agreement shall be interpreted under the laws of the Commonwealth of Virginia.

9. _____, the Noteholder, being the holder of a note or notes secured by a lien on the Property through a deed of trust dated _____, from _____ to _____ and _____, Trustees, either of whom may act, record in the clerk's Office of the Circuit Court of the City of Virginia Beach, Virginia (the "Clerk's Office") by Instrument # _____ (the "Deed of Trust"), joins in the execution of this Agreement to evidence its consent to the provisions hereof and to direct the Trustee to execute same for subordination purposes. At the direction of the Noteholder, the Trustee joins herein to subordinate the lien of the Deed of Trust, and the Noteholder and the Trustee hereby acknowledge and agree that the lien of the Deed of Trust is hereby subordinated to this Agreement, the covenants created or set forth herein and all of the rights of the City hereunder.

10. This Agreement shall be recorded in the Clerk's Office.

11. In the event that the City shall determine at its sole discretion at any future time that the Facility and System is no longer required, then at the request of the Covenantor, its successors and/or assigns, the city shall execute a release of this

Agreement which the Covenantor, it successors and/or assigns, shall record in the Clerk's Office, at its/their expense.

12. This Agreement shall be deemed to be a Virginia contract and shall be governed as to all matters whether of validity, interpretations, obligations, performance or otherwise exclusively by the laws of the Commonwealth of Virginia, and all questions arising with respect thereto shall be determined in accordance with such laws. Regardless of where actually delivered and accepted, this Agreement shall be deemed to have been delivered and accepted by all parties in the Commonwealth of Virginia.

13. Any and all suits for any claims or for any and every breach or dispute arising out of this Agreement shall be maintained in the appropriate court of competent jurisdiction in the City of Virginia Beach.

14. This Agreement shall not be modified except by written instrument executed by the City and the owner(s) of the Property at the time of modification, and no modification shall be effective until recorded in the Clerk's Office.

IN WITENESS WHEREOF, the Covenantor has executed this Agreement as of the date first set forth above.

_____
Covenantor's Name

BY: _____
(individual, partnership, association, corporation) Title

ATTEST:

By: _____
Name Title

_____
Owner's Initials

ACKNOWLEDGMENT OF OWNER/DEVELOPER

STATE OF _____
CITY OF _____, to-wit:

I, _____, a Notary Public in and for the City and State aforesaid, do hereby certify that _____, _____ for , whose name is signed to the foregoing Instrument, has acknowledged the same before me in my City and State aforesaid. He/She/They is/are personally known to me or has/have produced identification.

GIVEN under my hand this _____ day of _____, 20____.

Notary Public_____ My Commission _____

Notary Registration Number: _____

_____
Noteholder

BY: _____
Name Title

ATTEST:

By: _____
Name Title

NOTEHOLDER ACKNOWLEDGEMENT

STATE OF _____
CITY OF _____, to wit:

I, _____, a Notary Public in and for the City and state aforesaid, do hereby certify that _____, Name _____ Title And _____, Name _____ Title Respectfully, of _____, (name of Noteholder.)

_____
Owner's Initials

whose names as such are signed to the foregoing Agreement, have acknowledged the same before me in my City and State aforesaid. He/She/They is/are personally known to me or has/have produced _____ identification.

GIVEN under my hand this _____ day of _____, 20_____.

_____ My Commission Expires: _____
Notary Public

Notary Registration Number: _____

_____
Trustee (for Noteholder)

_____
Trustee (for Noteholder)

TRUSTEE ACKNOWLEDGEMENT

STATE OF _____
CITY OF _____, to wit:

I, _____, a Notary Public in and for the City and state aforesaid, do hereby certify that _____ and _____, Trustee, whose names as such are signed to the foregoing Agreement, have acknowledged the same before me in my City and State aforesaid. He/She/They is/are personally known to me or has/have produced _____ identification.

Name

GIVEN under my hand this _____ day of _____, 20_____.

_____ My Commission Expires: _____
Notary Public

Notary Registration Number: _____

_____
Owner's Initials

ATTEST: CITY OF VIRGINIA BEACH, VIRGINIA

_____ _____

Signature – City Clerk City Manager/Authorized Designee of City Manager

CITY'S ACKNOWLEDGEMENT

STATE OF VIRGINIA
CITY OF VIRGINIA BEACH, to wit:

I, _____, a Notary Public in and for the City and state aforesaid, do hereby certify that _____ CITY MANAGER/AUTHORIZED DESIGNEE OF THE CITY MANAGER PURSUANT TO §2-154 OF THE CITY CODE, whose name is signed to the foregoing Agreement, bearing date the _____ day of _____, 20_____, has acknowledged the same before me in my City and State aforesaid. He/She is personally known to me. GIVEN under my hand this _____ day of _____, 20_____.

_____ My Commission Expires: _____

Notary Registration Number: _____

STATE OF VIRGINIA
CITY OF VIRGINIA BEACH, to wit:

I, _____, a Notary Public in and for the City and state aforesaid, do hereby certify that _____ City Clerk for the City of Virginia Beach, Virginia, whose name is signed to the foregoing Agreement, bearing date the _____ day of _____, 20_____, has acknowledged the same before me in my City and State aforesaid. She is personally known to me.

GIVEN under my hand this _____ day of _____, 20_____.

_____ My Commission Expires: _____

Notary Registration Number: _____

APPROVED AS TO CONTENT: APPROVED AS TO FORM:

_____ _____

Signature – Development Services Center Signature – City Attorney

_____
Owner's Initials

9-B.4.0. FAIRFAX COUNTY, VIRGINIA

Tax Map:_____

District:_____

STORMWATER MANAGEMENT AGREEMENT

THIS AGREEMENT, made this _____ day of _____, _____, by and between

_____

_____

Insert Full Name of Owner(s)

hereinafter called "Landowner", and the Board of Supervisors of Fairfax County, Virginia, hereinafter called "County":

WITNESSETH:

WHEREAS, the Landowner is the owner of certain real property, more particularly described as

_____

Insert Legal Description of Property

_____

_____

_____ _____

Plan Name Tax Map Number

as recorded by Deed in the land records of Fairfax County, Virginia, in Deed Book _____at

Page _____, hereinafter called the "Property"; and

WHEREAS, the Landowner is proceeding to build on and develop the Property; and

WHEREAS, The Site Plan/Subdivision Plan Number _____-_____-_____ hereinafter called the "Plan" which is expressly made a part hereof, as approved or to be approved by the County, provides for management of stormwater within the confines of the property; and

WHEREAS, the County and the Landowner agree that the health, safety, and welfare of the residents of Fairfax County, Virginia, require that on-site stormwater detention facilities, and/or stormwater quality control facilities, hereinafter call stormwater management facilities, be constructed and maintained on the property; and

WHEREAS, the County requires that on-site stormwater management facilities as shown on the Plan be constructed and adequately maintained by the Landowner,

NOW, THEREFORE, in consideration of the foregoing premises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The on-site stormwater management facilities shall be constructed by the Landowner in accordance with the plans and specifications identified in the Plan.

2. The Landowner shall maintain the stormwater management facilities as shown on the Plan in good working order acceptable to the County and in accordance with the specific maintenance requirements noted on the Plan and/or attached hereto as Attachment A, where applicable.

3. The Landowner hereby grants permission to the County, its authorized agents and employees, to enter upon the Property and to inspect the stormwater management facilities whenever it deems necessary. Whenever reasonably possible, the County shall attempt to notify the Landowner prior to entering the Property.

4. In the event the Landowner fails to maintain the stormwater management facilities, as shown on the Plan, in good working order acceptable to the County and in accordance with the specific maintenance requirements noted on the Plan and attached hereto, the County may enter upon the Property and take whatever steps it deems necessary to maintain said stormwater management facilities. This provision shall not be constructed to allow the County to erect any structure of a permanent nature on the land of the Landowner. It is expressly understood and agreed that the County is under no obligation to maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the County.

5. In the event the County, pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner shall reimburse the County upon demand, within ten (10) days of receipt of an invoice thereof for all costs incurred by the County hereunder.

6. It is the intent of this Agreement to insure the proper maintenance of on-site stormwater management facilities by the Landowner; provide, however, that this Agreement shall not be deemed to create or affect any additional liability of any party for damage alleged to result from or be caused by stormwater drainage.

7. The Landowner, its executors, administrators, assigns, and any other successors in interest, shall indemnify and hold harmless the County and its agents and employees for any and all damages, accidents, casualties, occurrences or claims which might arise or be asserted against the County from the construction, presence, existence or maintenance of the stormwater management facilities by the Landowner or the County.

In the event a claim is asserted against the County, its agents or employees, the County shall promptly notify the Landowner and the Landowner shall defend at his own expense any suit based on such claim. If any judgment or claims against the County, its agents or employees shall be allowed, the Landowner shall pay all costs and expenses in connection therewith.

8. This Agreement shall be recorded among the land records of Fairfax County, Virginia, and shall constitute a covenant running with the land, and shall be binding on the Landowner, its administrators, executors, assigns, heirs and any other successors in interest.

IN WITNESS of all of which, the parties hereto have caused this Agreement to be executed under seal on their behalf.

_____ _____
Landowner Landowner

By:_____ _____
Signature Signature

_____ _____
(Print or type name and title) (Print or type name and title)

Address:_____

_____

STATE OF_____

COUNTY/CITY OF_____

I, _____, Notary Public in and for the State and County/City

aforesaid, do hereby certify that _____

_____ whose hame(s) is (are) signed to the foregoing agreement, this day
Personally appeared before me in my State and County/City aforesaid and acknowledged the same.

Given under my hand this _____ day of _____, _____.

My commission expires: _____ _____
Notary Public

BOARD OF SUPERVISORS OF FAIRFAX COUNTY, VIRGINIA

By:_____
Director, Land Development Services
Department of Public Works and Environmental Services

COMMONWEALTH OF VIRGINIA:

COUNTY OF FAIRFAX:

This _____ of _____, _____, appeared before me in my State and County aforesaid, _____, Directpr, Land Development Services, Department of Public Works and Environmental Services, or agent and acknowledged signature.

My commission expires: _____ _____
Notary Public

Approved As To Form:

_____
County Attorney

BAAforms/StormwaterManagementAgr-revised 10/24/05

ATTACHMENT A

BIORETENTION BASIN (Rain Garden) MAINTENANCE SPECIFICATIONS

1. Bioretention Basin(s) and appurtenances shall be maintained in good working condition acceptable to the County.

2. The Bioretention Basin(s) and appurtenances shall be privately owned and maintained.

3. Bioretention Basin(s) and appurtenances shall be inspected in accordance with the following schedule by a qualified individual to ensure that they operate in good working condition acceptable to the County. Items in need of repair shall be promptly addressed.

    - Embankment settling, woody growth, and signs of piping (annually)
    - Signs of seepage on the downstream face of the embankment (annually)
    - Condition of grass cover on the embankment and perimeter (annually)
    - Riprap displacement or failure (annually)
    - Outlet (annually)
    - Outlet channel conditions (annually)
    - Inlet pipe conditions (annually)
    - Safety features of the facility (annually)
    - Access for maintenance equipment (annually)
    - Sediment accumulation (monthly)
    - Debris and trash accumulation (monthly)
    - Erosion in bioretention area and on the embankment (monthly)
    - Species distribution/survival for plantings shown on the design plans essential to the pollutant removal capability of the facility (twice per year)
    - Condition of mulch (monthly)
    - Condition of grass buffer

4. The pH of the soil shall be tested annually. The pH level of the soil shall be maintained as neutral (within a pH range of 6.5 to 7.5). Limestone shall be spread over the bioretention facility if the soil pH is less than 6.5.

5. The mulch layer and soils shall be examined for evidence of hydrocarbons or other deleterious materials if the plant community experiences unsatisfactory growth or mortality. Any contaminated mulch shall be removed and replaced with clean mulch. In the event of persistent unsatisfactory growth, the soils shall be tested as needed for hydrocarbons or other toxic substances. If excess levels of these toxic substances are encountered, then the soils, plants and mulch shall be replaced as needed in conformance with the approved construction plans.

6. Trees and shrubs shall be mulched to a minimum thickness of 2 inches. Mulch shall be removed and replaced every two to three years. Ground cover specified as plugs shall be installed after the area has been mulched. Ground cover established by seeding and/or consisting of grass shall not be covered with mulch.

7. Watering of plant material shall be performed as needed to ensure survival.

8. The basin's embankment and overflow spillway shall be mowed at least twice during the Spring, at least once during the Summer, and at least twice during the Fall to discourage woody growth with the last cutting occurring at the end of the growing season. The grass should not be cut to less than 6 to 8 inches in height.

9. If necessary, the embankment shall be limed, fertilized and seeded in the Fall, after the growing season. Lime and fertilizer application rates shall be based on soil test results. The type of seed should be consistent with that originally specified on the construction plans.

10. All erosion gullies noted during the growing season shall be backfilled with topsoil, reseeded and protected (mulched) until vegetation is established.

11. All bare areas and pathways on the embankment shall be promptly seeded and protected (mulched) or otherwise stabilized to eliminate the potential for erosion.

12. All animal burrows shall be backfilled and compacted and burrowing animals shall be removed from the area.

13. All trees, woody vegetation and other deep-rooted growth, including stumps and associated root systems, shall be removed from the embankment. The root systems shall be extracted and the excavated volume replaced and compacted with material similar to the surrounding area. All seedlings shall be removed at the first opportunity. Similarly, any vine cover and brush shall be removed from the embankment to allow for inspections.

14. Grass buffer strips shall be maintained at a height of 6 to 12 inches.

15. A reinforcement planting for the vegetation shown on the design plans, essential to the pollutant removal capability of the facility, shall be scheduled at the onset of the second growing season after construction. The size and species for the reinforcement plantings shall be based on an inspection of the growth and survival of the plantings at the end of the first growing season.

16. Water shall not be allowed to pond on the surface of the basin for more than 48 hours after a storm. Water ponding more than 48 hours after a storm is an indication that the underlying soil interface is clogged. Any evidence of clogging of the underlying soil interface shall be investigated and promptly addressed.

17. The owner shall provide an annual report of inspections and maintenance activities including a fiscal summary of budgeted and actual expenditures to the County (Maintenance and Stormwater Management Division) within 45 days of the end of the calendar year. The annual report shall include the names, addresses, telephone numbers, and other available means of contact (FAX numbers and email addresses) of the current owner(s) and the individual(s) responsible for maintenance of the facility. Inspection and maintenance records also shall be kept on-site or at a location that is readily accessible and shall be made available to County officials upon request.

9-B.5.0. EXAMPLE STORMWATER FACILITY MAINTENANCE AGREEMENT (STATE OF GEORGIA)

THIS AGREEMENT, made and entered into this ___ day of _____, 20___, by and between (Insert Full Name of Owner)_____ hereinafter called the "Landowner", and the [Local Jurisdiction], hereinafter called the "[City/County]". WITNESSETH, that

WHEREAS, the Landowner is the owner of certain real property described as (Tax Map/Parcel Identification Number) _____ as recorded by deed in the land records of [Local Jurisdiction], Georgia, Deed Book _____ Page _____, hereinafter called the "Property".

WHEREAS, the Landowner is proceeding to build on and develop the property; and WHEREAS, the Site Plan/Subdivision Plan known as _____, (Name of Plan/Development) hereinafter called the "Plan", which is expressly made a part hereof, as approved or to be approved by the County, provides for detention of stormwater within the confines of the property; and

WHEREAS, the [City/County] and the Landowner, its successors and assigns, including any homeowners association, agree that the health, safety, and welfare of the residents of [Local Jurisdiction], Georgia, require that on-site stormwater management facilities be constructed and maintained on the Property; and

WHEREAS, the County requires that on-site stormwater management facilities as shown on the Plan be constructed and adequately maintained by the Landowner, its successors and assigns, including any homeowners association.

NOW, THEREFORE, in consideration of the foregoing premises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The on-site stormwater management facilities shall be constructed by the Landowner, its successors and assigns, in accordance with the plans and specifications identified in the Plan.

2. The Landowner, its successors and assigns, including any homeowners association, shall adequately maintain the stormwater management facilities. This includes all pipes, channels or other conveyances built to convey stormwater to the facility, as well as all structures, improvements, and vegetation provided to control the quantity and quality of the stormwater. Adequate maintenance is herein defined as good working condition so that these facilities are performing their design functions. The Stormwater Structural Control Maintenance Checklists are to be used to establish what good working condition is acceptable to the [City/County].

3. The Landowner, its successors and assigns, shall inspect the stormwater management facility and submit an inspection report annually. The purpose of the inspection is to assure safe and proper functioning of the facilities. The inspection shall cover the entire facilities, berms, outlet structure, pond areas, access roads, etc. Deficiencies shall be noted in the inspection report.

4. The Landowner, its successors and assigns, hereby grant permission to the [City/County], its authorized agents and employees, to enter upon the Property and to inspect the stormwater management facilities whenever the [City/County] deems necessary. The purpose of inspection is to follow-up on reported deficiencies and/or to respond to citizen complaints. The [City/County] shall provide the Landowner, its successors and assigns, copies of the inspection findings and a directive to commence with the repairs if necessary.

5. In the event the Landowner, its successors and assigns, fails to maintain the stormwater management facilities in good working condition acceptable to the [City/County], the [City/County] may enter upon the Property and take whatever steps necessary to correct deficiencies identified in the inspection report and to charge the costs of such repairs to the Landowner, its successors and assigns. This provision shall not be construed to allow the [City/County] to erect any structure of permanent nature on the land of the Landowner outside of the easement for the stormwater management facilities. It is expressly understood and agreed that the City/County] is under no obligation to routinely maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the [City/County].

6. The Landowner, its successors and assigns, will perform the work necessary to keep these facilities in good working order as appropriate. In the event a maintenance schedule for the stormwater management facilities (including sediment removal) is outlined on the approved plans, the schedule will be followed.

7. In the event the [City/County] pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner, its successors and assigns, shall reimburse the [City/County] upon demand, within thirty (30) days of receipt thereof for all actual costs incurred by the [City/County] hereunder.

8. This Agreement imposes no liability of any kind whatsoever on the [City/County] and the Landowner agrees to hold the [City/County] harmless from any liability in the event the stormwater management facilities fail to operate properly.

9. This Agreement shall be recorded among the land records of [Local Jurisdiction], Georgia, and shall constitute a covenant running with the land, and shall be binding on the Landowner, its administrators, executors, assigns, heirs and any other successors in interests, including any homeowners association.

WITNESS the following signatures and seals:

_____
Company/Corporation/Partnership Name (Seal)

By: _____
_____
(Type Name and Title)

The foregoing Agreement was acknowledged before me this ____ day of _____, 20___, by _____.

_____
NOTARY PUBLIC
My Commission Expires: _____
COUNTY OF _____, GEORGIA

By: _____
_____
(Type Name and Title)
The foregoing Agreement was acknowledged before me this ____ day of _____, 20___, by _____.

_____
NOTARY PUBLIC
My Commission Expires: _____
Approved as to Form:

_____ _____
[City/County] Attorney Date

9-B.6.0. REFERENCES

Atlanta Regional Commission (ARC). 2001. *Georgia Stormwater Management Manual*. Prepared by AMEC, the Center for Watershed Protection, Debo and Associates, Jordan Jones and Goulding, and the Atlanta Regional Commission. Atlanta, Georgia.

City of Virginia Beach, Virginia. 2007. *Stormwater Management Facilities Maintenance Agreement*. Virginia Beach, VA.

Fairfax County Department of Public Works and Environmental Services. 1998 *Stormwater Management Agreements – Sand Filters*. Fairfax, VA.

Fairfax County Department of Public Works and Environmental Services. 2005 *Stormwater Management Agreements – Bioretention Basin*. Fairfax, VA.

Stafford County, Virginia. March, 2003. *Stormwater Management Design Manual.* Stafford, VA.

Appendix 9-C

EXAMPLE BMP INSPECTION & MAINTENANCE CHECKLISTS

Table of Contents

APPENDIX SECTION HEADINGS

9-C.1.0. INTRODUCTION

Once construction is completed, the SWM BMP takes on the role for which it was intended. Periodic site inspections are essential in order to monitor the effectiveness and to anticipate the maintenance needs of the BMP. When conducting inspections, attention should be given not only to the BMP installed for stormwater control, but also to the conveyance system carrying runoff to the BMP and the receiving channel immediately downstream of the BMP. The conveyance channel, curbing and/or storm sewer that convey flow to the BMP or, by design, intentionally divert flows around it are all considered BMP components and must function as intended.

The necessary frequency of inspections will vary with each BMP based on the type of facility, the size of the contributing drainage area, and the land use conditions within the contributing drainage area. The Virginia Stormwater Management Regulations (9 VAC 25-870-114) provide criteria governing local government BMP inspection programs. There is some flexibility provided for inspection frequency for BMPs treating stormwater from an individual residential lot and those BMPs for which schedules are established in individual BMP Maintenance Agreements. Other BMPS must be inspected at least once every five years. However, DEQ recommends that, if feasible, a full inspection should be performed at least once a year, at least for highly engineered facilities such as ponds, constructed wetlands and filters. Localities can take into account the property owners track records pertaining to inspection and maintenance of BMPs on their properties. Ideally, periodic inspections for trash and debris accumulation and general aesthetics should be performed more frequently, after significant storm events.

The first example form provided on the next page is a generic inspection checklist developed by the Center for Watershed Protection. This form allows one to quickly assess urban BMP performance using simple visual indicators. This approach was refined and tested through an extensive analysis of hundreds of BMPs located in the James River Basin of the Chesapeake Bay watershed. More detail on the methods and results can be found in Hirschman et al (2009). It is recommended that these rapid investigations be conducted during every other routine stormwater BMP inspection conducted by a locality in order to verify BMP performance. In many cases, the locality may choose to sub-sample their existing inventory of stormwater practices to gain better information. This basic form can be modified, simplified or customized to meet the unique BMP terminology and design criteria employed in the locality. As well, the locality may elect to develop or adapt your own indicators, checklists and field inspection procedures.

This Appendix also provides a series of individual BMP example checklists for local governments and others to use to guide inspection and maintenance of specific stormwater control measures. Users should feel free to customize these templates, as appropriate, to more effectively address the situations typically encountered during inspection and maintenance activities and to make them easier for inspectors to use. The checklists are detailed enough for an inexperienced inspector or homeowner not familiar with the specific components of the facility. Checking the column provided under the ***Investigate*** heading for any given item indicates a potential problem that requires attention by a qualified individual to interpret the visual indicators for possible maintenance. The checklists should be signed, dated, and maintained at an accessible location such as with an official representative of the homeowners association, the individual or company contracted for maintenance, owner, etc.

FACILITY ID:	**DATE:** ___/_____/___	**ASSESSED BY:**

NAME: _____ **HANDHELD/ GPS ID:**

ADDRESS: _____

PHOTO IDS: _____

SECTION 1- BACKGROUND INFORMATION (GIS)

BMP TYPE :

- ☐ Dry Detention Pond
- ☐ Extended Detention Pond
- ☐ Wet Pond
- ☐ Filter (specify: _____)
- ☐ Infiltration (specify:_____)
- ☐ Check if structure is underground
- ☐ Dry Swale
- ☐ Wet Swale
- ☐ Grass Channel
- ☐ Dry Well
- ☐ Permeable Pavement
- ☐ Bioretention
- ☐ Wetland
- ☐ Level Spreader
- ☐ WQ Inlet
- ☐ Proprietary Device
- ☐ Other _____

YEAR CONSTRUCTED: _____

OWNERSHIP
☐ Public ☐ Private ☐ Unknown

SITE CHARACTERIZATION

DRAINAGE AREA: _____(acres) **IMPERVIOUS COVER:** _____(acres) Discerned from: ☐ Plan ☐ County Data ☐ GIS ☐ Field

CONTRIBUTING DRAINAGE AREA (% land use**):** *Note – All percentages should sum up to 100%.*

_____Industrial _____Commercial _____Urban/Residential _____Suburban/Res
_____Forested _____Institutional _____Golf course _____Park
_____Crop _____Pasture _____Other: _____

WATER QUALITY VOL (FROM DESIGN PLAN): _____(ft^3)

SECTION 2- FIELD VISIT

Rain in last 48 hrs? ☐ Yes ☐ No

Evidence of high water table (e.g., excessive soil saturation)*?* ☐ Yes ☐ No

DESIGN ELEMENTS

FACILITY SIZE:
Length: _____(ft)
Width: _____(ft)
Surface Area: _____(ft^2)
Depth of WQ storage _____(ft)

OBSERVED WQ STORAGE VOL:
_____(ft^3)

HYDRAULIC CONFIGURATION
☐ On-line Facility
☐ Off-line Facility

DESIGN STORM(S):
☐ Water Quality
☐ Flood Control
☐ Channel Protection
☐ Unknown

BMP SIGNAGE: (check all that apply)
☐ None ☐ Flood Warning ☐ Stormwater Education ☐ No Trespassing ☐ Wildlife Habitat
☐ Public Property ☐ Do Not Mow ☐ Other: _____

OUTLET CHARACTERISTICS

PRIMARY OUTLET STRUCTURE:
☐ N/A – infiltration w/ no outlet ☐ Pipe ☐ Riser ☐ Weir ☐ Large Storm Overflow ☐ Open channel
☐ Large Storm By-pass ☐ Other: _____

OUTLET FEATURES:
☐ N/A ☐ Trash Rack ☐ Pond Drain ☐ Inverted outlet pipe ☐ Hooded outlet ☐ Anti-vortex device
☐ Perforated pipe ☐ Gravel Diaphragm ☐ Micropool outlet ☐ Multiple outlet levels
Outlet includes restrictor? ☐ Yes ☐ No

OUTLET STRUCTURE CONDITIONS:
Erosion at Outlet: ☐None ☐Slight ☐Moderate ☐Severe
Outlet Clogging: ☐None ☐Slight ☐Moderate ☐Severe
Structural Problems: ☐None ☐Slight ☐Moderate ☐Severe

CONDITIONS AT OUTFALL:
☐ Stream ☐ Closed storm sewer ☐ Surface channel ☐ Road ditch ☐ Other: _____
☐Unknown

Active Erosion: ☐None ☐Slight ☐Moderate ☐Severe
Trash: ☐None ☐Slight ☐Moderate ☐Severe
Sedimentation: ☐None ☐Slight ☐Moderate ☐Severe
Odor: ☐None ☐Slight ☐Moderate ☐Severe
Algae: ☐None ☐Slight ☐Moderate ☐Severe
Other WQ Problems: ☐None ☐Slight ☐Moderate ☐Severe

Emergency Spillway Type: ☐ Channel ☐ Riser Overflow ☐ Weir ☐ Other: _____

SOIL OR FILTER MEDIA

TYPE OF FILTER/INFILTRATION MEDIA: (check all that apply)
☐ Soil mix _____(in) ☐ Sand _____(in) ☐ Gravel _____(in) ☐ Large Stone _____(in)
☐ Organic material _____(in) ☐ Other_____ ☐ N/A ☐ Unknown
Avg. depth of sediment build-up on surface?_____(in)

SOIL MEDIA SAMPLE: *Note – Complete during site investigation, if applicable*
Dominant Soil Type ☐ Clay ☐ Loam ☐ Sand ☐ Sand/Loam
Is the soil homogenous? ☐ Yes ☐ No

Comments:

VEGETATION

GENERAL OBSERVATIONS:
☐ Landscaped
☐ Aquatic Bench
☐ Invasive Species
☐ Plant Diversity

TYPE OF GROUND COVER (% of Surface Area in Plan View up to low Outlet**):**
Note – All percentages should sum up to 100 %.
_____Trees _____Grasses/Perennials _____ Ponded water _____ Other: _____
_____ Managed Turf _____ Bare Soil _____Shrubs _____ N/A
_____ Gravel/stone _____ Mulch _____ Emergent wetland

Depth of mulch, if present: ☐ Hardwood _____(in) ☐ Pine Straw _____ (in) ☐ Other_____ (in)
Rate degree of shading of BMP Surface Area by trees: ☐ Well Shaded ☐ Some Shading ☐ No Shading ☐ N/A

INLET CHARACTERISTICS

INLET #1:
Diameter/Width:
_____(in)

TYPE OF INLET: ☐ Open Channel ☐ Closed Pipe
☐ Sheet Flow ☐ Curb Cut ☐ Other: _____

Elevation difference between bottom of inlet and BMP surface:
_____ (in)

INLET SUBMERSION:
☐ Complete
☐ Partial
☐ None

INLET CONDITIONS:
Inlet Erosion ☐None ☐Slight ☐Moderate ☐Severe
Inlet Clogging ☐None ☐Slight ☐Moderate ☐Severe
Structural Problems ☐None ☐Slight ☐Moderate ☐Severe

Comments:

INLET #2:
Diameter/Width:
_____(in)

TYPE OF INLET: ☐ Open Channel ☐ Closed Pipe
☐ Sheet Flow ☐ Curb Cut ☐ Other: _____

Elevation difference between bottom of inlet and BMP surface:
_____ (in)

INLET SUBMERSION:
☐ Complete
☐ Partial
☐ None

INLET CONDITIONS:
Inlet Erosion ☐None ☐Slight ☐Moderate ☐Severe
Inlet Clogging ☐None ☐Slight ☐Moderate ☐Severe
Structural Problems ☐None ☐Slight ☐Moderate ☐Severe

Comments:

PRETREATMENT

TYPE OF PRETREATMENT *(check all that apply)*
☐ None
☐ Sediment Forebay (_____ ft^3)
☐ Grass Channel
☐ Riprap Channel or Apron
☐ Grass Filter Strip
☐ Plunge Pool?
☐ Stone Diaphragm
☐ Other: _____

PRETREATMENT FUNCTION ☐ By design ☐ Incidental
Is pretreatment functioning? ☐ Yes ☐ No
Is sediment removal necessary? ☐ Yes ☐ No
Signs of pretreatment bypass? ☐ Yes ☐ No
Signs of flow of sediment from pretreatment to BMP? ☐ Yes ☐ No
Severity: ☐ Slight ☐Moderate ☐Severe

GENERAL DESIGN

BMP FEATURES (check all that apply)
☐ Maintenance Access
☐ Fence
☐ Multi-cell
☐ Micropool
☐ Impermeable Liner
☐ Underdrain
☐ Clean Out
☐ Observation Well
Is water present in observation well?
☐ Yes ☐ No Depth: _____ ft
☐ Pond Drain
☐ Other:_____

CONVEYANCE THROUGH BMP
☐ No Defined Channel
☐ Low Flow Channel
☐ Concrete ☐ Eroded ☐ Earthen ☐ Other _____
Length of Shortest Flow Path: _____(ft)

Is BMP designed with a Permanent Pool? ☐ Yes ☐ No

PERFORMANCE

GENERAL PROBLEMS: (check all that apply)

☐ Maintenance Needed	☐ Erosion at Embankments	☐ Permanent Pools not stable
☐ Water Bypass of Inlet	☐ Erosion within Facility	☐ Inadequate vegetation
☐ Water Bypass of Outlet	☐ Deposition within Facility	☐ Dead or Diseased Vegetation
☐ Incorrect Flow Paths	☐ Inappropriate Ponding of Water	☐ Too many invasive plants
☐ Short-circuiting of treatment mechanism	☐ Clogged Pond Drain/Underdrain	☐ Trees on Embankment
☐ No or ineffective treatment	☐ Clogged Media	☐ Failing structural components
☐ Ineffective pretreatment	☐ Inappropriate media material	☐ Safety issue (Note:_____)
☐ Others _____ __	☐ Inappropriate underlying soil (infiltration)	

WATER QUALITY IN FACILITY: ☐N/A

Algae	☐None	☐Slight	☐Moderate	☐Severe
Odor	☐None	☐Slight	☐Moderate	☐Severe
Turbidity	☐None	☐Slight	☐Moderate	☐Severe
Color	☐Normal	☐Abnormal: _____		

EVIDENCE OF:

- ☐ Geese
- ☐ Animal Burrows
- ☐ Mosquitoes
- ☐ BMP Alteration

PROBLEM		1=NONE	2 - FEW	3 – SEVERAL	4-SEVERE
TRASH		No evidence of trash	A few pieces of trash throughout BMP	Trash accumulation near inlet/outlet	Lots of trash in BMP or BMP used for storage
BMP BANK EROSION		No noticeable erosion	Slight erosion < 5% of bank affected	Moderate erosion ~15% of bank affected	Banks severely eroded, >25% of bank affected
SEDIMENT DEPOSITION		No sediment deposition	Areas of minor sediment deposition	Areas of some deposition, may be severe near inlet/outlets	Lots of deposition resulting in pond bottom clogging
SURFACE SLOPE		0-1% BMP surface slope	1-3% BMP surface slope or steeper slopes with check dams,	3-5% BMP surface slope with no check dams,	>5% surface slope;
SIDE SLOPES		BMP side slopes 3:1 or flatter	BMP side slopes 2:1	Steep BMP side slopes	Risk of side slope failure
STRUCTURAL		No evidence of structural damage	Minor problems (e.g., bank slump, eroded channels)	Moderate structural problems –failure pending	Structural failures (e.g., bank failure, blowout)
VISIBILITY		High visibility, near high-traffic areas	Some visibility, near traffic areas	Limited visibility, near low traffic areas	No visibility, behind buildings or fences
ACCESSIBILITY		Maintained access area for vehicles	Access area designated, but not maintained	Access for vehicles not designated	Access for vehicles not possible
VEG COVER		No mowing in/around BMP	Mowing along BMP edges but areas of no mow in BMP bottom	Mowed turf vegetation	BMP bottom has large areas of bare soil
		Dense plant cover (>75%)	Plant cover, 50-75%	Some plant cover, 25-50%	Sparse vegetative cover (<25%),
VEG HEALTH	TREES	Healthy and established	Slightly stressed	Stressed	Dead
	GROUND COVER	Healthy and established	Slightly stressed	Stressed	Dead
	SHRUBS	Healthy and established	Slightly stressed	Stressed	Dead
	EMERGENT WETLAND	Healthy and established	Slightly stressed	Stressed	Dead

OVERALL PERFORMANCE SCORE (circle one number)

Excellent design and function, no general problems with performance	BMP is well designed, but is undersized or has a few performance problems	BMP is adequately designed, several problems with performance are noted	Poor BMP design, severe performance problems or failure

10 9 8 7 6 5 4 3 2 1

FIELD NOTES

GOOD OR INTERESTING DESIGN FEATURES:
PHOTO #'S:

POOR OR PROBLEMATIC DESIGN FEATURES:
PHOTO #'S:

SECTION 3 – DESIGN PLAN VERIFICATION

PLAN AVAILABLE: ☐ As-built ☐ Other: _____

Do field observations match design plans/as-builts? Describe any differences.

Soil type in facility	☐ N/A	☐ Yes	☐ No	If no, describe:
Pretreatment type and size	☐ N/A	☐ Yes	☐ No	If no, describe:
Signage	☐ N/A	☐ Yes	☐ No	If no, describe:
Low-flow channel	☐ N/A	☐ Yes	☐ No	If no, describe:
Dimensions/volume	☐ N/A	☐ Yes	☐ No	If no, describe:
Inlet type, #, and sizing	☐ N/A	☐ Yes	☐ No	If no, describe:
Outlet type, #, and sizing	☐ N/A	☐ Yes	☐ No	If no, describe:
Vegetation composition	☐ N/A	☐ Yes	☐ No	If no, describe:
Other features	☐ N/A	☐ Yes	☐ No	If no, describe:

9-C.2.0. ROOFTOP DISCONNECTION: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Compensatory device type (include if the pervious area flow path is less than the required minimum length):
(NOTE: See the separate plan review checklist for the compensatory device)

- ☐ Dry Well
- ☐ French Drain
- ☐ Rain Garden
- ☐ Other: _____

Element of BMP	Potential Problem	Problem? Y/ N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Piping, Gutters, Drains and Pre-Treatment Sumps	Fluid from a different practice is being piped near pervious areas				Prevent adjacent uses from piping through or around pervious area.	Professional	
	Sediment and debris accumulation				Correct the source of sediment and debris and remove it immediately	Owner or professional	
	Mosquito proliferation				Correct gutter flow to eliminate standing water; treat for mosquitoes, as needed	Owner or professional	
	Runoff is not entering the receiving pervious area				Check to see if connection spout or overflow pipe is clogged. Remove the sediment.	Owner or professional	
	The downspouts remain disconnected				Restore disconnection	Owner or professional	
Manufactured Products	Product or component is broken or not functioning correctly.				Follow the manufacturer's maintenance recommendations, and repair or replace as needed.	Owner or professional	
Downstream Treatment	The compensatory treatment units have not been maintained				Correct identifiedd problems, according to the maintenance guidelines for the specific supplementary BMP.	Owner or professional	
	Stormwater discharge is ponding at point of disconnection				Dry wells or french drains may be needed, if not already present. Clean out manually, and reconstruct or replace when no longer functioning.	Professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Downstream Treatment (continued)	Erosion is evident at the simple disconnection, bioretention/rain gardens, filter paths, or foundation planter				Remove the sediment and debris build-up at the points where runoff enters the pervious area. Then re-stabilize.	Owner or professional	
	Practices to which the disconnection discharges are not functioning				Reference that practice's checklist for instructions to fix problems.	Professional	
	Practices to which the disconnection discharges are disturbed or have been converted				Correct identified problems and stabilize as needed	Owner or professional	
	The receiving pervious area(s) retain dimensions as shown on plans and are in good condition				Restore dimensions and make needed repairs	Owner or professional	
	There is encroachment on the receiving pervious area(s) or easement by buildings or other structures				Inform involved property owners of BMPs status ; clearly mark the boundaries of the receiving pervious area, as needed	Owner or professional (and perhaps the locality)	

9-C.3.0. SHEET FLOW TO VEGETATED FILTER AREAS AND CONSERVED OPEN SPACE: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Facility Type: Level 1 _____ Level 2 _____

Ideally, these BMP areas should be inspected annually, with the inspection conducted during the non-growing season when it is easier to observe the flow path. Once established, vegetated filter strips have minimal maintenance needs outside of the Spring clean up: regular mowing, repair of check dams and other measures to maintain the hydraulic efficiency of the filter strip and a dense, healthy grass cover. Grass filter strips and boundary zones must be mowed at least twice a year to prevent woody growth. A conservation easement may be required to ensure that the vegetated filter strip area and any newly established or restored forest cover may not be cleared. Also, a responsible party should ensure that routine forest improvements are made over time (i.e., thinning, invasive plant removal, etc.).

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Contributing Drainage Area	There is excessive trash and debris				Remove immediately.	Owner or professional	
	There is evidence of erosino and/or bare or exposed soil				Stabilize immediately.	Owner or professional	
Inlet	Inlets provide stable conveyance into facility				Stabilize immediately, as needed.	Owner or professional	
	Excessive trash / debris / sediment accumulation at the inlet				Remove trash and debris immediately	Owner	
	Evidence of erosion at / around the inlet				Correct the source problem and stabilize immediately	Owner or professional	
Channel	Scour and erosion are present within the vegetated filter area				Sediments are to be cleaned out of Level Spreader forebays and flow splitters	Owner or professional	
	Debris and sediment build-up is present at the top of the vegetated filter area				Check conveyance(s) to the filter area for trouble spots and correct any problems immediately. Manually remove the deposited sediment.	Owner or professional	
Gravel Diaphragm	Foot or vehicular traffic is compromising the gravel diaphragm.				Block foot and vehicular traffic. Re-stabilize the area immediately.	Professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Level Spreader	The level spreader is performing properly. Flows are not concentrating on the down-gradient side of the element				Search the spreader for chips, cracks, or any other fundamental compromise of the structure. Repair immediately.	Professional	
	There is excessive landscape waste and yard clippings				Remove immediately.	Owner or professional	
Vegetation	Vegetative density is less than 90% cover in the boundary zone or grass filter				Reseed and fertilize (if necessary) the exposed soil	Owner or professional	
	The plant composition is consistent with the approved plans				Make a judgment regarding whether plants need to be replaced, and replace if necessary	Professional	
	Invasive species or weeds are present				Correctly destroy and/or remove the invasive species; make a judgment regarding whether other weeds need to be removed, and remove if necessary	Owner or professional	
	There is troublesome pest infestation				Use integrated pest management (IPM) techniques to minimize the use of pesticides and herbicides. Minimize use of organic (not chemical) fertilizer, as needed.	Owner or professional	
	There is dead vegetation and/or exposed soil				Reseed or replace dead vegetation on exposed soil areas	Owner or professional	
Overflow Area	Flows through the filter area short-circuit the overflow control section				Check that the structure is not clogged. If so, manually clean out debris immediately.	Owner or professional	
Outlet	The outlet provides stable conveyance away from the filter area				Stabilize immediately, as needed.	Professional	
Overall	There is adequate access to the level spreader and filter area				Establish adequate access	Professional	
	There is evidence of standing water				Fill in low spots and stabilize; correct flow problems causing ponding	Owner or professional	
	There is excessive trash and debris	.			Remove immediately	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Overall (continued)	Mosquito proliferation				Eliminate stagnant pools and establish vegetation; treat for mosquitoes as needed. If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied *only if absolutely necessary*.	Owner or professional	
	Complaints from local residents				Correct real problems	Owner or professional	
	Encroachment on the filter area or easement by buildings/structures				Inform involved property owners of BMPs status ; clearly mark the boundaries of the receiving pervious area, as needed	Owner or professional (and perhaps the locality)	

9-C.4.0. GRASS CHANNELS: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Type of pretreatment facility:

- ☐ Sediment Forebay
- ☐ Check Dam
- ☐ Grass Filter Strip
- ☐ Stone Diaphragm
- ☐ Other: _____
- ☐ None

Ideally, these BMP areas should be inspected annually, with the inspection conducted spring when the health of the grass channel lining should be evident. Once established, Grass Channels have minimal maintenance needs outside of the Spring clean up: regular mowing, repair of check dams and other measures to maintain the hydraulic efficiency of the channel and a dense, healthy grass cover.

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Contributing Drainage Area	There is excessive trash and debris				Remove immediately	Owner or professional	
	There is evidence of erosion and / or bare or exposed soil				Stabilize immediately	Owner or professional	
Pre-treatment	There is adequate access to the pre-treatment facility				Establish adequate access	Professional and, perhaps, the locality	
	There is excessive trash / debris / sediment in the facility				Remove immediately	Owner or professional	
	There is evidence of erosion and / or exposed soil				Stabilize immediately	Owner or professional	
	There is evidence of diaphragm or other clogging				Identify and eliminate the source of the problem; . If necessary, remove and clean or replace the stone.	Professional	
	There is dead vegetation and evidence of erosion and / or exposed soil				Repair erosion damage, and reseed or otherwise restabilize with vegetation	Owner or professional	
Inlets	The inlet is not maintaining a calm flow of water entering the channel or the conveyance capacity is blocked				Remove trash and sediment accumulated at the inflow. Sources of sediment and debris must be identified and corrected. Stone splash pads must be replenished to prevent erosion.	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
	There is evidence of erosion at / around inlet				Repair erosion damage, and reseed or otherwise restabilize with vegetation.	Owner or professional	
Vegetation	Native soil is exposed or erosion channels are forming				If sediment deposits are thick enough to damage or kill vegetation, remove the sediment by hand, while protecting the vegetation.	Owner or Professional	
	Grass height does not reach standards				Grass channels must be mowed to keep grass at a height of 4" to 9". Remove grass clippings after mowing.	Owner or Professional	
	Vegetation requires fertilizer or pest control				Fertilize according to specifications. Use organic rather than chemical fertilizer. If feasible, use compost. Use integrated pest management (IPM) techniques to minimize the use of pesticides and herbicides.	Owner or Professional	
	The plant composition is consistent with the approved plans				Make a judgment regarding whether plants need to be replaced, and replace if necessary	Professional	
	Invasive species or weeds are present				Correctly destroy and/or remove the invasive species; make a judgment regarding whether other weeds need to be removed, and remove if necessary	Owner or professional	
	There is dead vegetation and/or exposed soil				Reseed or replace dead vegetation and exposed soil areas	Owner or professional	
Side Slopes	Evidence of erosion on side slopes, introducing sediment into the swale.				Repair erosion damage immediately. Stabilize slopes using appropriate erosion control measures and plant appropriate vegetation.	Owner or Professional	
Check Dams	Dam is not functioning properly.				Check upstream and downstream sides of check dams for evidence of undercutting, side cutting or erosion and repair immediately.	Professional	
	There is a large accumulation of sediment or trash/debris behind the check dam.				Remove sediment when the accumulation exceeds 25% of the original Tv. Remove trash/debris and clear blockages of weep holes.	Professional	
Channel Bottom	Undesirable plant species, accumulations of fallen leaves, and other debris from deciduous plant foliage are present.				Remove woody vegetation from the channel. Prune adjacent trees and shrubs to keep the channel clear. Remove/replace invasive veg. or weeds if they cover < 25% of the channel area. Remove accumulated organic matter and debris immediately.	Owner or Professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Channel Bottom (continued)	Base soils are compacted. The practice does not draw down within 48 hours after a storm.				De-thatch and aerate the channel. Remove sediment when the accumulation exceeds 25% of channel volume. Restore the original cross section and revegetate the channel.	Owner or Professional	
	There is unhealthy or dead grass cover or evidence of erosion, braiding, or excessive ponding in the channel bottom				Fill in low spots, repair erosion, and add reinforcement planting to maintain 90% turf cover. Reseed any salt killed vegetation and stabilize immediately. Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel.	Owner or Professional	
Channel Outlet	The outlet does not maintain sheet flow of water exiting the channel (unless a collection drain is used).				The source of erosion damage must be identified and controlled when native soil is exposed or erosion channels are forming. Check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes.	Owner or professional	
	The outlet provides stable conveyance out of the channel				Stabilize immediately, as needed.	Professional	
	There is excessive trash, debris or sediment accumulation at outlet				Check inflow points for cogging and remove any trash and sediment deposits	Owner or professional	
	There is dead vegetation and/or exposed soil				Reseed or replace dead vegetation and exposed soil areas	Owner or professional	
Pest Control	There is evidence of standing water and mosquito habitat or rodent damage				Pest control measures must be taken when mosquitoes and/or rodents are found to be present. If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied *only if absolutely necessary*. Holes in the ground located in and around the swale must be filled and stabilized with vegetation.	Professional	
Overall	Access to the Grass Channel is adequate				Establish adequate access	Professional and, perhaps, the locality	
	Complaints from local residents				Correct real problems	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Overall (continued)	Encroachment by buildings or other structures				Clearly mark BMP and inform those involved of the BMPs.	Owner, pro (and perhaps the locality)	

9-C.5.0. SOIL COMPOST AMENDMENTS: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Ideally, the amended soil area should be watered once every 3 days for the first month, and then weekly during the first growing season (April-October), depending upon rainfall. The area should be inspected at least after each storm event that exceeds 1/2-inch of rainfall during the first six months following the incorporation of soil amendments. Depending on the results of a soil test for the amended area, a one-time spot fertilization may be needed in the fall after the first growing season to increase plant vigor. The area should be de-thatched every few years to increase permeability.

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
	There is excessive trash and debris				Remove immediately	Owner or professional	
	There is evidence of erosion and / or bare or exposed soil				Stabilize immediately with grass cover	Owner or professional	
	Evidence of excessive use of fertilizer or lawn chemicals				Develop and implement a nutrient and pest control management plan	Owner or professional	
	Runoff is ponding, creating rills, and/or causing erosion				Dethatch or aerate the soil. Introduce more compost amendments and/or lime. Restabilize eroded areas by replanting vegetation.	Owner or professional	
	Access to the amended soil area for maintenance is adequate.				Establish adequate access	Professional	
	Absence of signs designating the area as a Conservation Area				Obtain or create and post appropriate signage	Owner (and perhaps the locality)	
	There is evidence of erosion and / or bare or exposed soil				Stabilize immediately	Owner or professional	
	Encroachment on the amended area or easement by buildings or other structures				Inform involved property owners of BMPs status ; clearly mark the boundaries of the receiving pervious area, as needed	Owner or professional (and perhaps the locality)	
NOTE: Soil compost amendments do not need to be addressed in a maintenance agreement if they are incorporated to reduce lawn runoff volume or improve a residential rooftop disconnection. They probably should be addressed in a simple maintenance agreement if the soil restoration/improvement is associated with more than 10,000 square feet of reforestation. Soil compost amendments within a vegetated filter strip or grass channel should be located in a public right of way or within a dedicated stormwater or drainage easement.							

9-C.6.0. VEGETATED ROOFS: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Facility Type: Level 1 _____ Level 2 _____

Ideally, following construction, this practice should be inspected monthly during the vegetation establishment period, and then every six months thereafter to assess the state of vegetative cover and to look for leaks, drainage problems and other functional or structural concerns. Maintenance may include watering, hand-weeding to remove invasive or volunteer plants, and to add plant materials to repair bare areas. The use of herbicides, insecticides, fungicides, and fertilizers should be avoided, since their presence could hasten degradation of the waterproof membrane. Also, power-washing and other exterior maintenance operations should be avoided so that cleaning agents and other chemicals do not harm the vegetated roof plant communities.

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Vegetation	Plant cover is less 90% plant cover				During establishment period, replace dead plants as needed. During the long-term period, dead plants must generally be replaced once per year in the fall.	Owner or professional	
	Plants are wilting				Water more frequently to promote growth and survival. Annual application of slow-release fertilizer is recommended in the fall during the first five years following installation. After that, fertilizer is generally not necessary and should not be applied.	Owner or professional	
	Plants are choking on excess vegetation				Fallen leaves and debris from deciduous plant foliage must be removed and should be recycled or composted.	Owner or professional	
	Invasive and nuisance plant species are present				Completely remove invasive plant species. Weeding must be done by hand, without the use of herbicides or pesticides. Remov weeds regularly and do not allow them to accumulate.	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Vegetation (continued)	Drought conditions are present				Mulch or shade cloth may be applied to prevent excess solar damage and water loss	Professional	
	There is troublesome pest infestation				Use integrated pest management (IPM) techniques to minimize the use of pesticides and herbicides. Minimize use of organic (not chemical) fertilizer, as needed.	Owner or professional	
	There is excessive trash and debris				Remove immediately	Owner or professional	
	Grass has become unruly				Grass should be mowed as needed. Clippings must be removed and should be recycled or composted.	Owner or professional	
Vegetation Irrigation	During the establishment period (initial 1-3 years)				Water sufficiently to assure plant establishment, but do not exceed 1/4-inch of water once every 3 days	Owner or professional	
	During the long-term period (3+ years)				Water sufficiently to maintain plant cover, but do not exceed 1/4-inch of water once every 14 days. For automatic sprinklers, use manufacturers' instructions for operation and maintenance.	Owner or professional	
Structural Components	Waterproof membrane is leaking or cracked				Make necessary repairs immediately	Professional	
	Root barrier is perforated				Replace swatch	Professional	
Drainage Layer/Inlet Pipes	Soil substrate, vegetation, debris, litter or other materials clog the roof drain inlet, scuppers or gutters				Sources of organic matter, debris, litter, and other sediment must be identified and materials removed to prevent clogging drainage structures	Professional	
	Drain inlet pipe is in poor condition				Repair as needed	Professional	
Soil Substrate/ Growing Medium	Evidence of erosion from wind or water				If erosion channels are evident, they must be stabilized with additional soil substrate/growth medium and covered with additional plants	Professional	
	Growth media has become clogged with sediment				Manually remove sediment so as not to damage plant materials.	Professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Overall	Access to the vegetated roof is adequate.				Egress and ingress routes must be restored to design standards. Walkways must be clear of obstructions and maintained to design standards.	Professional	
	There is evidence of damage or vandalism				Maintain the vegetated roof's aesthetics as an asset to the property owner and community.	Owner or professional	
	Mosquitoes or other insects are breeding/ abundant at the practice				Standing water creating an environment for development of insect larvae must be eliminated manually. Chemical sprays must not be used.	Owner or professional	
	Threat of a spill is imminent				Spill prevention measures must be exercised for mechanical systems located on roofs when substances that can contaminate stormwater are used. Releases of pollutants must be corrected as soon as they are identified.	Owner or professional	

9-C.7.0. RAINWATER HARVESTING: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Ideally, this practice should be inspected each Spring and Fall by the owner, with an extensive inspection every three years by a qualified third party inspector.

Element of BMP	Potential Problems	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to fix problem	Who Will Address Problem	Comments
Overall (*Every third year*)	A component of the system is leaking or damaged				Make necessary repairs or replace damaged components	Professional	
	Water is flowing out of the overflow pipe during the design rainfall or smaller storm (1-1.5 inch)				Check for clogging or damage and ensure the pump is operating correctly. Ensure water is being used at the volume for which the system was designed.	Owner or professional	
	Electric system is flawed				Make any necessary repairs/adjustments	Professional	
	Sediment accumulation in cistern exceeds 5% of the design volume				Remove sediment	Professional	
	Excessive overhanging vegetation/trees present				Trim branches back to meet standards	Professional	
Captured roof area (*Twice a year*)	Excess debris/sediment on the rooftop				Remove debris immediately	Owner or professional	
Gutter system (*Twice a year*)	Gutters are clogged and water is backed up				Unclog/remove leaves and debris. May need to install gutter screens.	Owner or professional	
	Rooftop runoff is not reaching the gutter system				Correct the positioning or installation of gutters. May need to replace the system	Owner or professional	
	Algae growth				Do not allow sunlight to penetrate cistern. Treat the water to remove/prevent algae	Owner or professional	
	Mosquitoes are present in the cistern				Check screens for damage and repair/ replace. Treat with mosquito dunks if necessary	Owner or professional	
	Lids are damaged. Be sure to check vents and screens on inflow and outflow spigots and mosquito screens				Repair immediately. Ensure that lid damage has not led to any of the aforementioned problems with the cistern	Owner or professional	

Element of BMP	Potential Problems	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to fix problem	Who Will Address Problem	Comments
Screens and filters (*Twice a year*)	Debris/sediment accumulation. Screens are clogged				Find the source of debris and sediment and remedy. Clear the screen/filter. Replace if necessary	Professional	
Pump (*Twice a year*)	Not operating properly				Check for clogging. Flush if needed. May need to be replaced	Professional	
Pre-screening devices and first flush devices (*Every 3 months*)	Dirty/clogged				Have a professional ensure screens have not caused bacterial growth within the gutters or downspouts. The owner may remove the clean out plug from the first flush device and manually wipe it clean.	Owner or Professional	
Backflow preventer (*Every third year*)	Pressure is uneven and is causing backpressure or back-siphonage				Immediately stop use of the indoor water supplied by the tank and call a professional.	Professional	
Secondary water supply (*Every third year*)	Not operating properly				Consult an expert only	Professional	
Overflow pipe (*Annually*)	Erosion is evident at overflow discharge point, along the filter path/secondary runoff reduction practices				Stabilize immediately. It may be necessary to refer to inspection checklists for other BMPs.	Professional	
	Overflow pipe in poor condition				Repair or replace pipe	Professional	

9-C.8.0. PERMEABLE PAVEMENT: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit**
Number_____
Location_____ **Date BMP Placed in**
Service_____
Date of Last
Inspection_____ **Inspector**
_____
Owner/Owner's
Representative
_____
As-Built Plans available: Y / N

Facility Type: Level 1 _____ Level 2
_____

Ideally, each permeable pavement installation should be inspected in the Spring of each year, especially at large-scale installations.

Elemant of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Contributing Drainage Area	There is excessive trash and debris				Remove immediately.	Owner or professional	
	There is evidence of erosino and/or bare or exposed soil				Stabilize immediately.	Owner or professional	
	There is excessive landscape waste and yard clippings				Remove immediately.	Owner or professional	
Adjacent Vegetation	Trees and shrubs are within 5 feet of the pavement surface				Check that tree roots have not penetrated the pavement and leaf residue has not clogged the pavement. Vegetation that limits access or interferes with the permeable pavement operation must be pruned or removed.	Owner or Professional	
Inlets, Pre-Treatment Cells and Flow Diversion Structures	There is excessive trash, debris or sediment accumulation				Remove immediately	Owner or Professional	
	There is evidence of erosion and / or exposed soil				Stabilize immediately	Owner or professional	
	Evidence of clogging				Clean out sediment or debris. Remove and wash or replace stone, as needed	Professional	
Pavement Surface	Mosquito proliferation				Eliminate standing water and establish vegetation; treat for	Owner or professional	

Elemant of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
					mosquitoes as needed. If sprays are considered, then use a licensed pest controller to apply an approved mosquito larvicide *(only if absolutely necessary).*		
Pavement Surface	There is evidence of erosion and / or bare or exposed soil in grid paver areas				Stabilize immediately. Mow, irrigate and apply organic (not chemical) fertilizer, as needed to keep grass healthy and dense enough to provide filtering while protecting the underlying soil. Remove any grass clippings.	Owner or professional	
	There is loose material (e.g., bark, sand, etc.) stored on the pavement surface				Remove immediately and vacuum sweep the area to prevent clogging the pavement pores.	Professional	
	Pavement is stained and/or clogged or water is ponded, indicating the pavement is not draining properly. Measure the drawdown rate in the observation well for three (3) days following a storm event that exceeds 1/2-inch of rain. If standing water is still observed in the well after three days, this is a clear sign that the pavement is clogged. There are significant amounts of sediment have accumulated between the pavers.				The surface must be kept clean and free of leaves, debris, and sediment by vacuum sweeping (without brooms or water spray) immediately and, otherwise, at a frequency consistent with the use and loadings encountered (at a minimum, annual dry-weather sweeping in the Spring). Where paving blocks are installed, the sweeper must be calibrated so it does *not* pick up the stones between the paver blocks. Following the vacuum sweeping, test pavement sections by pouring water from 5 gallon buckets, to ensure proper drainage.	Professional	
Structural Integrity	There is evidence of surface deteriortation, such as slumping, cracking, spalling or broken pavers.				Repair or replace affected areas, as necessary.	Professional	
Observation Wells	Is each observation well still capped?				Repair, as necessary.	Professional	
Outlet	Outlets are obstructed or erosion and soil exposure is evident below the outlet.				Remove obstructions and stabilize eroded or exposed areas.	Owner or Professional	

9-C.9.0. INFILTRATION PRACTICES: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Facility Type: Level 1 _____ Level 2 _____

Facility Location:
- G Surface
- G Underground

Filtration Media:
- ☐ No filtration (e.g., dry well, permeable pavement, infiltration facility, etc.
- ☐ Sand
- ☐ Bioretention Soil
- ☐ Peat
- ☐ Other: _____

Hydraulic Configuration:
- ☐ On-line facility
- ☐ Off-line facility

Type of Pre-Treatment Facility:
- ☐ Sediment forebay (above ground)
- ☐ Sedimentation chamber
- ☐ Plunge pool
- ☐ Stone diaphragm
- ☐ Grass filter strip
- ☐ Grass channel
- ☐ Other: _____

Ideally, infiltration facilities should be inspected annually. Spill Prevention measures should be used around infiltration facilities when handling substances that contaminate stormwater. Releases of pollutants should be corrected as soon as identified.

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Contributing Drainage Area	There is excessive trash and debris				Remove immediately	Owner or professional	
	There is evidence of erosion and / or exposed soil				Stabilize immediately	Owner or professional	
	Vegetative cover is adequate				Supplement as needed	Owner or professional	
	There are excessive landscape waste or yard clippings				Remove immediately and recycle or compost	Owner or professional	
Pre-Treatment Facility	There is adequate access to the pre-treatment facility				Establish adequate access	Professional and, perhaps, the locality	
	There is excessive trash, debris, or sediment.				Remove immediately	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Pre-Treatment Facility (continued)	There is evidence of erosion and/or exposed soil				Stabilize immediately	Owner or professional	
	There is evidence of clogging (standing water, noticeable odors, water stains, algae or floating aquatic vegetation)				Identify and eliminate the source of the problem. If necessary, remove and clean or replace the clogged material.	Professional	
	There is dead vegetation or exposed soil in the grass filter				Restabilize and revegetate as necessary	Owner or professional	
Inlets	Inlets provide a stable conveyance into facility				Stabilize immediately, as needed.	Owner or professional	
	There is excessive trash/debris/sediment.				Remove immediately	Owner or professional	
	There is evidence of erosion at or around the inlet				Repair erosion damage and reseed or otherwise restabilize with vegetation	Owner or professional	
Embankment, Flow Diversion Structures (e.g., Dikes, Berms, etc.) and Side Slopes	There is evidence of erosion or bare soil				Identify the source of erosion damage and prevent it from recurring. Repair erosion damage and reseed or otherwise restabilize with vegetation	Owner or professional	
	There is excess sediment accumulation				Remove immediately	Owner or professional	
	Water is not detained in the infiltration basin				Check for a breach in the containment structure and repair immediately.	Professional	
	Side slopes support nuisance animals.				Animal burrows must be backfilled and compacted. Burrowing animals should be humanely removed frm area.	Professional	
Maintaining Facility Capacity and Proper Drainage	Look for weedy growth on the stone surface indicating sediment accumulation and potential clogging				Identify and control sources of sediment and debris. Remove sediment and debris in excess of 4" in depth every 2-5 years (or sooner if performance is affected).	Professional	
	Measure the draw-down rate of the observation well for three days following a storm event in excess of 1/2 inches in depth. If standing water is still observed after three days, this is a clear sign that clogging is a problem.				Immediately clear debris from the underdrain. Replace the underdrain if necessary. If needed, regrade and till to restore infiltration capacity (the need for this can be prevented by preventing upstream erosion and subsequent sediment transport to the facility).	Professional	
	There is excessive trash/debris				Remove immediately	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Vegetation	Grass within the practice is overgrown				Grass must be mowed to a height of 4"-9" and grass clippings removed (ideally recycled or composted).	Owner or professional	
	Pioneer trees are sprouting in the base of the facility				Remove trees to prevent roots from puncturing the filter fabric, allowing sediment to enter		
	Vegetation forms an overhead canopy that may drop leaf litter, fruit and other vegetative materials that may cause clogging.				Prune or remove vegetation as necessary	Owner or professional	
Observation Well	Is each observation well still capped?				Repair, as necessary.	Professional	
Outlet	Outlets are obstructed or erosion and soil exposure is evident below the outlet.				Remove obstructions and stabilize eroded or exposed areas.	Owner or Professional	
	Evidence of flow bypassing facility				Repair immediately	Professional	
	There is excessive trash, debris, or sediment at the outlet				Remove immediately	Owner or professional	
Overflow or Emergency Spillway	The pipe or spillway is not effectively conveying excess water to an adequate receiving system				Clear sediment and debris whenever 25% or more of the conveyance capacity is blocked. When damaged pipe is discovered, it must be repaired or replaced immediately. Identify and control sources of erosion damage. Replace or reinforce stone armament whenever only one layer of stone remains.	Professional	
Structural Components	Evidence of structural deterioration				Repair as necessary	Professional	
	Evidence of spalling or cracking of structural components				Repair or replace, as necessary	Professional	
	Grates are in good condition				Repair or replace, as necessary	Owner or professional	
Overall	Access to the Infiltration facility or its components is adequate				Establish adequate access. Remove woody vegetation and debris that may block access. Ensure that manholes, valves and/or locks can be opened and operated.	Professional and, perhaps, the locality	
	There is evidence of standing water				Fill in low spots and stabilize; correct flow problems causing ponding	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Overall (continued)	Mosquito proliferation				Eliminate standing water and establish vegetation; treat for mosquitoes as needed. If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied *only if absolutely necessary*.	Owner or professional	
	Complaints from local residents				Correct real problems	Owner or professional	
	Encroachment on the infiltration area or easement by buildings or other structures				Inform involved property owners of BMPs status ; clearly mark the boundaries of the receiving pervious area, as needed	Owner or professional (and perhaps the locality)	

9-C.10.0. BIORETENTION PRACTICES: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Facility Type: Level 1 _____ Level 2 _____

Facility Location:
- G Surface
- G Underground

Filtration Media:
- ☐ No filtration (e.g., dry well, permeable pavement, infiltration facility, etc.
- ☐ Sand
- ☐ Bioretention Soil
- ☐ Peat
- ☐ Other: _____

Hydraulic Configuration:
- ☐ On-line facility
- ☐ Off-line facility

Type of Pre-Treatment Facility:
- ☐ Sediment forebay (above ground)
- ☐ Sedimentation chamber
- ☐ Plunge pool
- ☐ Stone diaphragm
- ☐ Grass filter strip
- ☐ Grass channel
- ☐ Other: _____

Ideally, Bioretention facilities should be inspected and cleaned up annually, peferably during the Spring. During the first 6 months following construction of a bioretention facility, the site should be inspected at least twice after storm events that exceed 1/2-inch of rainfall. Watering is needed once a week during the first 2 months following installation, and then as needed during the first growing season (April-October), depending upon rainfall. If vegetation needs to be replaced, one-time spot fertilization may be needed, preferably using an organic rather than a chemical fertilizer. Each facility should have a customized routine maintenance schedule addressing issues such as the following: grass mowing, weeding, trash removal, .mulch raking and maintenance, erosion repair, reinforcement plantings, tree and shrub pruing, and sediment removal.

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to fix problem	Who Will Address Problem	Comments
Contributing Drainage Area	Adequate vegetation				Supplement as necessary	Owner or professional	
	There is excessive trash and debris				Remove immediately	Owner or professional	
	There is evidence of erosion and / or bare or exposed soil				Stabilize immediately	Owner or professional	
	There are excessive landscape waste or yard clippings				Remove immediately and recycle or compost	Owner or professional	
	Oil, grease or other unauthorized substances are entering the facility				Identify and control the source of this pollution. It may be necessary to erect fences, signs, etc	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to fix problem	Who Will Address Problem	Comments
Pre-Treatment	There is adequate access to the pre-treatment facility				Establish adequate access	Professional and, perhaps, the locality	
	Excessive trash, debris, or sediment.				Remove immediately	Owner or professional	
Pre-Treatment (continued)	There is evidence of clogging (standing water, noticeable odors, water stains, algae or floating aquatic vegetation, or oil/grease)				Identify and eliminate the source of the problem. If necessary, remove and clean or replace the clogged material.	Professional	
	There is evidence of erosion and / or exposed soil				Stabilize immediately	Owner or professional	
	There is dead vegetation or exposed soil in the grass filter				Restabilize and revegetate as necessary	Owner or professional	
Inlets	Check for sediment build-up at curb cuts, gravel diaphragms or pavement edges that prevent flow from getting into the bed, and check for bypassing.				Remove sediment and correct any other problems that block inflow.	Owner or professional	
	There is excessive trash, debris, or sediment.				Remove immediately	Owner or professional	
	There is evidence of erosion at or around the inlet				Repair erosion damage and reseed or otherwise restabilize with vegetation	Owner or professional	
	Inflow is hindered by trees and/or shrubs.				Remove woody vegetation from points of inflow and directly above underdrains. (Trees and shrubs may be located closer to the perimeter.)	Owner or professional	
Side Slopes (*Annually, after major storms*)	There is evidence of rill or gully erosion or bare soil				Identify the source of erosion damage and prevent it from recurring. Repair erosion damage and reseed or otherwise restabilize with vegetation	Owner or professional	
	There is excess sediment accumulation				Remove immediately	Owner or professional	
	Side slopes support nuisance animals.				Animal burrows must be backfilled and compacted. Burrowing animals should be humanely removed from the area.	Professional	
Vegetation (*monthly*)	Plant composition is consistent with the approved plans and any stakes or wires are in good condition.				Determine if existing plant materials are at least consistent with general Bioretention design criteria and replace inconsistent species.	Professional	
	There should be 75-90% cover (mulch plus vegetation), and the mulch cover				Supplement vegetation and mulch as needed.		

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to fix problem	Who Will Address Problem	Comments
	should be 2-3 inches deep.						

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to fix problem	Who Will Address Problem	Comments
Vegetation (*monthly*) **(continued)**	There is evidence of hydrocarbons or other deleterious materials, resulting in unsatisfactory plant growth or mortality,				Replace contaminated mulch. If problem persists, test soils for hydrocarbons and other toxic substances. If excess levels are found, the soils, plants and mulch may all need to be replaced in accordance with the approved construction plans.	Professional	
	Invasive species or weeds make up at least 10% of the facility's vegetation				Remove invasive species and excessive weeds immediately and replace vegetation as needed.	Owner or professional	
	The grass is too high				Mow within a week. Grass species should be selected that have dense cover, are relatively slow growing, and require the least mowing and chemical inputs. Grass should be from 6-10 inches high.	Owner or professional	
	Vegetation is diseased, dying or dead				Remove and replace. Increase watering, but avoid using chemical fertilizers, unless absolutely necessary.	Professional	
	Winter-killed or salt-killed vegetation is present.				Replace with hardier species.	Owner or professional	
Filter Media (*Annually*)	The filter media is too low, too compacted, or the composition is inconsistent with design specifications				Raise the level, loosen and amend or replace the media, as needed, to be consistent with the state design criteria for Bioretention (85-88% sand 8-12% soil fines 3-5% organic matter in form of leaf compost). Other remediation options are described in the maintenance section of the state design criteria for Bioretention	Professional	
	The mulch is older than 3 years or is otherwise in poor condition				The mulch must be replaced every 2-3 years	Professional	
	There is evidence that chemicals, fertilizers, and/or oil/grease are present				Remove undesirable chemicals from media and facility immediately, and replace mulch or media as needed	Professional	
	There is excessive trash, debris, or sediment.				Remove trash and debris immediately. Check plant health and, without damaging plants, manually remove the sediment, especially if the depth exceeds 20% of the facility's design depth.	Owner or professional	
	There is evidence of concentrated flows, erosion or exposed soil				Identify the source of erosion damage and prevent it from recurring. Repair the erosion damage and reseed or otherwise restabilize with vegetation.	Professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to fix problem	Who Will Address Problem	Comments
Filter Media (*Annually*) **(continued)**	The filter bed is clogged and/or filled inappropriately				Redistribute the soil substrate and remove sediment within 2 weeks.	Professional	
	The topsoil is in poor condition (e.g., the pH level is not 6-7, the composition is inappropriate, etc.)				Ensure a 3-inch surface depth of topsoil consistent with the state design criteria for Bioretention (loamy sand or sandy loam texture, with less than 5% clay content, and organic matter content of at least 2%). If the pH is less than 6.5, spread limestone.	Professional	
Underdrain/ Proper Drainage	The perforated pipe is not conveying water as designed				Determine if the pipe is clogged with debris or if woody roots have pierced the pipe. Immediately clean out or replace the pipe, as necessary.	Professional	
	The underlying soil interface is clogged (there is evidence on the surface of soil crusting, standing water, the facility does not dewater between storms, or water ponds on the surface of basin for more than 48 hours after an event).				Measure the draw-down rate of the observation well for three days following a storm event in excess of 1/2 inches in depth. .After three days, if there is standing water on top but not in the underdrain, this indicates a clogged soil layer. If standing water is both on the surface and in the underdrain, then the underdrain is probably clogged. This should be promptly investigated and remediated to restore proper filtration. Grading changes may be needed or underdrain repairs made. The filter media may need to be raked, excavated and cleaned or replaced to correct the problem. Holes that are not consistent with the design and allow water to flow directly through a planter to the ground must be plugged.	Professional	
Planters	The planter is unable to receive or detain stormwater prior to infiltration. Water does not drain from the reservoir within 3-4 hours of after a storm event.				Identify and correct sources of clogging. Topsoil and sand/peat layer may need to be amended with sand or replaced all together.	Owner or professional	
	The planter has structural deficiencies, including rot, cracks, and failure, or the planter is unable to contain the filter media or vegetation				Make needed repairs immediately.	Owner or professional	
Outlet/ Overflow Spillway	Outlets are obstructed or erosion and soil exposure is evident below the outlet.				Remove obstructions and stabilize eroded or exposed areas.	Owner or Professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to fix problem	Who Will Address Problem	Comments
Outlet/ Overflow Spillway (continued)	There is excessive trash, debris, or sediment at the outlet				Remove immediately, and keep the contributing area free of trash and debris.	Owner or professional	
	Any grates present are in good condition				Repair or replace as necessary	Owner or professional	
Observation Well	Is the observation well still capped?				Repair, as necessary.	Professional	
Overall	Access to the Infiltration facility or its components is adequate				Establish adequate access. Remove woody vegetation and debris that may block access. Ensure that hardware can be opened and operated.	Professional and, perhaps, the locality	
	There is evidence of standing water				Fill in low spots and stabilize; correct flow problems causing ponding.	Owner or professional	
	Mosquito proliferation				Eliminate stangant pools and establish vegetation; treat for mosquitoes as needed. If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied *only if absolutely necessary*.	Owner or professional	
	Complaints from local residents				Correct real problems	Owner or professional	
	Encroachment on the bioretention area or easement by buildings or other structures				Inform involved property owners of BMPs status ; clearly mark the boundaries of the receiving pervious area, as needed	Owner or professional (and perhaps the locality)	

9-C.11.0. DRY SWALES: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Facility Type: Level 1 _____ Level 2 _____

Facility Location:
- G Surface
- G Underground

Filtration Media:
- ☐ No filtration (e.g., dry well, permeable pavement, infiltration facility, etc.
- ☐ Sand
- ☐ Bioretention Soil
- ☐ Peat
- ☐ Other: _____

Hydraulic Configuration:
- ☐ On-line facility
- ☐ Off-line facility

Type of Pre-Treatment Facility:
- ☐ Sediment forebay (above ground)
- ☐ Sedimentation chamber
- ☐ Plunge pool
- ☐ Stone diaphragm
- ☐ Grass filter strip
- ☐ Grass channel
- ☐ Other: _____

Ideally, Dry Swales should be inspected annually in the Spring, triggering such maintenance activities as sediment removal, spot revegetation, inlet stabilization, and repairs to check dams, underdrains and outlets.

Element of BMP	Potential Problem	Problem? Y / N			How to Fix Problem	Who Will Address Problem	Comments
Contributing Drainage Area	There is excessive trash and debris				Remove immediately	Owner or professional	
	There is evidence of erosion and / or bare or exposed soil				Stabilize immediately	Owner or professional	
	There are excessive landscape waste or yard clippings				Remove immediately and recycle or compost	Owner or professional	
Pre-Treatment and Flow Spreaders	There is adequate access to the pre-treatment facility.				Establish adequate access	Professional and, perhaps, the locality	
	There is excessive trash, debris, or sediment.				Remove immediately	Owner or professional	
	There is evidence of erosion and / or exposed soil				Stabilize immediately	Owner or professional	
	There is evidence of clogging (standing water, noticeable odors, water stains, algae or floating aquatic vegetation)				Identify and eliminate the source of the problem. If necessary, remove and clean or replace the clogged material.	Professional	

Element of BMP	Potential Problem	Problem? Y / N			How to Fix Problem	Who Will Address Problem	Comments
Pre-Treatment and Flow Spreaders (continued)	There is dead vegetation or exposed soil in the grass filter				Restabilize and revegetate as necessary	Owner or professional	
	The pea gravel diaphragm is at the correct level				Correct the installation, as needed	Professional	
Inlet and Swale Sides and Base	The inlet provides a stable conveyance into the swale				Stabilize immediately, as needed, and clear blockages.	Owner or professional	
	There is excessive trash, debris, or sediment.				Remove immediately	Owner or professional	
	There is evidence of erosion at or around the inlet				Repair erosion damage and reseed	Owner or professional	
Check Dams	A check dam is not functioning properly.				Check upstream and downstream sides of check dams for evidence of undercutting, side cutting or erosion and repair immediately.	Professional	
	There is a large accumulation of sediment or trash/debris behind the check dam.				Remove sediment when the accumulation exceeds 25% of the original Tv. Remove trash/debris and clear blockages of weep holes.	Professional	
Vegetation	Invasive species or weeds make up at least 10% of the facility's vegetation				Remove invasive species and excessive weeds immediately and replace vegetation as needed.	Owner or professional	
	Trees form an overhead canopy that may drop leaf litter, fruit and other vegetative materials that may cause clogging.				Prune or remove vegetation and organic litter as necessary.	Owner or professional	
	Grass height is not consistent with standards.				Dry Swales must be mowed to keep grass at a height of 4" to 9". Remove grass clippings after mowing.	Owner or professional	
	The grass cover is not dense enough or is dead or dying				Increase watering and reseed, if necessary, to maintain 95% turf cover, but avoid using chemical fertilizers unless absolutely necessary. Replace salt-killed vegetation with salt-tolerant species.	Professional	
Filter Media/ Soil	There is evidence that chemicals, fertilizers, and/or oil are present				Remove undesirable chemicals from media and facility immediately, and replace mulch or media as needed	Professional	

Element of BMP	Potential Problem	Problem? Y / N			How to Fix Problem	Who Will Address Problem	Comments
Filter Media/ Soil (continued)	There is excessive trash, debris, or sediment.				Remove trash and debris immediately. Check plant health and, without damaging plants, manually remove the sediment, especially if the depth exceeds 20% of the facility's design depth.	Owner or professional	
	There is evidence of erosion and / or exposed soil				Stabilize immediately	Owner or professional	
	There is evidence that chemicals, fertilizers, and/or oil are present				Remove undesirable chemicals from media immediately, and replace mulch or media as needed	Professional	
Underdrain	The perforated pipe is not conveying water as designed				Determine if the pipe is clogged with debris or if woody roots have pierced the pipe. Immediately clean out or replace the pipe, as necessary.	Professional	
	The underlying soil interface is clogged (there is evidence on the surface of soil crusting, standing water, the facility does not dewater between storms, or water ponds on the surface of basin for more than 48 hours after an event).				Measure the draw-down rate of the observation well for three days following a storm event in excess of 1/2 inches in depth. .After three days, if there is standing water on top but not in the underdrain, this indicates a clogged soil layer. If standing water is both on the surface and in the underdrain, then the underdrain is probably clogged. This should be promptly investigated and remediated to restore proper filtration. Grading changes may be needed or underdrain repairs made.	Professional	
Outlet	Outlets are obstructed or erosion and soil exposure is evident below the outlet.				Remove obstructions and stabilize eroded or exposed areas.	Owner or Professional	
	There is excessive trash, debris, or sediment at the outlet				Remove immediately, and keep the contributing area free of trash and debris.	Owner or professional	
Overall	Access to the Infiltration facility or its components is adequate				Establish adequate access. Remove woody vegetation and debris that may block access. Ensure that hardware can be opened and operated.	Professional and, perhaps, the locality	

Element of BMP	Potential Problem	Problem? Y / N			How to Fix Problem	Who Will Address Problem	Comments
Overall (continued)	Mosquito proliferation				Eliminate stangant pools and establish vegetation; treat for mosquitoes as needed. If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied *only if absolutely necessary*.	Owner or professional	
	Complaints from local residents				Correct real problems.	Owner or professional	
	Encroachment on the swale or easement by buildings or other structures				Inform involved property owners of BMPs status ; clearly mark the boundaries of the receiving pervious area, as needed	Owner or professional (and perhaps the locality)	

9-C.12.0. WET SWALES: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Facility Type: Level 1 _____ Level 2 _____

Facility Location:
- G Surface
- G Underground

Hydraulic Configuration:
- ☐ On-line facility
- ☐ Off-line facility

Filtration Media:
- ☐ No filtration (e.g., dry well, permeable pavement, infiltration facility, etc.
- ☐ Sand
- ☐ Bioretention Soil
- ☐ Peat
- ☐ Other: _____

Type of Pre-Treatment Facility:
- ☐ Sediment forebay (above ground)
- ☐ Sedimentation chamber
- ☐ Plunge pool
- ☐ Stone diaphragm
- ☐ Grass filter strip
- ☐ Grass channel
- ☐ Other: _____

Wet Swales have maintenance needs similar to Dry Swales, although woody wetland vegetation may need to be removed periodically.

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Contributing Drainage Area	There is excessive trash and debris				Remove immediately	Owner or professional	
	There is evidence of erosion and / or bare or exposed soil				Stabilize immediately	Owner or professional	
	There are excessive landscape waste or yard clippings				Remove immediately and recycle or compost	Owner or professional	
Pre-Treatment	There is adequate access to the pre-treatment facility				Establish adequate access	Professional and, perhaps, the locality	
	There is excessive trash, debris, or sediment.				Remove immediately	Owner or professional	
	There is evidence of erosion and / or exposed soil				Stabilize immediately	Owner or professional	
	There is evidence of clogging (standing water, noticeable odors, water stains, algae or floating aquatic vegetation)				Identify and eliminate the source of the problem. If necessary, remove and clean or replace the clogged material.	Professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Pre-Treatment (continued)	There is dead vegetation.				Replace dead vegetation as necessary	Professional	
Inlets	The inlet provides a stable conveyance into the swale				Stabilize immediately, as needed, and clear blockages.	Owner or professional	
	There is excessive trash, debris, or sediment.				Remove immediately	Owner or professional	
	There is evidence of erosion at or around the inlet				Repair erosion damage and reseed	Owner or professional	
Check Dams	A check dam is not functioning properly.				Check upstream and downstream sides of check dams for evidence of undercutting, side cutting or erosion and repair immediately.	Professional	
	There is a large accumulation of sediment or trash/debris behind the check dam.				Remove sediment when the accumulation exceeds 25% of the original Tv. Remove trash/debris and clear blockages of weep holes.	Professional	
Vegetation (*monthly*)	Plant composition is consistent with the approved plans				Replace inconsistent species	Professional	
	Invasive species (e.g., phragmites) are present.				Remove invasive species immediately and replace vegetation as needed.	Professional	
	Vegetation is dead or dying				Replace dead vegetation as needed.	Professional	
Outlet	Outlets are obstructed or erosion and soil exposure is evident below the outlet.				Remove obstructions and stabilize eroded or exposed areas.	Owner or Professional	
	There is excessive trash, debris, or sediment at the outlet				Remove immediately, and keep the contributing area free of trash and debris.	Owner or professional	
Overall	Access to the Infiltration facility or its components is adequate.				Establish adequate access. Remove woody vegetation and debris that may block access. Ensure that hardware can be opened and operated.	Professional and, perhaps, the locality	
	Mosquito proliferation				Eliminate stagnant pools if feasible, and treat for mosquitoes as needed. If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied *only if absolutely necessary*.	Owner or professional	
	Complaints from local residents				Correct real problems.	Owner or professional	
	Encroachment on the swale or easement by buildings or other structures				Inform involved property owners of BMPs status ; clearly mark the boundaries of the receiving pervious area, as needed	Owner or professional (and perhaps the locality)	

9-C.13.0. FILTERING PRACTICES: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit**
Number_____
Location_____ **Date BMP Placed in**
Service_____
Date of Last
Inspection_____ **Inspector**

_____
Owner/Owner's
Representative

As-Built Plans available: Y / N

Facility Type: Level 1 _____ Level 2

Facility Location:
- G Surface
- G Underground

Filtration Media:
- ☐ No filtration (e.g., dry well, permeable pavement, infiltration facility, etc.
- ☐ Sand
- ☐ Bioretention Soil
- ☐ Peat
- ☐ Other: _____

Hydraulic Configuration:
- ☐ On-line facility
- ☐ Off-line facility

Type of Pre-Treatment Facility:
- ☐ Sediment forebay (above ground)
- ☐ Sedimentation chamber
- ☐ Plunge pool
- ☐ Stone diaphragm
- ☐ Grass filter strip
- ☐ Grass channel
- ☐ Other: _____

An inspection and clean-up should be scheduled annually to remove trash and floatables that accumulate in the pre-treatment celss and filter bed. Frequent sediment cleanouts in the dry and wet sedimentation chambers are recommended every 2-3 years to maintain the function and performance of the filter. If the filter treats runoff from a hotspot, crews may need to test the filter bed media before disposing of the media and trapped pollutants. If the filter does not treat runoff from a hotspot, the media can be safely disposed by either land application or land filling, without prior testing.
***Warning:** If the filtering facility has a watertight cover; be careful regarding the possibility of flammable gases within the facility. Care should be taken lighting a match or smoking while inspecting facilities that are not vented. If the filtering facility is in a completely enclosed vault, the **OSHA Confined Space Entry** procedures must be followed.*

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Contributing Drainage Area	Adequate vegetation				Supplement as necessary	Owner	
	There is excessive trash and debris				Remove immediately	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
and Side Slopes	There is evidence of erosion and / or bare or exposed soil				Stabilize immediately	Owner or professional	
	There are excessive landscape waste or yard clippings				Remove immediately and recycle or compost	Owner or professional	
Pre-Treatment	There is adequate access to the pre-treatment facility				Establish adequate access	Professional and, perhaps, the locality	
	Excessive trash, debris, or sediment.				Remove immediately	Owner or professional	
Pre-Treatment (continued)	There is evidence of erosion and / or exposed soil				Stabilize immediately	Owner or professional	
	There is dead vegetation.				Replace dead vegetation as necessary	Professional	
	Perimeter turf (or a grass filter strip) is too high.				Mow at least 4 times a year to keep the grass at a height of 4" to 9". Remove grass clippings after mowing.	Owner or professional	
	There is evidence of oil, grease,clogging (standing water, noticeable odors, water stains, algae)				Identify and eliminate the source of the problem. If necessary, remove and clean or replace the clogged material.	Professional	
Inlets	The inlet provides a stable conveyance into the swale				Stabilize immediately, as needed, and clear blockages.	Owner or professional	
	There is excessive trash, debris, or sediment.				Remove immediately	Owner or professional	
	There is evidence of erosion at or around the inlet				Repair erosion damage and reseed	Owner or professional	
Sedimentation Chambers	Sediment or debris accumulations are excessive				Clean out the wet and dry sedimentation chambers	Professional	
Filter Media	If facility takes longer than 48 hours to drain or filter media is discolored, the media is probably clogged				Replace the top sand layer of an enclosed filter (typically done every 5 years). Till or aerate the surface to improve infiltration and grass cover of an open filter (also typically done every 5 years.		
Oil and Grease	Evidence of filter surface clogging				Clean or replace filter media, as necessary.	Professional	
Underdrain	The underdrain is not conveying water as designed				To determine if the pipe is clogged, measure the draw-down rate of the observation well for three days following a storm event in excess of 1/2 inches in depth. .After three days, if there is standing water on top but not in the underdrain, this indicates a clogged sand layer that must be replaced. If standing water is both on the surface and in the	Professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
					underdrain, then the underdrain is probably clogged. Immediately clean out the pipe manually or, if needed, use a high-pressure hose. Replace the underdrain if it is structurally damaged.		
Observation Well (*every 2 years*)	Is the observation well still capped?				Repair, as necessary.	Professional	
Outlet	The outlet provides stable conveyance				Remove blockages and stabilize, as needed.	Professional	
	Evidence of flow bypassing facility				Repair immediately	Professional	
	Outlets are obstructed or erosion and soil exposure is evident below the outlet.				Remove obstructions and stabilize eroded or exposed areas.	Owner or Professional	
Structural Components	Evidence of structural deterioration				Repair as necessary	Professional	
	Evidence of spalling or cracking of structural components				Repair or replace, as necessary	Professional	
	Grates are in good condition				Repair or replace, as necessary	Owner or professional	
Pump (where applicable)	Catalog cuts and wiring diagram for pump available				If missing, obtain replacements	Owner	
	Waterproff conduits for wiring appear to be intact				Repair as necessary	Professional	
	Panel box is well marked				If not, mark it correctly	Professional	
	No evidence of pump failure (excess water in pump well, etc.)				Repair as necessary	Professional	
Overall	Access to the facility or its components is adequate.				Establish adequate access. Remove woody vegetation and debris that may block access. Ensure that hardware can be opened and operated.	Professional and, perhaps, the locality	
	Condition of hydraulic control components				Repair, as necessary.	Professional	
	Complaints from local residents				Correct real problems.	Owner or professional	
	Noticeable odors outside facility				Determine source and eliminate it.	Professional	
	Mosquito proliferation				Eliminate stagnant pools if feasible, and treat for mosquitoes as needed. If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied *only if absolutely necessary*.	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
	Encroachment on the filter or easement by buildings or other structures				Inform involved property owners of BMPs status ; clearly mark the boundaries of the receiving pervious area, as needed	Owner or professional (and perhaps the locality)	

9-C.14.0. CONSTRUCTED WETLANDS: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Facility Type: Level 1 _____ Level 2 _____

Hydraulic Configuration:
- ☐ On-line facility
- ☐ Off-line facility

Type of wetland
- ☐ Emergent
- ☐ Forested

Type of Pre-Treatment Facility:
- ☐ Sediment forebay (above ground)
- ☐ Vegetated buffer area
- ☐ Grass filter strip
- ☐ Grass channel
- ☐ Other: _____

During the first 6 months following construction, the wetland should be inspected twice after storm events that exceed 1/2 inch of rainfall. Bare or eroding areas in the CDA or around the wetland buffer should be stabilized immediately with grass cover. Trees planted in the buffer and on wetland islands and peninsulas need to be watered every 3 days for the first month, and then weekly during the remainder of the first growing season (April-October), depending on rainfall. Due to typical vegetation survival problems, it is typical to plan and budget for a round of reinforcement planting after one or two growing seasons. Constructed wetlands should be inspected and cleaned up annually. A wetland professional should inspect the facility every 5 years, especially to determine if there is any significant negative change in the wetland species composition from the design or an otherwise healthy wetland.

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Contributing Drainage Area	Adequate vegetation				Supplement as needed	Owner	
	There is excessive trash and debris				Remove immediately.	Owner or professional	
	There is evidence of erosion and/or bare or exposed soil				Stabilize immediately.	Owner or professional	
	There are excessive landscape waste and yard clippings				Remove immediately and recycle or compost	Owner or professional	
Pre-Treatment	There is adequate access to the pre-treatment facility				Establish adequate access	Professional and, perhaps, the locality	
	There is excessive trash and debris				Remove immediately.	Owner or professional	
	There is evidence of erosion and/or exposed soil.				Immediately identify and correct the cause of the erosion and stabilize the eroded or bare area.	Owner or professional	
	Sediment deposits are 50% or more of forebay capacity.				Dredge the sediment to restore the design capacity; sediment should be dredged from forebays at least every 5 years.	Professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Pre-Treatment (continued)	The sediment marker is not vertical.				Adjust the sediment depth marker to a vertical alignment	Professional	
	There is dead vegetation				Revegetate, as needed	Owner or professional	
Inlets	The inlet provides a stable conveyance.				Stabilize immediately, as needed; clear blockages.	Owner or professional	
	There is excessive trash, debris, or sediment.				Remove immediately	Owner or professional	
	There is evidence of erosion/undercutting at or around the inlet				Repair erosion damage and reseed	Owner or professional	
	There is cracking, bulging, erosion or sloughing of the forebay dam.				Repair and restabilize immediately.	Professional	
	There is woody growth on the forebay dam.				Remove within 2 weeks of discovery.	Professional	
	There is evidence of nuisance animals.				Animal burrows must be backfilled and compacted. Burrowing animals should be humanely removed frm area	Professional	
Vegetation (trees, shrubs, aquatic plants)	Plant composition is consistent with the approved plans				Determine if existing plant materials are at least consistent with the general Constructed Wetland design criteria, and replace inconsistent species.	Professional	
	Invasive species are present.				Remove invasive species immediately and replace vegetation as needed. As a general rule, control of undesirable invasive species (e.g., cattail and Phragmites) should commence when their coverage exceeds more than 15% of a wetland cell area. Although the application of herbicides is not recommended, some types, such as Glyphosate, have been used to control cattails with some success. Extended periods of dewatering may also work, since early manual removal provides only short-term relief from invasive species.	Professional	
	Vegetation is dead or reinforcement planting is needed.				Remove and replace dead or dying vegetation.	Professional	
	Trees planted in the buffer and on wetland islands and peninsulas need watering during the first growing season				Consider watering every 3 days for first month, and then weekly during first year (April – October), depending on rainfall.	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Vegetation (trees, shrubs, aquatic plants) **(continued)**	Practice has become overgrown and is not developing into a mature wetland.				Harvest vegetation periodically if the wetland becomes overgrown or to guide maturing of forested wetlands (typically 5 and 10 years after constr.).	Owner or professional	
Wetland Cells and Pools	Sediment accumulation is 50% or more of capacity.				Dredge the sediment to restore the design capacity	Professional	
	There is evidence of floating debris, sparse vegetative cover, erosion or slumping of side slopes.				Remove debris. Repair and stabilize.	Owner or professional	
	Open water is becoming overgrown.				Harvest the unwanted vegetation.	Professional	
	There is evidence of nuisance animals.				Animal burrows must be backfilled and compacted. Burrowing animals should be humanely removed from the area.		
Riser/Principle Spillway and Low-Flow Orifice(s)	There is adequate access to riser for maintenance.				Establish adequate access	Professional and, perhaps, the locality	
	Pieces of the riser are deteriorating, misaligned, broken or missing.				Repair immediately.	Professional	
	Adjustable control valves are accessible and operational.				Repair, as needed.	Professional	
	Reverse-slope pipes and flashboard risers are in good condition.				Repair, as needed.	Professional	
	There is excessive trash, debris, or other obstructions in the trash rack.				Remove immediately.	Owner or professional	
	Seepage into conduit				Seal the conduit	Professional	
Berm/Dam/ Embankment and Abutments	There is sparse veg. cover, settlement, cracking, bulging, misalignment, erosion rills deeper than 2 inches, or sloughing of the dam.				Repair and restabilize immediately.	Professional	
	There are soft spots, boggy areas, seepage or sinkholes present.				Reinforce, fill and stabilize immediately.	Professional	
	There is evidence of nuisance animals.				Animal burrows must be backfilled and compacted. Burrowing animals should be humanely removed frm area.	Professional	
	There is woody vegetation on the embankment.				Removal of woody species near or on the embankment and maintenance access areas should be done when discovered, but at least every 2 years.		

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Emergency Spillway	There is woody growth on the spillway.				Removal of woody species near or on the emergency spillway should be done when discovered, but at least every 2 years.	Owner or professional	
	There is excessive trash, debris, or other obstructions.				Remove immediately.	Owner or professional	
	There is evidence of erosion/back-cutting				Repair erosion damage and reseed	Owner or professional	
	There are soft spots, seepage or sinkholes.				Reinforce, fill and stabilize immediately.	Owner or professional	
Outlet	The outlet provides stable conveyance from the wetland.				Stabilize as needed.	Professional	
	There are excessive sediment deposits.				Remove sediment.	Professional	
	Released water is causing undercutting, erosion or displaced rip-rap at or around the outlet				Repair, reinforce or replace rip rap as needed, and restabilize.	Professional	
	Woody growth within 5 feet of the outlet pipe barrel.				Prune vegetation back to leave a clear discharge area.	Owner or Professional	
	There is excessive trash, debris, or other obstructions.				Remove immediately.	Owner or professional	
Overall	Access to the facility or its components is adequate.				Establish adequate access. Remove woody vegetation and debris that may block access. Ensure that hardware can be opened and operated.	Professional and, perhaps, the locality	
	Water levels in one or more cells are abnormally high or low.				Clear blockages of the riser or orifice(s) and make other adjustments needed to meet the approved design specifications.	Professional	
	Complaints from local residents				Correct real problems.	Owner or professional	
	Mosquito proliferation				Eliminate stagnant pools if feasible, and treat for mosquitoes as needed. If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied *only if absolutely necessary*. Can also stock the basin with mosquito fish to provide natural mosquito & midge control.	Owner or professional	
	Encroachment on the wetland or easement by buildings or other structures				Inform involved property owners of BMPs status ; clearly mark the boundaries of the receiving pervious area, as needed	Owner or professional (and perhaps the locality)	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Overall (continued)	Safety signage is not adequate.				Provide sufficient, legible safety signage.	Owner or professional	

9-C.15.0. WET PONDS: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Facility Type: Level 1 _____ Level 2 _____

Pond characteristics and functions
(check all that apply)
- ☐ Water quality treatment
- ☐ Extended detention included
- ☐ Channel protection
- ☐ Ties into groundwater
- ☐ Single cell pond
- ☐ Multiple-cell pond system
- ☐ Pond with one or more wetland cells

Hydraulic Configuration:
- ☐ On-line facility
- ☐ Off-line facility

Type of Pre-Treatment Facility:
- ☐ Sediment forebay (above ground)
- ☐ Vegetated buffer area
- ☐ Grass filter strip
- ☐ Grass channel
- ☐ Other: _____

During the first 6 months following construction, the pond should be inspected twice after storm events that exceed 1/2 inch of rainfall. The aquatic benches shuld be planted with emergent wetland species, consistent with the Wet Pond design specifications. Bare or eroding areas in the CDA or around the pond buffer should be stabilized immediately with grass cover. Trees planted in the buffer need to be watered every 3 days for the first month, and then weekly during the remainder of the first growing season (April-October), depending on rainfall. Due to typical vegetation survival problems, it is typical to plan and budget for a round of reinforcement planting during the second growing season after construction. Wet Ponds should be inspected and cleaned up annually.

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Contributing Drainage Area	Adequate vegetation				Supplement as needed	Owner	
	There is excessive trash and debris				Remove immediately.	Owner or professional	
	There is evidence of erosion and/or bare or exposed soil				Stabilize immediately.	Owner or professional	
	There are excessive landscape waste and yard clippings				Remove immediately and recycle or compost	Owner or professional	
Pre-Treatment	There is adequate access to the pre-treatment facility				Establish adequate access	Professional and, perhaps, the locality	
	There is excessive trash and debris				Remove immediately.	Owner or professional	
	There is evidence of erosion and/or exposed soil.				Immediately identify and correct the cause of the erosion and stabilize the eroded or bare area.	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Pre-Treatment (continued)	Sediment deposits are 50% or more of forebay capacity.				Dredge the sediment to restore the design capacity; sediment should be dredged from forebays at least every 5-7 years, and earlier if performance is being affected.	Professional	
	The sediment marker is not vertical.				Adjust the sediment depth marker to a vertical alignment	Professional	
	There is evidence of clogging				Clear blockages of the riser or orifice(s) and make other adjustments needed to meet the approved design specifications	Professional	
	There is dead vegetation				Revegetate, as needed	Owner or professional	
Inlet	The inlet provides a stable conveyance into the pond				Stabilize immediately, as needed, and clear blockages.	Owner or professional	
	There is excessive trash, debris, or sediment.				Remove immediately	Owner or professional	
	There is evidence of erosion/undercutting at or around the inlet				Repair erosion damage and restabilize	Owner or professional	
	There is cracking, bulging, erosion or sloughing of the forebay dam.				Repair and restabilize immediately.	Professional	
	There is woody growth on the forebay dam.				Remove within 2 weeks of discovery.	Professional	
	There is evidence of nuisance animals.				Animal burrows must be backfilled and compacted. Burrowing animals should be humanely removed from the area.	Professional	
	There is more than 1 inch of settlement.				Add fill material and compact the soil to the design grade	Owner or Professional	
	The inlet alignment is incorrect.				Correct immediately.	Owner or Professional	
Vegetation	Plant composition is consistent with the approved plans				Determine if existing plant materials are consistent with the general Wet Pond design criteria, and replace inconsistent species.	Professional	
	Invasive species are present.				Remove invasive species immediately and replace vegetation as needed.	Professional	
	Trees planted in the buffer and on wetland islands and peninsulas need watering during the first growing season				Consider watering every 3 days for first month, and then weekly during first year (April – October), depending on rainfall.	Owner or professional	
	Grass around the facility is overgrown				Mow (at least twice a year) to a height of 4”-9” high and remove grass clippings	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Vegetation (continued)	Vegetation is dead or reinforcement planting is needed.				Remove and replace dead or dying vegetation.	Professional	
Permanent Pool and Side Slopes	There is excessive trash and/or debris.				Remove immediately	Owner or professional	
	There is evidence of sparse vegetative cover, erosion or slumping side slopes.				Repair and stabilize physical damage, and reseed or plant additional vegetation.	Owner or professional	
	There is evidence of nuisance animals.				Animal burrows must be backfilled and compacted. Remove burrowing animals humanely from the area.		
	There is significant sediment accumulation.				Conduct a bathymetric study to determine the impact to design volumes, and dredge if necessary.	Professional	
Riser/Principle Spillway and Low-Flow Orifice(s)	There is adequate access to the riser for maintenance.				Establish adequate access	Professional and, perhaps, the locality	
	Pieces of the riser are deteriorating, misaligned, broken or missing.				Repair immediately.	Professional	
	Adjustable control valves are accessible and operational.				Repair, as needed.	Professional	
	Reverse-slope pipes and flashboard risers are in good condition.				Repair, as needed.	Professional	
	There is evidence of clogging				Clear blockages of the riser or orifice(s) and make other adjustments needed to meet the approved design specs.	Professional	
	Seepage into conduit				Seal the conduit	Professional	
	There is excessive trash, debris, or other obstructions in the trash rack.				Remove immediately.	Owner or professional	
Dam/ Embankment and Abutments	There is sparse veg. cover, settlement, cracking, bulging, misalignment, erosion rills deeper than 2 inches, or sloughing of the dam.				Repair and restabilize immediately, especially after major storms.	Professional	
	There are soft spots, seepage, boggy areas or sinkholes present.				Reinforce, fill and stabilize immediately.		
	There is evidence of nuisance animals.				Animal burrows must be backfilled and compacted. Burrowing animals should be humanely removed frm area.		
	There is woody vegetation on the embankment.				Removal of woody species near or on the embankment and maintenance access areas should be done when discovered, but at least every 2 years.		

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Overflow/ Emergency Spillway	There is woody growth on the spillway.				Removal of woody species near or on the emergency spillway should be done when discovered, but at least every 2 years.	Owner or professional	
	There is excessive trash, debris, or other obstructions.				Remove immediately.	Owner or professional	
	There is evidence of erosion/backcutting				Repair erosion damage and reseed	Owner or professional	
	There are soft spots, seepage or sinkholes.				Reinforce, fill and stabilize immediately.	Owner or professional	
	Only one layer of stone armoring exists above the native soil.				Reinforce rip-rap or other armoring materials.	Professional	
Outlet	The outlet provides a stable conveyance from the pond.				Stabilize immediately, as needed, and clear blockages.	Owner or professional	
	There is woody growth within 5 feet of the outlet pipe barrel.				Prune vegetation back to leave a clear discharge area.	Owner or Professional	
	There is excessive trash, debris, or other obstructions.				Remove immediately.	Owner or professional	
	There are excessive sediment deposits at the outlet.				Remove sediment.	Professional	
	Discharge is causing undercutting, erosion or displaced rip-rap at or around the outlet.				Repair, reinforce or replace rip rap as needed, and restabilize.	Professional	
Overall	Access to the facility or its components is adequate.				Establish adequate access. Remove woody vegetation and debris that may block access. Ensure that hardware can be opened and operated.	Professional and, perhaps, the locality	
	Fences are inadequate				Collapsed fences must be restored to an upright position. Jagged edges and damaged fences must be repaired or replaced.	Professional	
	Water levels in one or more cells are abnormally high or low.				Clear blockages of the riser or orifice(s) and make other adjustments needed to meet the approved design specifications.	Professional	
	Complaints from local residents				Correct real problems.	Owner or professional	
	Mosquito proliferation				Eliminate stagnant pools and stock the basin with mosquito fish to provide natural mosquito & midge control. Treat for mosquitoes as needed. If spraying, then use mosquito larvicide, (e.g., Bacillus thurendensis or Altoside formulations) *only if absolutely necessary*.	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Overall (continued)	Encroachment on the pond or easement by buildings or other structures				Inform involved property owners of BMPs status ; clearly mark the boundaries of the receiving pervious area, as needed	Owner or professional (and perhaps the locality)	
	Safety signage is not adequate.				Provide sufficient, legible safety signage.	Owner or professional	

9-C.16.0. EXTENDED DETENTION PONDS: O&M CHECKLIST

Inspection Date_____
Project_____ **Site Plan/Permit Number**_____
Location_____ **Date BMP Placed in Service**_____
Date of Last Inspection_____ **Inspector**_____
Owner/Owner's Representative_____
As-Built Plans available: Y / N

Facility Type: Level 1 _____ Level 2 _____

Pond characteristics and functions (check all that apply)
- ☐ Water quality treatment
- ☐ Channel protection
- ☐ Ties into groundwater

Hydraulic Configuration:
- ☐ On-line facility
- ☐ Off-line facility

Type of Pre-Treatment Facility:
- ☐ Sediment forebay (above ground)
- ☐ Vegetated buffer area
- ☐ Grass filter strip
- ☐ Grass channel
- ☐ Other: _____

Ideally, Extended Detention Ponds should be inspected annually. ED Ponds are prone to a high clogging risk at the ED low-flow orifice. Ideally, the orifice should be inspected at least twice a year after initial construction. The constantly changing water levels in ED Ponds make it difficult to mow or manage vegetative growth. The bottom of ED Ponds often become soggy, and water-loving tees such as willows may invade and will need to be managed. Periodic mowing of the stormwater buffer is only required along maintenance rights-of-way and the embankment. The remaining buffer may be managed as a meadow (mowing every other year) or forest. Frequent removal of sediment from the forebay (every 5-7 years, or when 50% of the forebay capacity is filled) is essential to maintain the function and performance of the ED Pond. Sediments excavated from ED Ponds are usually not considered toxic or hazardous, so they can be safely disposed of either by land application of land filling.

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Contributing Drainage Area	Adequate vegetation				Supplement as needed.	Owner	
	There is excessive trash and debris				Remove immediately.	Owner or professional	
	There is evidence of erosino and/or bare or exposed soil				Stabilize immediately.	Owner or professional	
	There is excessive landscape waste and yard clippings				Remove immediately.	Owner or professional	
Pre-Treatment	There is adequate access to the pre-treatment facility				Establish adequate access	Professional and, perhaps, the locality	
	There is excessive trash and debris				Remove immediately.	Owner or professional	
	There is evidence of erosion and/or exposed soil.				Immediately identify and correct the cause of the erosion and stabilize the eroded or bare area.	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Pre-Treatment (continued)	Sediment deposits are 50% or more of forebay capacity.				Dredge the sediment to restore the design capacity; sediment should be dredged from forebays at least every 5-7 years, and earlier, as needed.	Professional	
	The sediment marker is not vertical.				Adjust the sediment depth marker to a vertical alignment	Professional	
	There is evidence of clogging				Clear blockages of the riser or orifice(s) and make other adjustments needed to meet the approved design specifications	Professional	
	There is dead vegetation				Revegetate, as needed	Owner or professional	
Inlet	The inlet provides a stable conveyance into the pond				Stabilize immediately, as needed, and clear blockages.	Owner or professional	
	There is excessive trash, debris, or sediment.				Remove immediately	Owner or professional	
	There is evidence of erosion/undercutting at or around the inlet				Repair erosion damage and restabilize	Owner or professional	
	There is cracking, bulging, erosion or sloughing of the forebay dam.				Repair and restabilize immediately.	Professional	
	There is woody growth on the forebay dam.				Remove within 2 weeks of discovery.	Professional	
	There is evidence of nuisance animals.				Animal burrows must be backfilled and compacted. Burrowing animals should be humanely removed from the area.	Professional	
	There is more than 1 inch of settlement.				Add fill material and compact the soil to the design grade	Owner or Professional	
	The inlet alignment is incorrect.				Correct immediately.	Owner or Professional	
Vegetation	Plant composition is consistent with the approved plans				Determine if existing plant materials are consistent with the general Wet Pond design criteria, and replace inconsistent species.	Professional	
	Invasive species are present.				Remove invasive species immediately and replace vegetation as needed.	Professional	
	Trees planted in the buffer and on wetland islands and peninsulas need watering during the first growing season				Consider watering every 3 days for first month, and then weekly during first year (April – October), depending on rainfall.	Owner or professional	
	Grass around the facility is overgrown				Mow (at least twice a year) to a height of 4”-9” high and remove grass clippings.	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Vegetation (continued)	Vegetation is dead or reinforcement planting is needed.				Remove and replace dead or dying vegetation.	Professional	
Permanent Pool and Side Slopes	There is excessive trash and/or debris.				Remove immediately	Owner or professional	
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	Pieces of the riser are deteriorating, misaligned, broken or missing.				Repair immediately.	Professional	
	Adjustable control valves are accessible and operational.				Repair, as needed.	Professional	
	Reverse-slope pipes and flashboard risers are in good condition.				Repair, as needed.	Professional	
	Seepage into conduit				Seal conduit	Professional	
	There is evidence of clogging				Clear blockages of the riser or orifice(s) and make other adjustments needed to meet the approved design specs.	Professional	
	There is excessive trash, debris, or other obstructions in the trash rack.				Remove immediately.	Owner or professional	
Dam/ Embankment and Abutments	There is sparse veg. cover, settlement, cracking, bulging, misalignment, erosion rills deeper than 2 inches, or sloughing.				Repair and restabilize immediately, especially after major storms.	Professional	
	There are soft spots, seepage, boggy areas or sinkholes.				Reinforce, fill and stabilize immediately.		
	There is evidence of nuisance animals.				Animal burrows must be backfilled and compacted. Burrowing animals should be humanely removed from the area.		
	There is woody vegetation on the embankment.				Removal of woody species near or on the embankment and maintenance access areas should be done when discovered, but at least every 2 years.		

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Overflow/Emergency Spillway	There is woody growth on the spillway.				Removal of woody species near or on the emergency spillway should be done when discovered, but at least every 2 years.	Owner or professional	
	There is excessive trash, debris, or other obstructions.				Remove immediately.	Owner or professional	
	There is evidence of erosion/backcutting				Repair erosion damage and reseed	Owner or professional	
	There are soft spots, seepage or sinkholes.				Reinforce, fill and stabilize immediately.	Owner or professional	
	Only one layer of stone armoring exists above the native soil.				Reinforce rip-rap or other armoring materials.	Professional	
Outlet	The outlet provides a stable conveyance from the pond.				Stabilize immediately, as needed, and clear blockages.	Owner or professional	
	There is woody growth within 5 feet of the outlet pipe barrel.				Prune vegetation back to leave a clear discharge area.	Owner or Professional	
	There is excessive trash, debris, or other obstructions.				Remove immediately.	Owner or professional	
	There are excessive sediment deposits at the outlet.				Remove sediment.	Professional	
	Discharge is causing undercutting, erosion or displaced rip-rap at or around the outlet.				Repair, reinforce or replace rip rap as needed, and restabilize.	Professional	
Overall	Access to the facility or its components is adequate.				Establish adequate access. Remove woody vegetation and debris that may block access. Ensure that hardware can be opened and operated.	Professional and, perhaps, the locality	
	Fences are inadequate				Collapsed fences must be restored to an upright position. Jagged edges and damaged fences must be repaired or replaced.	Professional	
	Water levels in one or more cells are abnormally high or low.				Clear blockages of the riser or orifice(s) and make other adjustments needed to meet the approved design specifications.	Professional	
	Complaints from local residents				Correct real problems.	Owner or professional	
	Mosquito proliferation				Eliminate stagnant pools and stock the basin with mosquito fish to provide natural mosquito & midge control. Treat for mosquitoes as needed. If spraying, then use mosquito larvicide, (e.g., Bacillus thurendensis or Altoside formulations) *only if absolutely necessary*.	Owner or professional	

Element of BMP	Potential Problem	Problem? Y / N	Investigate? Y / N	Repaired? Y / N	How to Fix Problem	Who Will Address Problem	Comments
Overall (continued)	Encroachment on the pond or easement by buildings or other structures				Inform involved property owners of BMPs status ; clearly mark the boundaries of the receiving pervious area, as needed	Owner or professional (and perhaps the locality)	
	Safety signage is not adequate.				Provide sufficient, legible safety signage.	Owner or professional	

9-C.17.0. REFERENCES

Center for Watershed protection (CWP). July, 2008b. *Post-Construction Guidance Manual: Tool 6 – Plan Review, BMP Construction, and Maintenance Checklists*. Ellicott City, MD.

City of Gresham, Oregon. 2003. *Inspection Checklist for Infiltration Systems*. Gresham, OR.

City of Gresham, Oregon. 2003. *Inspection Checklist for Ponds*. Gresham, OR.

Minnesota Pollution Control Agency. September, 2006. *Minnesota Stormwater Manual, Ver. 1.1, Appendix D: Operations and Maintenance Checklists.* St. Paul, MN.

Virginia Department of Conservation and Recreation (DCR). 2009. Various stormwater management BMP specifications. *Virginia Stormwater BMP Clearinghouse* web site: http://www.vwrrc.vt.edu/swc/. Richmond, VA.

Appendix 9-D

FROM THE DRAFTING BOARD TO THE FIELD – DESIGNING BMPs TO FACILITATE AND SIMPLIFY MAINTENANCE

Table of Contents

FIGURES

TABLES

9-D.1.0 INTRODUCTION

Maintenance must be considered throughout the entire stormwater program – from early program policy decisions, to design standards, to the development review process, and, most important, to inspection of BMPs in the field. The following section provides tips on how to tailor design and field procedures to minimize long-term maintenance needs. **Figures 9-D.1 and 9-D.2** show some good and bad examples of design features related to maintenance.

Issues related to BMP location are discussed in **Chapter 6*, Site Planning and Design Considerations***. Typical design issues that have been observed in the field include the following (examples in **Figure 9-D.3**):

- An appropriate BMP selection was made, but the BMP was located so it was not receiving and treating runoff from much of or important parts of the site.
- The BMP's geometry was incorrect (includes the flow path, short-circuiting or bypassing of the treatment mechanism, the residence time of runoff within the BMP, etc.).
- The size of the contributing drainage area (CDA) may have contributed to performance issues.
- The BMP was not sized correctly for the Treatment Volume.
- An incorrect type and depth of media was specified for filters.
- An improper type of pre-treatment was used and/or designed incorrectly.

Among the observed construction issues were the following:

- BMPs were installed differently than called for on the plans.
- Inappropriate types of filter media were used, or the media was installed at incorrect depths.
- The BMP site was not graded properly, resulting in backup of water, excessive erosion and clogging at/around inlets.

POOR EXAMPLES

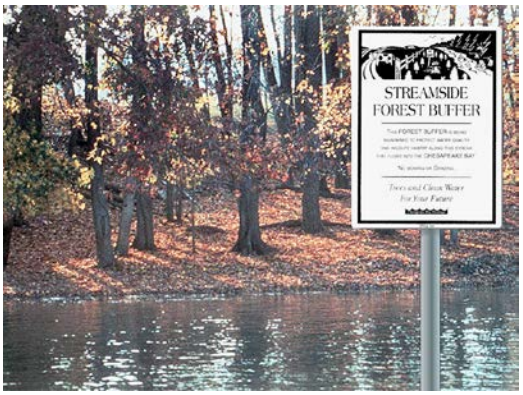
Maintenance Access and Safety:
Steep side slopes make maintenance
difficult and are a safety hazard.

Practice Selection:
Underground BMPs can be out of sight, out
of mind when it comes to maintenance.

No Pretreatment:
Without pretreatment, sediment can enter
The main treatment cell and inlets can erode.

GOOD EXAMPLES

Maintenance Access and Safety:
Shallow side slopes and wetland benches
Are a maintenance and safety feature.



Practice Selection:
Nonstructural BMPs, such as riparian
Restoration, can be low-maintenance
Options and community amenities.

Pretreatment:
Forebays and pretreatment cells help protect
The main pond and ease future maintenance.

Figure 9-D.1. Examples of Poor and Good Maintenance Features Related to the Design Process
Source: CWP 2008

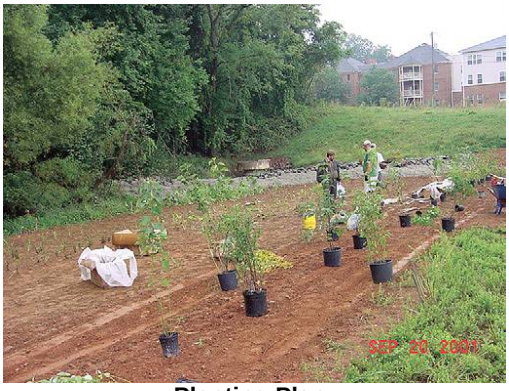
POOR EXAMPLES

Not a Community Amenity:
Unsightly basins in residential areas tend to become nuisances and generate complaints.

GOOD EXAMPLES

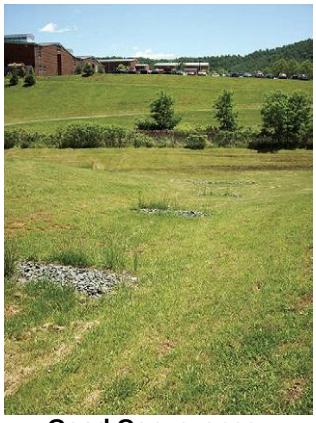
Community Amenity:
Stormwater BMPs, such as this rain garden, can be Designed as amenities, with plantings, interpretive Signage, and public access.

No Planting Plan:
Lack of plants and landscaping make BMPs Unattractive and undesirable to maintain.



Planting Plan:
Plants are being added to this regional basin to Enhance aesthetics and water quality functions.

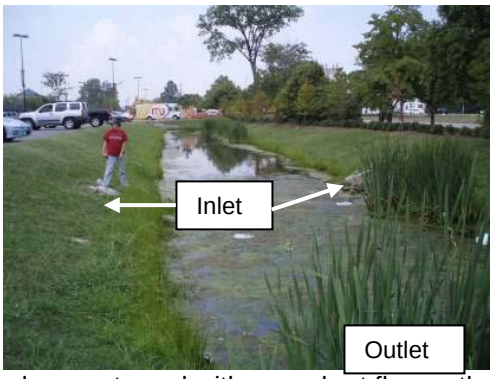
Poor Conveyance:
Improperly designed conveyances become Maintenance problems in the future.



Good Conveyance:
Good conveyance design can include check dams, Vegetation, and adequate channel lining.

Figure 9-D.2. More Examples of Poor and Good Maintenance Features Related to Design Process
Source: CWP 2008

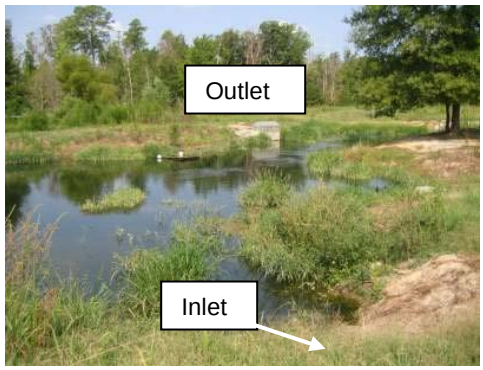
POOR EXAMPLES



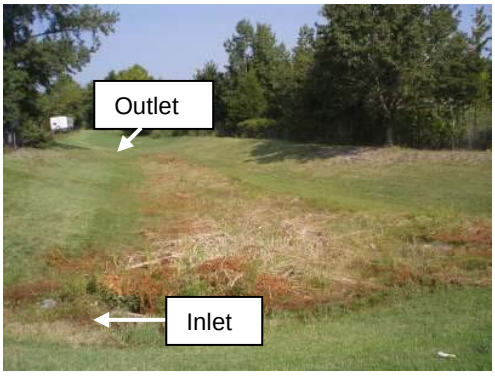
Very long wet pond with very short flow path; shortest flow path is 25' out a total pond length of 315'.

Dry pond with curb cuts very close to outlet, bypassing treatment mechanism.

GOOD EXAMPLES



Wet pond with a good length/width ratio of 3.4:1



Dry pond with length/width ratio = 8.9 and long flow path.

Figure 9-D.3. Examples of Improper BMP Design
(Source: CWP, 2009)

9-D.2.0 AUTHORIZE BMPs THE PROGRAM IS PREPARED TO MAINTAIN

Selecting or approving the right stormwater BMP is the key to ensuring success. Historically, poor selection of BMPs has usually contributed to failures and chronic maintenance problems. Adding nonstructural BMPs – such as conserving natural areas, restoring riparian areas, and disconnecting impervious surfaces – to the list of approved BMPs can also help reduce maintenance costs.

Designing BMPs as multifunctional and aesthetically pleasing facilities promotes maintenance because the public uses and takes interest in these areas. For instance, BMPs that are designed as components of greenways, walking trails, recreation areas, parks, streetscapes, and courtyards have a higher likelihood of receiving maintenance. **Table 9-D.1** outlines some of the key maintenance considerations for various BMPs. Specific design features are addressed in the BMP Specifications on the Virginia Stormwater BMP Clearinghouse web site. These maintenance items are also included in the various BMP Inspection/Maintenance Checklists found in **Appendix 9-C** of this chapter.

Table 9-D.1. Key Maintenance Considerations for Various BMPs

Type of Practice	Overall Maintenance Burden*	Key Maintenance Considerations
Stormwater Ponds	M	• Periodically remove and dispose of sediments • Control woody vegetation on dam • Repair slumping, animal burrows, and seepage associated with dam • Prevent clogging of orifices • Prevent unauthorized access to deep water areas, risers, pipes, and manholes due to safety concerns • Manage vegetation and remove trash • Prevent standing water and mosquito habitat (mostly associated with dry extended detention ponds)
Stormwater Wetlands	M	• See above for ponds • Manage invasive species
Filtering Practices	H	• Prevent clogging of filter surface through frequent cleaning and removal of top layer • Replace filter media when clogged • Pump out sedimentation chamber (e.g., sand filters) • Use confined-space entry procedures for some designs
Infiltration Practices	L - M	• Repair and restore clogged practices • Prevent standing water
Bioretention	M	• Prune, replace, and enhance vegetation • Replace mulch layer frequently • Keep inflow points (e.g., curb cuts) flowing and free of sediment and debris • Replace filter surface or install wick drains, if clogged • Keep underdrain clear • Control impacts from road salt and snow plows in cold climates
Open Channels	M	• Remove sediment periodically • Manage vegetation • Repair erosion after heavy storms • Clear debris from upstream face of check dams, if applicable • Minimize standing water and mosquito habitat
Grass Channels	L - M	• Remove sediment periodically • Repair erosion after heavy storms • Manage vegetation • Minimize standing water and mosquito habitat
Impervious Area Disconnection	M	• Ensure runoff enters pervious area • Remove sediment and debris build-up at points where runoff enters pervious area • Prevent adjacent uses from piping through or around pervious areas • Manage vegetation in pervious area • Maintain any “structural” elements in design: (e.g., level spreaders, energy dissipators, cisterns, rain gardens, etc.)
Sheet flow to Buffer or Open Space (e.g., Preserving Open Space Designed to Intercept and Treat Runoff)	L	• Maintain runoff as sheet flow; repair erosion rills and gullies • Maintain energy dissipators, level spreaders, and other devices to maintain sheet flow • Prevent adjacent uses from piping runoff through open space or buffer
Natural Area Conservation and Restoration	L	• Prevent encroachments, such as dumping yard waste, cutting of trees, clearing and minor encroachments (e.g., sheds, decks, etc.) • Manage invasive species
Proprietary Devices	H	• Conduct frequent to periodic pump-outs and disposal; requires approved disposal method for liquids and solids • Clean or replace cartridges, filter media, etc., depending on device • Repair clogged orifices and by-passes • Use confined-space entry procedures for some designs
* L = low; M = medium; H = high		

Source: CWP 2008

9-D.3.0 DEVELOP BMP-SPECIFIC MAINTENANCE PLANS

Maintenance plans can be incorporated into approved design plans and/or as a component of maintenance agreements. Maintenance plans should identify the responsible party, include a list and schedule for both routine and structural maintenance, and outline any legal mechanisms in place that guide long-term maintenance (i.e., maintenance agreements, easements, and/or deeds of easement). Checklists can assist with typical maintenance tasks for specific categories of BMPs.

9-D.4.0 OVER-SIZE BMP STORAGE

Over-sizing the storage provided in a BMP, as compared to what is required to achieve the BMP's performance targets, will decrease the maintenance frequency in a BMP and, thus, the potential life-cycle costs. It is left to the discretion of municipalities to increase design volume requirements for reduced maintenance frequency (if desired) beyond state stormwater management design requirements.

Extended detention outlets should be designed to allow for the adjustment of detention times. Information about the effects of detention times on water quality enhancement, erosion, and flooding is still evolving, and there may be a need for operational changes in the field to address site-specific or sub-watershed related concerns on a case-by-case basis (especially when sub-watershed planning has not been undertaken).

9-D.5.0 ENSURE LONG-TERM MAINTENANCE ACCESS

As noted in the body of this chapter, site access must be safe and must provide enough room for construction vehicles to perform maintenance. Access should include a dedicated easement that guarantees right-of-entry. These requirements are adequate for filtration and open-channel devices, but the access requirements for underground and above-ground (or open-air) BMPs and surface treatments are slightly different.

For example, for ponds and wetlands it is important that the access paths/roads have adequate width (12-foot minimum is common) and appropriate longitudinal slopes (no steeper than 15% is recommended) to allow maintenance vehicles to enter and turn around.

Programs can also consider surface treatments, such as reinforced turf, that do not increase a site's impervious cover. Maintenance access should extend to the forebay, safety bench, riser/outlet, and emergency spillway. Risers should be located in embankments for access from land, and they should include access to all elements via a manhole and steps.

A maintenance route should be established to allow vehiclular access to BMP. The slope of the access route should accommodate maintenance vehicles (i.e., 4H:1V or flatter). Access to stormwater lot-level controls may not be possible, given the tendency for homeowners to construct fences, gardens, landscaping, etc. If stormwater lot-level or conveyance controls (i.e., enhanced swales or trenches) are proposed along rear lot lines, municipalities can obtain an easement for maintenance. The logistics of maintaining access to such an easement may require considerable effort on the part of the municipality and may not be feasible.

Access to inlet and outlet structures, flow splitters, and by-pass manholes/chambers is also important. Access to an outlet structure for a pond or wetland can be provided by placing the outlet in a chamber in the embankment. Locating the outlet in a chamber enhances the aesthetics of the BMP and reduces the potential for vandalism.

9-D.6.0 PROVIDE RUNOFF PRE-TREATMENT

Pre-treatment refers to the techniques used to provide storage or to filter out coarse materials before stormwater enters the BMP. Proper pre-treatment preserves a greater fraction of the water Treatment Volume over time and prevents large particles from clogging orifices, filter material, and infiltration sites. The specific techniques and volumes of stormwater treated vary according to the type of BMP used.

Common pre-treatment practices include forebays, vegetated filter strips, stone filter strips (for higher velocities), and grass channels. One important consideration is that pre-treatment practices usually require frequent maintenance, such as sediment and trash removal. Practically all of the new BMP Specifications on the Virginia Stormwater BMP Clearinghouse web site require at least one type of pre-treatment. Adequate pre-treatment (oil/grit separators, roof leader filter traps, grass swales, etc.) must be provided for infiltration or filtration BMPs.

9-D.6.1 Forebays

Forebays are applicable for most large end-of-pipe stormwater management facilities (wetlands, wet ponds, dry ponds, infiltration basins). Forebays allow sediment deposits to be concentrated in one location, thereby simplifying maintenance operations. To minimize the potential for scour and re-suspension, forebays may have a deep permanent pool which should be lowered for maintenance. If water will remain in the downstream portion of the facility during maintenance, the berm between the forebay and the rest of the facility will need to be designed as a small dam.

In cases where the forebay releases to a dry pond or infiltration basin, a gravity drainable pipe can be installed in the berm (if physically feasible) to lower the water level of the forebay. In cases where the forebay releases to a wet pond or wetland, there are two options. The water level in the downstream portion of the facility can be lowered until the berm is emergent. Water can then be pumped from the forebay to the downstream portion of the facility until the forebay is dry. Maintaining water in the downstream portion of the facility has the benefit of reducing the impacts to the aquatic and shoreline fringe vegetation. The second option would be to drain both facilities. This could be accomplished by either valved gravity-draining maintenance pipes (if feasible) in both the forebay and the downstream portion of the facility, or by pumping if the facilities cannot be gravity drained.

9-D.6.2 Forebay Maintenance/Drawdown Pipe

A maintenance pipe should be provided to lower the level of a forebay's permanent pool for maintenance. This maintenance pipe should be set near or at the bottom of the facility. If gravity drainage is not feasible, the facility will have to be pumped when maintenance is required. If possible, the pond water level should be lowered early in the morning or overnight to reduce downstream thermal impacts. A geotextile filter bag should be attached to the end of the maintenance pipe to prevent the discharge of sediment from the facility into the receiving waters.

9-D.7.0 PROVIDE A MAINTENANCE BY-PASS

Maintenance may take from several days to a week to perform. Storms during this time should be *routed around* the BMP. The by-pass should be located either at the inlet or slightly upstream of the BMP. In piped systems, this is accommodated by fitting sluice gates to the by-pass pipe and BMP inlet pipe in an upstream manhole. For maintenance operations, the gate to the BMP can be closed and the gate to the by-pass pipe opened. This type of system can also be used for the seasonal operation of infiltration systems that accept roadway runoff.

9-D.8.0 CAREFULLY DESIGN CONVEYANCE SYSTEMS

High flows into, through, and out of the BMP often cause downstream erosion in off-site areas where access may be difficult. This increases the maintenance burden. To minimize erosion, designs should consider inlet and outlet protection, conveyance channels, and seepage prevention.

Conveyance channels can be an important part of the treatment train, but they require special design considerations to minimize maintenance. Otherwise, they can be a maintenance burden, particularly if sediment accumulates within the channel or if flows cause erosion within the channel. Good design can eliminate or at least minimize such problems.

Keep in mind that while check dams or inter-channel berms may be useful flow control devices, they can also increase the maintenance burden, clogging quickly with sediment and debris that must be removed to sustain design flows. Therefore, only use these devices when they are absolutely necessary, because they make the maintenance worker's job more difficult.

9-D.9.0 INCLUDE SAFETY FEATURES

The best overall approach is to select BMPs that include appropriate safety features. Many BMPs do not involve standing water, steep drop-offs, or large risers and barrels, and they should be considered as the best (and safest) options.

When ponds or basins are used, however, the design should incorporate safety features that prevent easy access to confined spaces (e.g., risers and barrels), limit drowning hazards associated with permanent pools of water, and protect the BMP from vandalism.

Many communities use fences to prevent access to ponds or basins. Alternative approaches include the use of mild side slopes, wetland or safety benches, and thick vegetation.

Riser structures can also be used, but methods to prevent vandalism must be implemented. Riser manholes should be locked, and any openings in the riser should be covered with an appropriate trash rack. In addition, the operator valves for pond drains should be chained and locked to prevent unauthorized use.

9-D.10.0 INCLUDE BENCHMARKS AND MARKERS IN THE DESIGN

Benchmarks must be established for tracking and monitoring BMPs. For example, in ponds and wetlands, sediment markers (graded measuring sticks) placed in forebays or permanent pools can be used to consistently measure the depth of sediment during inspections. Similar markers can be used to ensure that the elevation of the permanent pool remains relatively constant over time. Sediment clean-out markers should also be used in underground vaults and in the sediment chambers of sand filters.

9-D.11.0 PLAN FOR SEDIMENT REMOVAL AND DISPOSAL

Removing sediment and debris is a common maintenance item for many types of BMPs. Minor debris removal is relatively simple, but removing large quantities of sediment can be an involved and costly undertaking. Design features should enhance access, as described above, and include features that simplify removal efforts. For example, a pond drain is an important design feature that allows maintenance crews to drain ponds or wetlands before removing accumulated sediment.

Sediment removal is usually the largest single cost of maintaining a BMP facility, so the necessary funds should be allocated in advance. Since sediment removal costs are so site-specific and dependent on disposal plans, it is difficult to provide specific cost estimates. Actual estimates should be obtained from sediment removal contractors during the BMP's design phase, based on the planned situation. The estimates should include the following:

- Mobilization expenses
- Sediment removal expenses
- Material transport expenses (if applicable)
- Disposal expenses (if applicable).

More specific information about sediment removal is provided in **Section 7.4** of this chapter.

9-D.12.0 INCLUDE A PLANTING PLAN

All BMP designs should incorporate appropriate vegetation to improve both function and aesthetics. If designed correctly, planting plans can reduce future maintenance liabilities. Landscaping can help prevent access to ponds by geese and children, stabilize banks, and prevent upland erosion. Ponds may benefit from adjacent trees and shrubs (or on planted tree mounds within wetlands) for shading to reduce ambient water temperatures. Planting plans designed for bioretention should identify and recommend species that can tolerate both wet and dry conditions. Specify plant materials that are native to the area. Such plants will be more vigorous and hardy and less prone to pests and disease in the site environment than non-native plants. This will

minimize the need to replace failing plants. However, all planting plans should specify a care and replacement warranty.

9-D.13.0 REFERENCES

Center for Watershed Protection (CWP). July, 2008. *Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program*. Ellicott City, MD.

Center for Watershed protection (CWP). *Technical Report on Stormwater BMPs in Virginia's James River Basin: An Assessment of Field Conditions & Programs*. Ellicott City, MD.

Appendix 9-E

EXAMPLE OF A METHOD TO ESTIMATE SEDIMENT ACCUMULATION

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9-E.1.0 METHODOLOGY

There is limited data available about the variations in sediment accumulation. Monitoring of new ponds and retrofit ponds (converted ponds in older established areas) indicates a significant difference in sediment buildup for different ponds at different time periods. While sediment accumulation is typically rapid during the construction period, once a catchment area is completely developed and stabilizing vegetation is established, sediment accumulation drops markedly.

A study was done in Ontario, Canada, wherein continuous simulations were performed for end-of-pipe stormwater management facilities to assess the rate of sediment accumulation (OME, 2003). The average annual TSS removal efficiencies with specific volumes of storage were determined using continuous simulations and a sedimentation model. The required maintenance frequency was then determined based on the annual sediment accumulation and resulting annual loss in the facility's storage capacity.

The continuous simulations indicated total suspended solid (TSS) removal efficiencies for different end-of-pipe SWM facilities with varying volumes of storage and different levels of imperviousness. The removal efficiencies were converted into volumes of sediment captured by each type of facility on an annual basis. A set of curves was developed which indicate sediment removal frequency for facility type, storage volume, and level of upstream imperviousness (**Figures 9-D.1 to 9-D.4**).

Sediment accumulation reduces the effective storage volume and the long-term BMP removal efficiency for suspended solids. The theoretical maintenance frequency for sediment removal can be calculated based on the rate of performance reduction with loss in storage volume. The theoretical performance-storage relationship does not account for conditions such as upstream development and inadequate sediment and erosion control. Therefore, predicted maintenance frequencies are only estimates which should be refined based on operational and maintenance experience in the field.

The performance-storage curve becomes asymptotic quickly (i.e., a large increase in storage is required for small improvements in the removal performance). This means that for typical BMP storage volumes there must be a considerable loss in storage to reduce the effectiveness of the facility. The study concluded that 5% was an acceptable reduction in TSS removal efficiency due to gradual sediment accumulation. The time frame to reduce the storage to the point that the annual removal efficiency was 5% less than the original efficiency indicates the maintenance frequency for that BMP with that particular storage volume.

If excess storage is provided to lengthen the intervals between required maintenance, the time frame to reduce the efficiency by 5% below the original efficiency should be calculated. For example, if 80% removal is required, but excess storage is provided resulting in an initial efficiency of 85%, then maintenance would be required when the performance efficiency was reduced by 10% (i.e., 5% below the original target efficiency).

As noted above, a set of curves was developed which indicates sediment removal frequency for facility type, storage volume, and level of upstream imperviousness, based on the continuous simulation results and the requirement for maintenance with a 5% loss in TSS removal performance (**Figures 9-D.1 to 9-D.4**). These curves are best-fit lines based on linear regression over a period of 50 years. They indicate that there is a linear relationship between maintenance frequency and BMP storage volume. These graphs can be used to determine the required sediment removal frequency given the BMP type, storage volume, and imperviousness level of catchment basin.

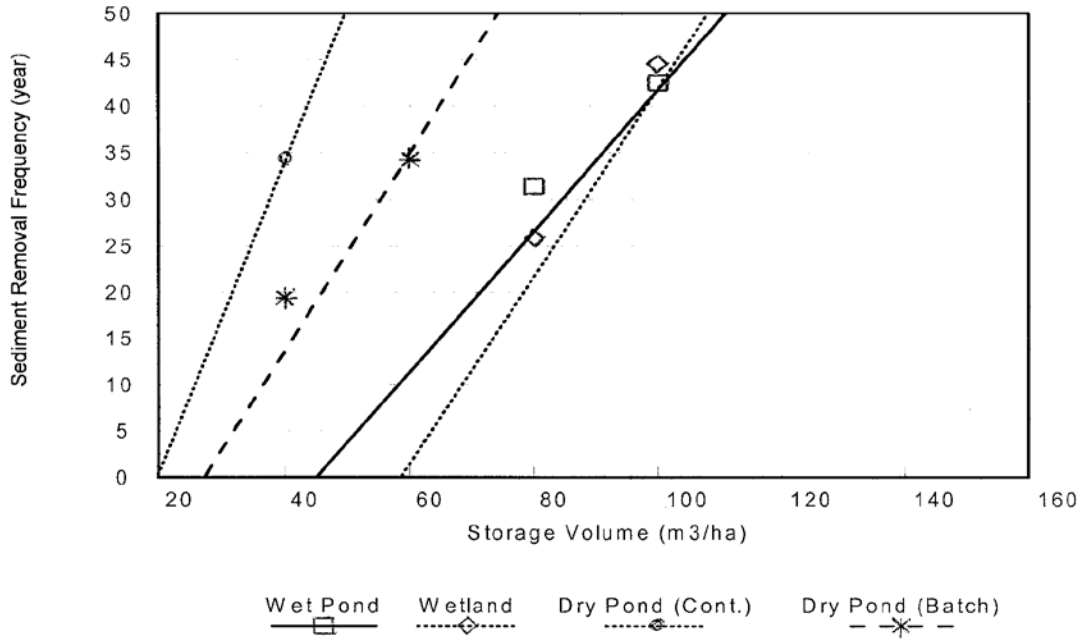

Figure 9-D.1. Storage Volume vs. Sediment Removal Frequency – for 35% Impervious Catchments
Source: Ontario, Canada, Stormwater Management Planning & Design Manual, 2003

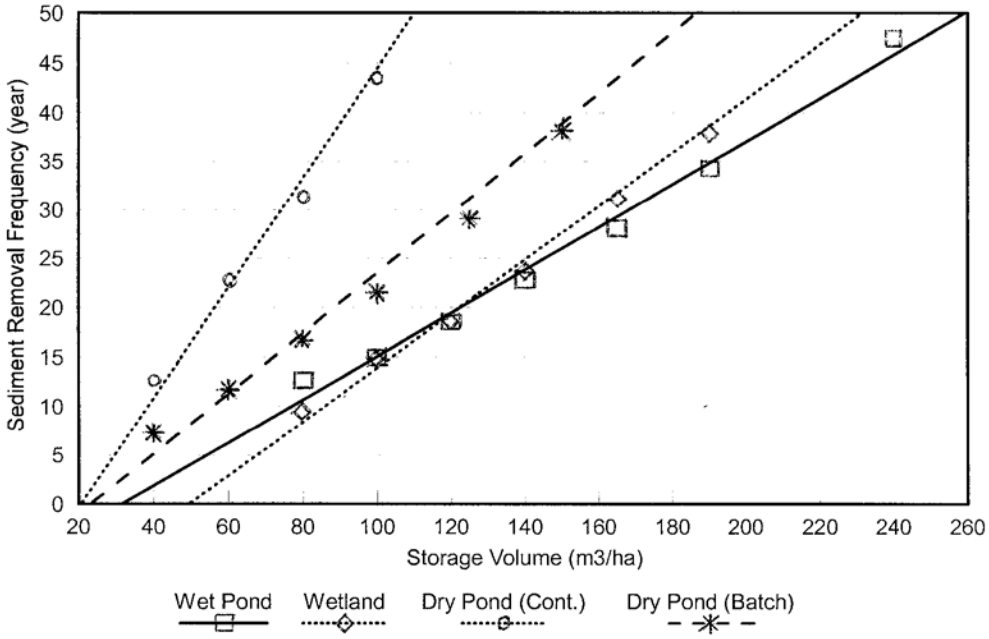

Figure 9-D.2. Storage Volume vs. Sediment Removal Frequency – for 55% Impervious Catchments
Source: Ontario, Canada, Stormwater Management Planning & Design Manual, 2003

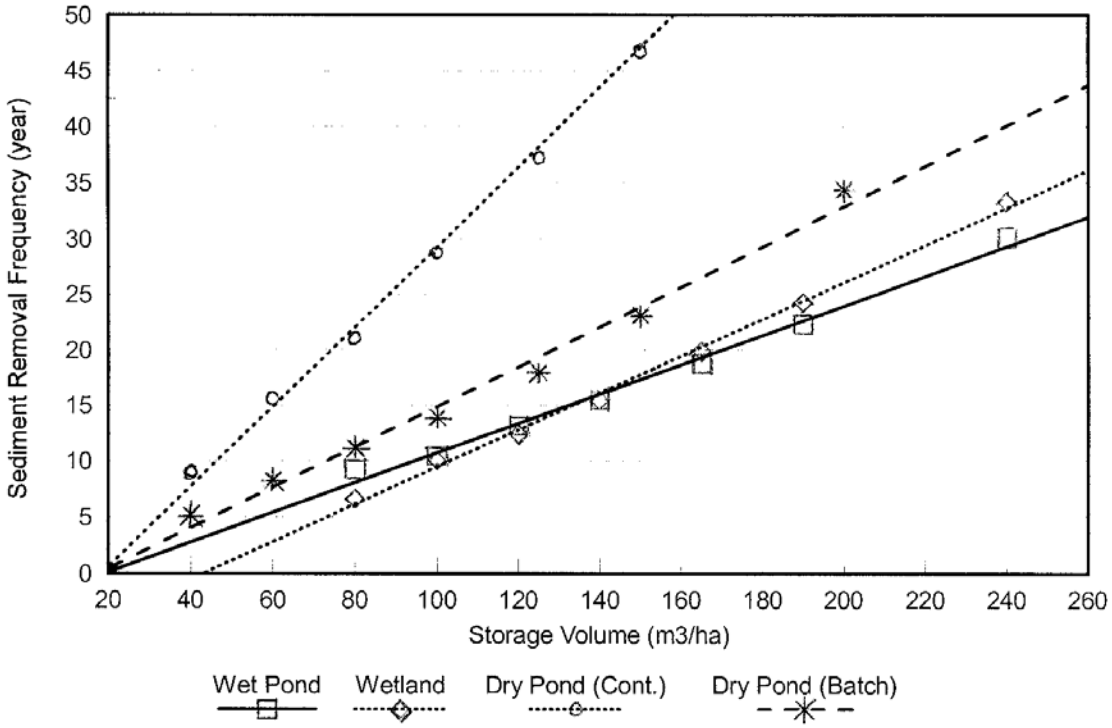

Figure 9-D.3. Storage Volume vs. Sediment Removal Frequency – for 70% Impervious Catchments
Source: Ontario, Canada, Stormwater Management Planning & Design Manual, 2003

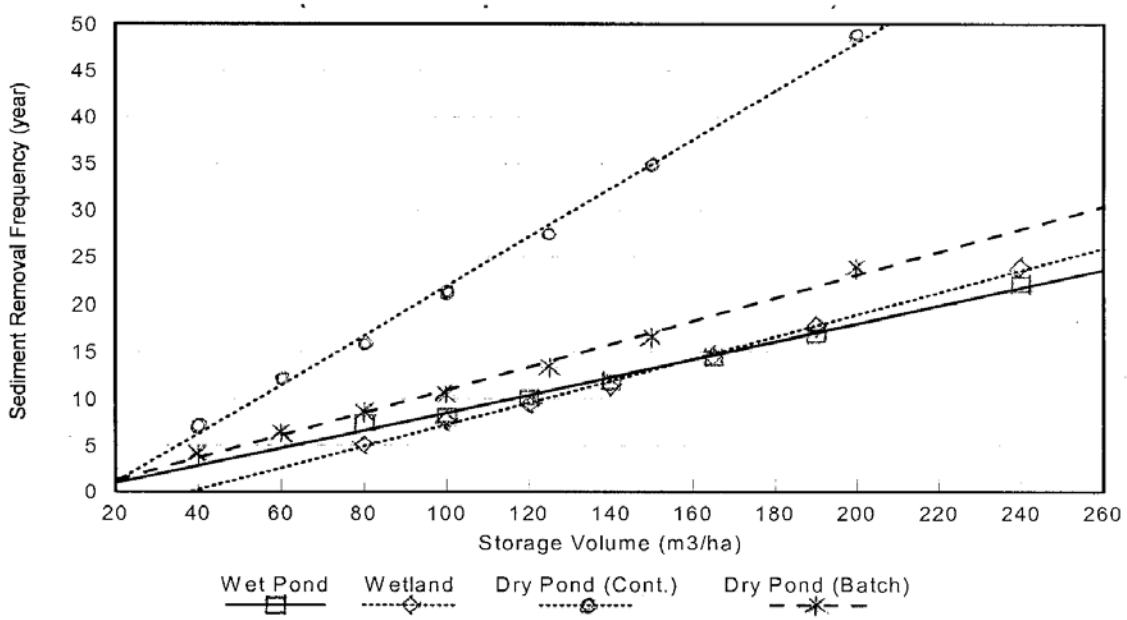

Figure 9-D.4. Storage Volume vs. Sediment Removal Frequency – for 85% Impervious Catchments
Source: Ontario, Canada, Stormwater Management Planning & Design Manual, 2003

Figures 9-D.1 to 9-D.4 also indicate that increased storage capacity increases the maintenance interval (i.e., less frequent maintenance is required). These curves are based on the assumption of a 5% loss of performance and should not be used for over-sized facilities. In order to allow users to calculate the required maintenance frequency for an over-sized BMP, annual suspended solids loadings in runoff from catchments with different levels of imperviousness and estimated sediment density are provided in **Table 9-D.1**.

The values of suspended solids loadings in **Table 9-D.1** were derived from U.S. Environmental Protection Agency (EPA) Stormwater Management Model (SWMM) simulation results. They are only intended to be used as estimates for planning purposes. The density of suspended solids was based on a review of the literature of stormwater sediment characteristics and recent pond sediment removal data. The following methodology should be used to calculate the maintenance frequency if storage for the BMP is over-sized (this calculation can be easily automated in a spreadsheet format):

1. Determine the appropriate total suspended solid (TSS) removal efficiency based on the level of protection required for the receiving stream.

2. Subtract 5% to obtain the target maintenance removal efficiency.

3. Determine the projected TSS removal efficiency based on the storage volume provided.

4. Calculate the loss in removal performance and loss in storage for each year, based on the removal performance at the start of the year, the suspended solids loading rate, and the sediment density. The removal efficiency at the start of the next year will be based on the resulting available storage volume at the end of the year. These calculations are continued

until the removal efficiency of the facility at the start of the year is equal to the target maintenance removal efficiency.

Alternatively, a conservative estimate of annual sediment accumulation in a BMP may be obtained by multiplying the annual loading of suspended solids (m^3/yr.) (see **Table 9-D.1**) by the initial removal efficiency for the particular BMP. Using this method, a calculation is made to determine how long it takes to accumulate the difference in storage volumes between the initial storage and the target maintenance storage volume.

Table 9-D.1. Annual Sediment Loadings

Catchment Imperviousness	Annual Loading (kg/ha)	Wet Density (kg/m^3)	Annual Loading (m^3/ha)
35%	770	1,230	0.6
55%	2,300	1,230	1.9
70%	3,495	1,230	2.8
85%	4,680	1,230	3.8

Source: USEPA Stormwater Management Model (SWMM) simulation results

9-E.2.0 REFERENCES

Ontario Ministry of the Environment (OME). March, 2003. *Stormwater Management Planning and Design Manual*.