

LYCOMING COUNTY MUNICIPAL OFFICIALS STORMWATER MANAGEMENT HANDBOOK



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SECTION 1.0 – INTRODUCTION

Urban development has a profound influence on the quality of Pennsylvania’s waters. To start, development dramatically alters the local hydrologic cycle (see Figure 1). The hydrology of a site changes during the initial clearing and grading that occurs during construction. Trees, meadow grasses, and agricultural crops that had intercepted and absorbed rainfall are removed while natural depressions that had temporarily ponded water are graded to a uniform slope. Cleared and graded sites erode, are often severely compacted, and percolation and evapotranspiration rates are reduced.

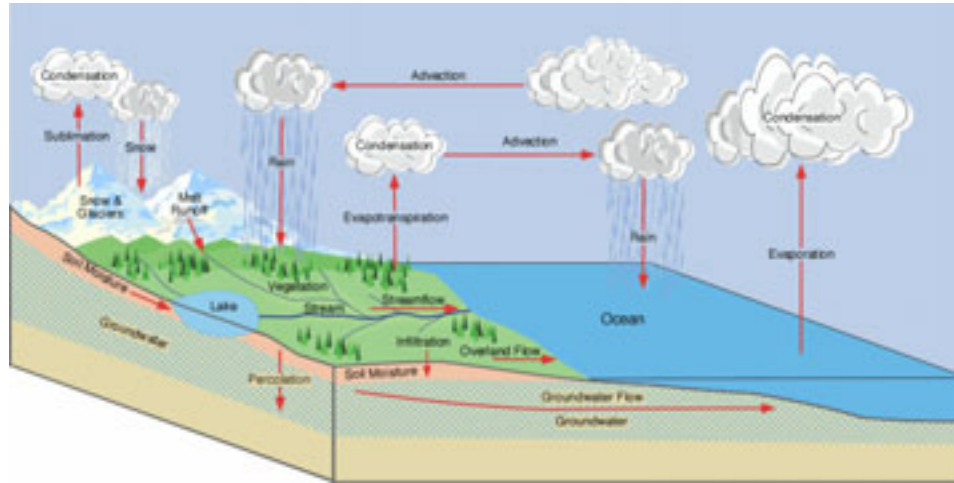


Figure 1: Hydrologic cycle

This situation worsens after construction. Rooftops, roads, parking lots, driveways, and other impervious surfaces no longer allow rainfall to soak into the ground. Consequently, most rainfall is converted directly to stormwater runoff. For example, a one acre parking lot can produce 16 times more stormwater runoff than a one acre meadow each year (Schueler, 1994). The increase in stormwater runoff can be too much for the existing natural drainage system to handle. As a result, the natural drainage system is often “improved” to rapidly collect runoff and quickly convey it away (using curb and gutter, enclosed storm sewers, and lined channels). The stormwater runoff is subsequently discharged to downstream waters such as streams, reservoirs, lakes or estuaries.

SECTION 2.0 – DECLINING WATER QUALITY

Impervious surfaces accumulate pollutants deposited from the atmosphere, leaked from vehicles, or windblown from adjacent areas. During storm events, these pollutants quickly wash off and are rapidly delivered to downstream waters. Some common pollutants found in urban runoff stormwater include nutrients, organic carbon, suspended solids, bacteria, hydrocarbons, pesticides, chlorides, trace metals, and debris.

SECTION 3.0 – INTENT OF THE ACT 167 PLAN

The Lycoming County Act 167 Plan (the Plan) is intended to provide stormwater management guidance on a watershed level, in urban planning and the design of land developments. A primary goal of the Act, and thus the Plan, is to prevent future problems resulting from uncontrolled runoff. These problems include flooding, erosion, sedimentation, landslides, pollution, and debris often carried by stormwater runoff. A basic premise of the Act is that those activities that generate additional runoff, increase its velocity, or change the direction of its flow, shall be responsible for controlling and managing the runoff so that these changes will not cause harm to other persons or property either now or in the future.

SECTION 4.0 – SUGGESTED BEST MANAGEMENT PRACTICES

Developers, municipalities, and others who disturb or develop the land will undoubtedly have an impact on stormwater runoff. It is the responsibility of these parties to mitigate any negative impacts caused by the disturbance. The Plan suggests the use of sound site planning and a number of structural and nonstructural best management practices (BMPs) to mitigate the negative impacts of stormwater runoff from land disturbances and developments.

Table 1, on page 12, lists suggested BMPs that are described in the Plan and detailed in the Pennsylvania Stormwater Management Best Management Practices Manual (PA BMP Manual).

SECTION 5.0 – LAND USE TECHNIQUES TO MINIMIZE EFFECTS OF DEVELOPMENT

The surest way to minimize disturbances to sensitive areas and natural features is to avoid them. However, absolute avoidance is not always practical. In understanding the critical functions of sensitive areas, site planners and designers, in cooperation with local zoning officials and plan reviewers, can implement planning concepts that both protect the resource and add to the value of the development and the community. Some of the concepts most useful for protecting sensitive areas include:

- *Setbacks and buffers* between development and sensitive areas allow for treatment of increased stormwater runoff.
- *Open space development* clusters the construction activity onto less-sensitive areas without substantially affecting the gross density of development.
- *Zoning overlay districts* identify sensitive areas that generally are unsuitable for intense development.

- *Conservation easements* preserve sensitive habitats.
- *Development designed to fit site topography* minimizes the amount of grading on the site.
- *Construction phasing* minimizes the time of disturbance by limiting grading activities only to areas where development is imminent.

Section 5.1 – Setbacks and Buffers

A *setback* is the area between intensive development (e.g. buildings, parking lots, roads) and a protected area, such as a wetland. Setbacks are necessary for:

- Controlling the peripheral effects of development
- Protecting developments
- Providing access for maintenance



For example, a highway or parking lot built directly on the edge of a high-quality wetland may adversely affect water quality and wildlife habitat. Setback requirements for structures, particularly adjacent to streams, reflect the fact that streams naturally meander and expand over time. Placing structures in the natural path of a meandering stream virtually guarantees that expensive stabilization measures will be needed in the future.

Only limited activities are recommended for approval in a *setback*. These types of activities include minor improvements, such as walkways, foot bridges, and observation decks; roadways necessary for crossing a waterbody; maintenance and repair of existing roads and utilities; and the establishment of landscaped lawns or parks. In general, major modifications to the land surface shall be avoided in setbacks.

Limiting activities in a *floodway* to appropriate uses is similar to a setback requirement. A floodway is the part of the floodplain, centered on the stream, that will convey most of the flow during a high water event. Appropriate uses exclude most buildings and structures. However, other uses that are allowed may adversely affect water quality and habitat. These include:

- Parking lots
- Roadways parallel to the waterbody

- Garages and storage sheds
- Treatment plants and pumping facilities

Within a setback, a *buffer strip* is the transitional vegetated area closest to the waterbody or wetland. The purposes of a buffer are to:

- Minimize erosion
- Stabilize the stream bank or lakeshore
- Filter runoff pollutants from adjacent developments
- Preserve fish and wildlife habitat
- Screen manmade structures and preserve aesthetic values
- Provide access for maintenance or trails



Section 5.2 – Open Space Development

One of the best site planning techniques for minimizing the disturbance of sensitive areas and natural drainage features while still allowing for reasonable economic use of the land is to incorporate open space developments. This type of development maintains the gross density of the site, but clusters the development (roads, buildings, parking lots, manicured landscape) onto only a part of the site, thereby protecting sensitive areas with no loss in the number of lots. In open space development, natural areas are maintained. Although the individual lots are smaller, often the impression is one of lower density because of the intermixing of natural areas and green space in the developed areas.

Section 5.3 – Zoning Restrictions

Some local governments place explicit zoning restrictions on wetlands, stream corridors, and woodlands. Using this approach, a municipality may identify sensitive areas on its zoning map.

Section 5.4 – Conservation Easements

A conservation easement incorporates legal provisions into a property deed that limits the use of the property. Conservation easements allow for the continued private ownership of the land but restrict land uses to current uses or to non-damaging activities.

Section 5.5 – Development Designed to Fit Site Topography

Too often sites are extensively graded to create site topography to fit a plan that was designed in the office rather than creating a design for the site to avoid the need for major changes in the contours. Not only is mass grading expensive, it requires stripping, stockpiling, and replacing the top soil. This results in compaction of the soil, destruction of natural drainage ways, and loss of site diversity. By varying lot sizes and building styles, the need for mass grading can be reduced.

SECTION 6.0 – EFFECTIVE SITE PLANNING

Avoiding the adverse effects of development requires the preparation of a comprehensive watershed management program. In addition to structural and non-structural BMPs, elements of a watershed management program include growth management, land-use planning, long-term operation and maintenance, public education, and dedicated funding sources. This section presents techniques for effective site planning that can enhance land values while reducing the impacts on water-resources.

Section 6.1 – Some Important Principles of Effective Site Planning

A central premise of site planning is that effective site layouts and designs can minimize the need for conventional structural measures such as storm sewers and detention basins, thereby reducing the cost of development.

Effective site planning can be facilitated by municipal ordinances that are flexible in allowing innovative layouts to avoid intruding on sensitive areas or natural drainage features. Similarly, it is helpful if both developers and local governments are open to alternative landscaping approaches, which can both lower long-term maintenance costs and reduce offsite impacts.

A truly comprehensive program for watershed management involves extensive planning by state and local government and coordination with potential developers. A comprehensive program might include:

- Permanently protecting sensitive resources through site acquisition or negotiation and development of conservation easements, and use of Transfer of Development Rights (TDRs).
- Preserving buffers adjacent to waterbodies and wetlands.
- Effectively mitigating the effects of development by using innovative approaches, such as wetland mitigation banking.


- Exploiting opportunities for restoring degraded waterbodies or wetlands.

Site planning and design is a complicated process involving many components. Traditional site planning must address zoning, densities, setbacks, access, traffic patterns, and a number of other factors. Additional site planning elements necessary to meet water-quality and sensitive-area objectives include:

- Identifying and mapping sensitive areas, soils, and natural drainage features early in the planning process.
- Developing a plan for avoiding or enhancing sensitive areas.
- Developing a plan for preserving or enhancing the site's natural hydrologic and pollution filtering functions.

Section 6.2 – Resources for Identifying and Mapping Sensitive Areas

The site planner should identify sensitive areas by using existing mapping resources available from federal, state, regional, and local entities. Below is a partial list of resources:

- US Fish and Wildlife Service – National Wetlands Inventory (NWI) Maps 
- US Department of Agriculture, Natural Resources Conservation Service – County Soil Surveys and Hydric Soils List
- US Geological Survey – Topographic maps, hydrologic atlas series maps, and information on the occurrence of karst bedrock in Pennsylvania
- Federal Emergency Management Agency (FEMA) – Flood insurance study maps
- Aerial photos (with planimetric features)

Additional resources may be available from the County Planning Commissions, Municipal Offices, and County Conservation Districts.

In general, the materials from these resources are appropriate only for preliminary planning. In most cases, the delineation of sensitive areas can be determined only through on-site evaluation. In particular, proper identification of wetlands requires knowledge of hydrology, soil, and vegetation as mandated by current wetland-determination methods. A wetlands scientist may be consulted to provide standard field identification practices to identify wetland and riparian plant and animal species and hydrologic conditions of wetlands and wetlands soil.

Section 6.3 – Important Functions of Sensitive Areas and How They Are Best Protected

Certain sensitive areas have unique hydrologic, habitat, or pollution-mitigation characteristics that warrant special protection. These areas are particularly susceptible to damage during site development.

Stream Corridors

Stream corridors include waterways and adjacent riparian lands. Natural waterways provide habitat for fish, aquatic plants, and benthic (bottom dwelling) organisms. Development in waterways may destroy aquatic organisms and introduce large loads of sediment and pollutants into the waterways. Modifying waterways may also destroy the physical features essential to a good habitat, including stable stream banks and bottom substrates, pools and riffles, meanders, and spawning areas.

Vegetated riparian land adjacent to streams stabilizes the stream bank, filters pollutants from storms and floods, and provides habitats for a variety of amphibians, aquatic birds, and mammals that depend on proximity to water for their life functions.

A filter strip or riparian forested buffer should be preserved or created along the banks of streams where possible. Furthermore, consideration should be given to establishing setbacks for intensive development (e.g., buildings, parking lots, roadways). This will minimize the potential for sediment releases to streams as well as maintain the corridor to achieve flood control, water quality, and habitat enhancement objectives. If a development site contains a channelized stream, the best interest of both the developer and the aquatic resource may be served by restoring the stream corridor.

Shorelines of ponds, lakes, and wetlands provide many of the same functions as riparian stream corridors. Stable vegetated shorelines are particularly valuable in preventing erosion caused by wave action.

Wetlands

Wetlands provide unique habitats for both plants and wildlife, including many sensitive and endangered species. As a consequence, wetlands are valued for aesthetic and recreational reasons. Wetlands also provide valuable flood storage, groundwater recharge, and pollutant-filtering functions.

Wetlands are widely scattered throughout Pennsylvania and are commonly encountered on development sites. Protecting the natural functions of wetlands is a critical element of the site planning process. Moderate to high-quality wetlands are very difficult to replace and avoidance is recommended. If the site contains scattered, small, low-quality wetlands, which are more readily replaced, mitigating the wetlands at a central location may be more appropriate.

Steep Slopes and Highly Erodible Soils

From an erodibility standpoint, the definition of steep can vary depending on surface soil type and underlying geology. In general, caution is warranted on slopes exceeding 25 percent.

Disturbing steep slopes may cause instability of the soil. Runoff velocities from exposed steep slopes may result in destructive and unsightly erosion, denuded slopes that may be difficult to revegetate, and sediment deposition in sensitive areas both on and off the site.

A general rule to be followed in site development is to minimize the extent and time of disturbance. Stabilizing vegetation should be protected to the maximum extent practicable and disturbed areas should be immediately revegetated.

Karst Bedrock

Karst bedrock areas are underlain by bedrock containing soluble minerals. Karst areas develop voids and solution channels as groundwater gradually dissolves the bedrock. In these terrains, groundwater flow can be extremely rapid and unpredictable. Furthermore, the concentration of runoff may stimulate the formation of sinkholes. Rapid degradation of groundwater resources may result when sediment or pollutant-laden runoff percolates into karst bedrock aquifers.

Before introducing site alterations, which could result in concentrated runoff or ponded water, the presence or absence of carbonate bedrock should be established. If carbonate geology is present, a professional geologist or civil engineer should be consulted to determine whether sinkhole activity is likely. The United States Geological Survey is a good source of information on karst bedrock in Pennsylvania. If an area is prone to sinkhole development, site drainage should be planned to minimize the concentration of runoff. This can be accomplished by reducing the hydraulic connectivity of impervious surfaces and by the use of filter strips. Channels or ponds should be lined.

BMPs for the recharge of groundwater in karst areas provide infiltration opportunities over a very large area. Examples are filter strips, large bioretention facilities, and permeable pavement. These practices mimic the natural process by which rainfall enters the subsurface. Point sources of infiltration, such as infiltration trenches or dry wells, should be avoided.

Section 6.4 – Preserving Natural Hydrologic Conditions

Natural hydrologic conditions and pollutant-filtering mechanisms may be altered radically by poor development practices. Deleterious activities include excessive impervious surfaces, destroying existing drainage paths, and changing local topography. A traditional drainage approach of development is to remove runoff from the site as quickly as possible.

An alternative approach is to minimize post-development runoff rates by minimizing needs for artificial conveyance and storage. To maintain pre-development hydrologic conditions, areas should be preserved for infiltrating water directly into the ground and to hold runoff on the ground surface to evaporate or infiltrate. Beneficial results may include stable baseflows in receiving streams, improved groundwater recharge, reduced flood flows, reduced pollutant loads, and reduced costs of conveyance and storage.

Preserving natural hydrologic conditions requires both implementing appropriate stormwater BMPs and practicing alternative site design. Alternative site design measures are essential for limiting increases in the volume of runoff and managing runoff quality. Site design practices include minimizing impervious surface area, reducing hydraulic connectivity, preserving natural drainage features, and protecting natural depression storage. A well-designed site will contain a mix of structural BMPs and site design BMPs.

Section 6.5 – Reducing or Disconnecting Impervious Surface Areas

Minimizing impervious surface areas is one of the most effective ways to preserve predevelopment hydrology. Techniques include:

Reducing Building Setbacks

Reducing building setbacks reduces driveway and entry walk lengths and is most readily accomplished along low-traffic streets where traffic noise is not a problem.

Reducing Street Widths

Street widths can be reduced by either eliminating onstreet parking or by reducing roadway widths. Municipal planners and traffic designers are beginning to favor narrower neighborhood streets for reasons unrelated to stormwater that include lower maintenance costs, traffic calming, and creation of friendlier residential environments.

Limiting Sidewalks to One Side of the Street

A sidewalk on one side of the street may suffice in low-traffic neighborhoods. The lost sidewalk can be replaced with recreational trails that follow back-of-lot lines. When appropriate, trails may be constructed using pervious materials.

Open Space Developments

Open space developments can reduce the amount of impervious area for a given number of lots.



Using Permeable Paving Materials

These materials include permeable interlocking concrete paving blocks or porous bituminous concrete. Such materials should be considered as alternatives to conventional pavement surfaces, especially for low-use surfaces such as driveways, overflow parking lots, and emergency access roads.

Reducing the Hydraulic Connectivity of Impervious Surfaces

Impervious surfaces are significantly less of a problem with respect to runoff pollutants if they are not directly connected to an impervious conveyance system (such as storm sewer).

Routing Roof Runoff Over Lawns

Roof runoff can be easily routed over lawns in most site designs. This practice discourages direct connections of downspouts to storm sewers or parking lots. By routing roof drains and crowning driveways to drain onto the lawn, the lawn is used as a filter strip.

Reducing the Use of Storm Sewers

By reducing the use of storm sewers for draining streets, parking lots, and backyards, the potential for infiltrating and filtering runoff from impervious surfaces can be greatly enhanced. This requires greater use of swales and may not be practical for some development sites.

Section 6.6 – Preserving Natural Drainage Features

Protecting natural drainage features, particularly vegetated drainage swales and channels, is desirable because of their ability to infiltrate, attenuate flows, and to filter pollutants. One method of preserving natural drainage features is to use open space development to avoid disturbing major swales.

Section 6.7 – Protecting Natural Depressional Storage Areas

Depressional storage areas have no surface outlet or drain very slowly following a storm event. They can commonly be seen as ponded areas in farm fields during the wet season or after large runoff events. Traditional development practices eliminate these depressions by filling or draining.

SECTION 7.0 – BMP MAINTENANCE

Although the actual time during which a BMP facility performs its function is relatively brief (during and immediately following a storm event), it must constantly be able to perform. The facilities must be available at all times because of the random nature of rainfall events and the impracticality of inspecting facilities and maintaining them immediately before a storm event. In addition, pollutant-removal efficiencies will decline over time if BMPs are not adequately maintained. For a BMP to be operational, the BMP operator must establish and implement a comprehensive, regularly scheduled maintenance program.

BMP maintenance starts by ensuring thorough inspections during construction. Proper construction of the BMP will reduce the future maintenance needs of the facility. The owner/operator needs to develop inspection checklists, and convey to the inspectors the importance of scheduling and coordinating the BMP construction with other site activities. For more information on BMP maintenance requirements, refer to the PA BMP Manual.

The following criteria will guide the responsible parties in maintenance of BMPs. Table 1 on page 12 provides a brief description of numerous BMPs. The criteria include access and maintenance easements, routine inspection of outlet structures, sediment disposal, maintenance agreements, and other maintenance aspects specific to wet ponds, extended detention dry ponds, and infiltration trenches.



TABLE 1 – Summary of BMP Descriptions

BMP	TYPE (structural/vegetative)	PERMANENCE (permanent/temporary)
Bioretention	vegetative	permanent
Constructed Treatment Wetland	structural	permanent
Critical-Area Planting	vegetative	permanent
Filter Bag	structural	temporary
Filter Strip	vegetative	permanent
Grass Swale	vegetative	permanent
Infiltration Trench and Dry Well	structural	permanent
Permanent Vegetative Stabilization	vegetative	permanent
Permeable Paving System	structural	permanent
Pond, Dry	structural	permanent
Pond, Wet	structural	permanent
Riparian Corridor Mgt.	vegetative	permanent
Riparian Forested Buffer	vegetative	permanent
Rooftop Runoff Mgt.	structural	permanent
Sand Filter, Closed	structural	permanent
Sand Filter, Open	structural	permanent
Stream Bank Stabilization	structural / vegetative	permanent
Tree Preservation and Protection	structural	temporary
Trench Plug	structural	permanent
Water Quality Inlets	structural	temporary

Section 7.1 – Overview of BMP Maintenance

Changes in downstream drainage may be too subtle or long in developing to provide adequate warning that the condition of a BMP is deteriorating. By the time problems are apparent, significant damage may have occurred. Often, impacts will not be experienced until the design storm occurs. Failures triggered by large storm events may be as dramatic as washouts, flooding, and erosion of stream banks (NVPDC 1991). Therefore, preventative maintenance is essential. The components of a maintenance program are listed in Table 2.

TABLE 2 – Components of a Maintenance Program

Routine	Non-routine
✦ Inspection	✦ Bank Stabilization and Erosion Control
✦ Vegetation Management	✦ Sediment Removal
✦ Insect Control	✦ Outlet Structure Maintenance and Replacement
✦ Debris and Litter Control	
✦ Mechanical Components Maintenance	

Although general maintenance tasks can be outlined, actual maintenance needs will vary according to specific site conditions, especially the following:

Visibility of the Facility

The needs and preferences of the surrounding community determine, to a large extent, the type and amount of necessary maintenance for aesthetics.

Landscaping

The maintenance needs of different types of vegetation will vary greatly.

Upstream Conditions

The condition of the watershed upstream of the facility will largely determine the amount of sediment and other pollutants that a facility must manage. For example, erosion problems upstream can dramatically increase the amount of sediment entering a BMP.

Safety

Most tasks can be carried out by non-technical staff or residents quite effectively. However, a program shall take precautions to ensure the safety of anyone maintaining a BMP.

Need for Professional Judgment

Although many maintenance tasks can be undertaken effectively by a non-professional, a professional should be consulted periodically to ensure that all needs of the facility are met.

Financing

A funding mechanism must be established to pay for long-term maintenance, such as removing sediment.

Section 7.2 – Routine Maintenance Needs

Inspections

At a minimum, BMPs shall be inspected annually and after any storm larger than the design storm. A sample inspection checklist is provided in Table 3 on page 15. Not all of the checklist items will apply to every BMP.

Terrestrial Vegetation Maintenance

Grasses and plants incorporated in vegetative BMPs, such as filter strips, grass swales, and bioretention facilities, require attention to ensure a robust stand of vegetation. The development of distressed vegetation, bare spots, and rills are an indication that a BMP is not functioning properly. Some typical causes of BMP failure are:

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

The soil in vegetated areas should be tested biannually and adjustments made to sustain vigorous plant growth with deep, well-developed root systems. Aeration of soils is recommended for filter strips where high sediment accumulation rates exist. Ideally, vegetative covers should be mowed infrequently, allowing them to develop thick stands of tall grass and other plant vegetation.

Aquatic Vegetation Maintenance

An important yet often overlooked aspect of routine maintenance of wet ponds and constructed treatment wetlands, is the need to regularly monitor and manage conditions to promote a healthy aquatic environment. An indicator of excess nutrients (a common problem) is excessive algae growth in the permanent pool of a wet pond. In most cases, these problems can be addressed by encouraging the growth of more desirable aquatic and semi-aquatic vegetation in and around the permanent pool.

Insect Control

Breeding grounds for mosquitoes and other insects can be created by ponded water. The best control technique for wet ponds is to ensure that the permanent pool does not develop stagnant areas. Wet ponds and constructed treatment wetlands should include a source of steady dry weather flow. Prompt removal of floatable debris helps eliminate still surface waters and fountains can be installed to circulate water. In larger ponds, fish that feed on mosquito larvae may be stocked.

Debris and Litter Removal

Regularly removing debris and litter is well worth the effort and can be expected to help with the following:

- Reduce the chance of clogged outlet structures, trash racks, and other facility components
- Prevent possible damage to vegetated areas
- Reduce mosquito breeding habitats
- Maintain facility appearance
- Reduce conditions for surface algae



Maintenance of Mechanical Components

Each type of BMP may have mechanical components that need periodic attention to ensure their continued performance. Valves, sluice gates, fence gates, locks, and access hatches shall be functional at all times.

TABLE 3 – Inspection Checklist

- | |
|--|
| <ul style="list-style-type: none">○ <i>Obstructions of the inlet or outlet device</i>○ <i>Excessive erosion or sedimentation</i>○ <i>Cracking or settling</i>○ <i>Animal burrowing</i>○ <i>Permanently ponded areas in the bottom of an extended detention dry pond or bioretention facility</i>○ <i>Sluggishly draining infiltration devices</i>○ <i>Algae growth, stagnant pools, or noxious odors</i>○ <i>Poor or distressed stands of grass</i>○ <i>Distressed aquatic vegetation</i>○ <i>Deterioration of pipes and conduits</i>○ <i>Deteriorated emergency spillways</i>○ <i>Washouts, bulges, or slumps</i>○ <i>Seepage at the toe of wet ponds or constructed treatment wetlands</i>○ <i>Unstable side slopes and embankments</i>○ <i>Deterioration of downstream channels</i>○ <i>Signs of vandalism</i> |
|--|

Section 7.3 – Non-Routine Maintenance

Bank Stabilization and Erosion Control

The integrity of the banks and bottom of extended detention dry ponds and the visible banks of wet ponds and constructed treatment wetlands must be maintained. Areas of bare soil will erode quickly, clogging the facility and threatening its integrity. Therefore, bare areas must be stabilized as quickly as possible to avoid erosion. Newly seeded areas should be protected with an erosion mat that is securely staked.

Erosion in or around the inlet and outlet of the BMP facility needs to be repaired as soon as possible. Erosion control activities must also extend to areas immediately downstream of the BMP.

The roots of woody growth, such as young trees and bushes, can jeopardize the integrity of an embankment. Consistent mowing of the embankment will control stray seedlings that take root. Woody growth further away from the embankment should not pose a threat to the stability of the embankment and can provide important runoff filtering benefits.

Animal burrows will deteriorate the structural integrity of an embankment. Muskrats in particular will burrow tunnels up to six inches (6") in diameter. Efforts should be made to control excessive animal burrowing. Burrows should be filled as soon as possible.

Sediment Removal – Wet and Extended Detention Dry Ponds

Sediment will gradually accumulate in many BMPs, including wet ponds, extended detention dry ponds, constructed treatment wetlands, bioretention facilities, and grass swales. Constructed treatment wetlands should be designed to accommodate sediment accumulation without the need for sediment removal during the life of the facility. To accommodate the sediment, constructed treatment wetlands have variable-height weirs and should have added embankment freeboard to anticipate sediment accumulations.

For most other BMP applications, accumulated sediment will have to be removed eventually. However, facilities vary so dramatically that no “rules of thumb” exist to guide responsible parties about removing sediment. The specific setting of a BMP will be an important determinant in how often sediment must be removed. Important factors that determine rates of sedimentation are:

- Land uses and condition of the upstream watershed
- Future land-disturbing activities in upstream areas
- Presence of other sediment trapping BMPs in upgradient locations

Removing sediment from swales and bio-retention areas is generally not a significant maintenance concern. However, wet ponds and extended detention dry ponds can be a significant undertaking.

In the absence of site-specific sediment loss computations, sediment removal from ponds should be anticipated as follows:

- Extended detention ponds: Once every 2 to 10 years
- Wet ponds: Once every 5 to 15 years

Sediment removal is usually the single largest cost of maintaining a BMP facility. It is best to plan ahead and set aside the necessary funds in advance.

The sediment removed from a pond must be disposed of. The best solution is to have an onsite area or a site adjacent to the facility, but outside of the floodplain, set aside for the sediment. If such a disposal area is not set aside, transportation and landfill tipping fees can greatly increase the cost.

Disposal of wet sediment is not allowed in many landfills, so the material often must be dried before disposal. This extra step adds to the cost and requires a place where wet material can be temporarily placed to dry. The additional cost of sediment removal for a wet pond is partially offset by the longer interval between dredging cycles.

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 included in all ponds to bypass stormwater flow during maintenance. However, in many wet ponds and extended detention dry ponds, periodic rainfall will maintain the sediment in a soft condition, preventing access by heavy equipment. In these cases, sediment may need to be removed from the shoreline using backhoes, gradalls, or similar equipment.

Sediment Removal – Infiltration Devices

Infiltration devices include infiltration trenches, dry wells, and seepage beds beneath permeable pavements. Infiltration facilities are prone to losing function from clogging by sediment. Therefore, these facilities should be inspected two to four times a year. Frequently, sediment-trapping measures such as filter fabric or a graded sand filter will require routine maintenance. Keeping the sediment filter clean is vital to ensuring the long-term performance of the infiltration trench. Although maintenance must be undertaken more often with infiltration than with other facilities, the costs are significantly less.

For trenches or dry wells, periodic maintenance usually includes removing the top 6 to 12 inches of filter gravel and replacing the filter fabric covering the aggregate reservoir. A layer of clean filter gravel replaces the gravel removed.

Maintenance of permeable pavement systems typically requires sweeping of the surface. All infiltration devices should be provided with standpipes to observe water levels. If an overflow condition occurs, the observation standpipe should be checked to determine the cause. If the device continues to overflow after the sediment filter is repaired, the aggregate stone should be excavated and the facility rebuilt.

Section 7.4 – Maintenance Responsibilities

Safety, cost, and effectiveness of maintenance need to be balanced. Minor landscaping tasks, litter removal, and mowing are tasks appropriate for owners to handle. However, it is often worth while to have a professional do the more difficult tasks. Mowing and handling a wheelbarrow can be dangerous on the sloping embankments of an extended dry pond. Filling eroded areas and soil-disturbing activities, such as resodding or replanting vegetation, also are tasks that a professional landscaping firm might best manage. If not performed properly the first time, not only will the effort have been wasted, but damage may also be done to the facility by creating excessive erosion. Grading and sediment removal are best left to professional contractors. In addition, trained personnel will be able to identify potential problems in the early stages of development when repairs or alterations can be made cost-effectively.

Section 7.5 – Estimating Routine Costs

The routine costs of maintaining a BMP are site specific. Factors that influence costs include the type of development on the site and the landscape of the site. Routine maintenance includes inspections, debris and litter control, mechanical components maintenance, vegetation management, and other routine tasks as determined for the specific facility. Quotations may be obtained from firms experienced with the tasks that are relevant for selected BMPs. If high costs are projected, then modifying the design or using alternative BMPs with lower maintenance costs may be considered.

Section 7.6 – Estimating Non-Routine Costs

Costs for non-routine maintenance of BMPs are also site specific and will vary greatly depending on the size and depth of the facility, the volume of sediment trapped in the BMP, the accessibility of the BMP, and whether or not onsite disposal of the dredged sediment is possible. In general, maintenance costs for both wet and dry ponds are similar unless otherwise noted.

One of the larger fixed costs in dredging a BMP facility is the mobilization and demobilization of the machinery and manpower needed to dredge a BMP. Large wet ponds or flood control dams will often require a waterborne operation during which an excavator or a crane must be mounted to a floating barge and moved into position. For smaller ponds, which can be drained or dredged from the banks, the costs of mobilizing and demobilizing for this type of operation are significantly less.

The cost of physically dredging the sediment from a BMP once mobilization has taken place depends on the total volume of sediment removed. The cost per cubic yard is largely influenced by the depth of the water and the distance between the excavation area and the “staging area” where sediment is transferred for removal. A further consideration is whether the equipment can easily access the bottom of the BMP.

Section 7.7 – Planning Ahead

The costs of maintaining a BMP for the long term can be considerable, particularly if dredging or other non-routine maintenance is required. To lessen the immediate financial impact of the non-routine costs, the party responsible for BMP maintenance should create a sinking fund for this eventuality. For dry ponds, from which sediment must be removed every 2 to 10 years, 10 to 50 percent of the anticipated dredging costs should be collected each year. For wet ponds, which need to be dredged every 5 to 15 years, approximately 6 to 20 percent of the anticipated costs should be accrued per year. Present value of the assessment can include anticipated interest.

Section 7.8 – Access for Maintenance

Access for inspections, maintenance personnel, and equipment must be provided to all areas of a facility that must be observed or maintained. The location and configuration of easements must be established during the design phase, and the facility must be built to design standards. The areas requiring access include the dam embankment, emergency spillway, side slopes, inlets, sediment forebays, riser structures, BMP devices, and pond outlets. To provide access for heavy equipment, a suitable 10-foot-wide roadway in a 20-foot-wide cleared access easement should be provided to the BMP facility. At large or regional facilities, additional easements to both upstream and downstream areas may be required for maintenance access and additional improvements. Furthermore, all-weather roads, access restrictions, and vandalism deterrents should be considered.

Section 7.9 – Maintenance Agreements

An agreement providing for long-term maintenance should accompany any BMP, including ponds, constructed wetlands, bioretention areas, and grass swales. In many cases the agreements will be incorporated into conventional grounds maintenance contracts.

Maintenance agreements should be specific regarding schedules and required tasks such as inspections, routine and non-routine maintenance obligations, and emergency response measures. In addition, the agreement shall include clauses to allow the municipality to conduct the maintenance if the owner/operator fails to inspect and maintain the facility in accordance with an established maintenance schedule. Typical agreements also include indemnification and hold harmless clauses, and are recorded at the County Courthouse.



NOTES

