west virginia department of environmental protection

Stormwater Management Structure Guidance Document

Groundwater/UIC Program

September 2006

Promoting a healthy environment.

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Preface

Stormwater management has become a growing concern in West Virginia as land development and groundwater usage increases. Stormwater runoff from land development and other earth disturbing activities directly impacts the quality of surface and groundwater. The West Virginia Department of Environmental Protection (WVDEP) Groundwater/UIC Program has prepared this guidance document to assist developers, planners and engineers in constructing and maintaining stormwater management structures that protect all waters of the State.

This guidance document provides a variety of acceptable practices for developing stormwater management structures, while allowing engineers and property owners leeway to tailor the designs to best suit their sites.

The information presented in this document is a compilation of discussions among numerous state regulatory agencies, industry, and staff of the WVDEP, published sources, and information from technical seminars and meetings.

I wish to thank the personnel in the Federal and State Government agencies, private companies, experts, my co-workers in the WVDEP, and Marshall University faculty whose expertise, comments and advice have made possible the development of this *Stormwater Management Structure Guidance Document*.

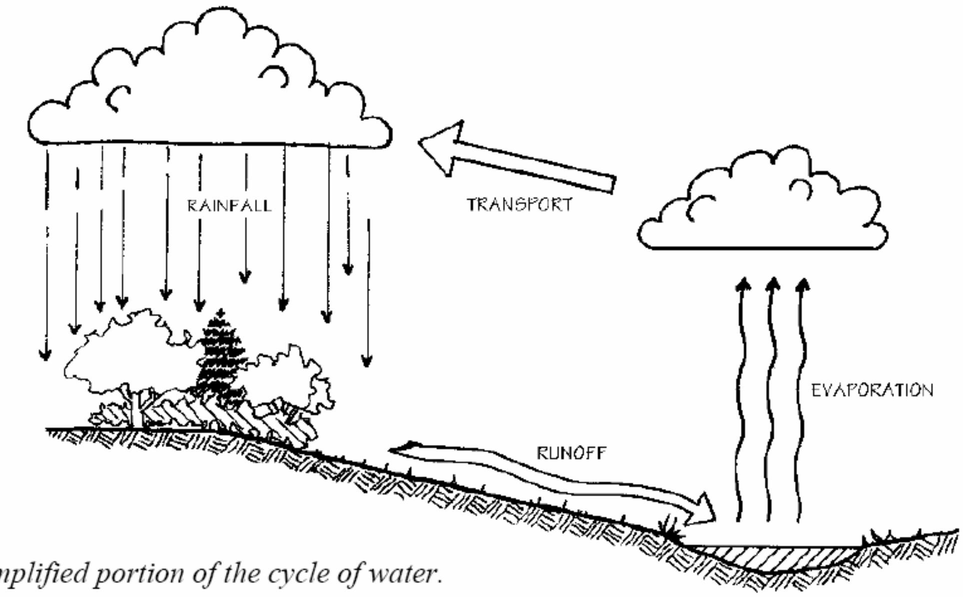
Chad C. Board
Groundwater/UIC Program Manager/Geologist

This guidance document is available for purchase from the West Virginia Department of Environmental Protection's Groundwater Program or is available at no cost online at:

http://wvdep.org
Offices
Division of Water and Waste Management
Groundwater/UIC
Stormwater Management Structure Guidance Document

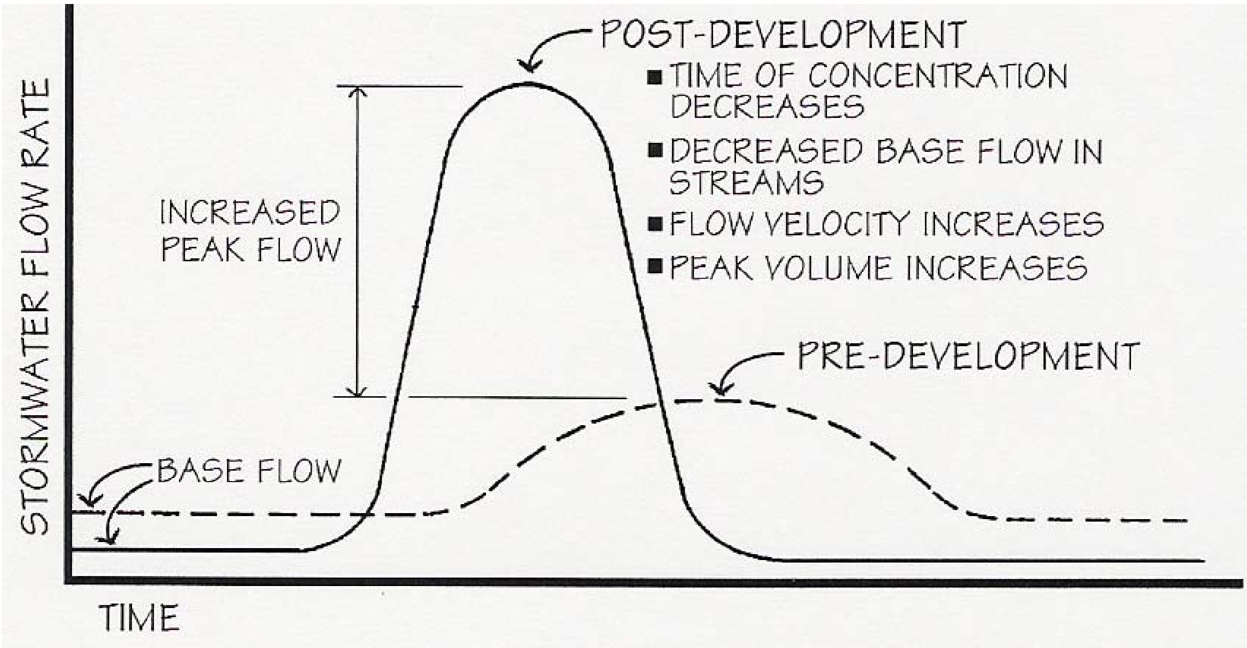
Introduction

Stormwater is a natural part of the hydrologic cycle. Land alteration directly affects this cycle and increases the amount of surface runoff that must be temporarily stored and treated through the use of Best Management Practices (BMPs). The purpose of this *Stormwater Management Structure Guidance Document* is to protect the Waters of the State while offering the most effective BMPs for stormwater management structures, such as infiltration rates, suitable separation distances from the bottom of the structure to the seasonal high groundwater table, and acceptable lateral separation from nearby potable water wells.

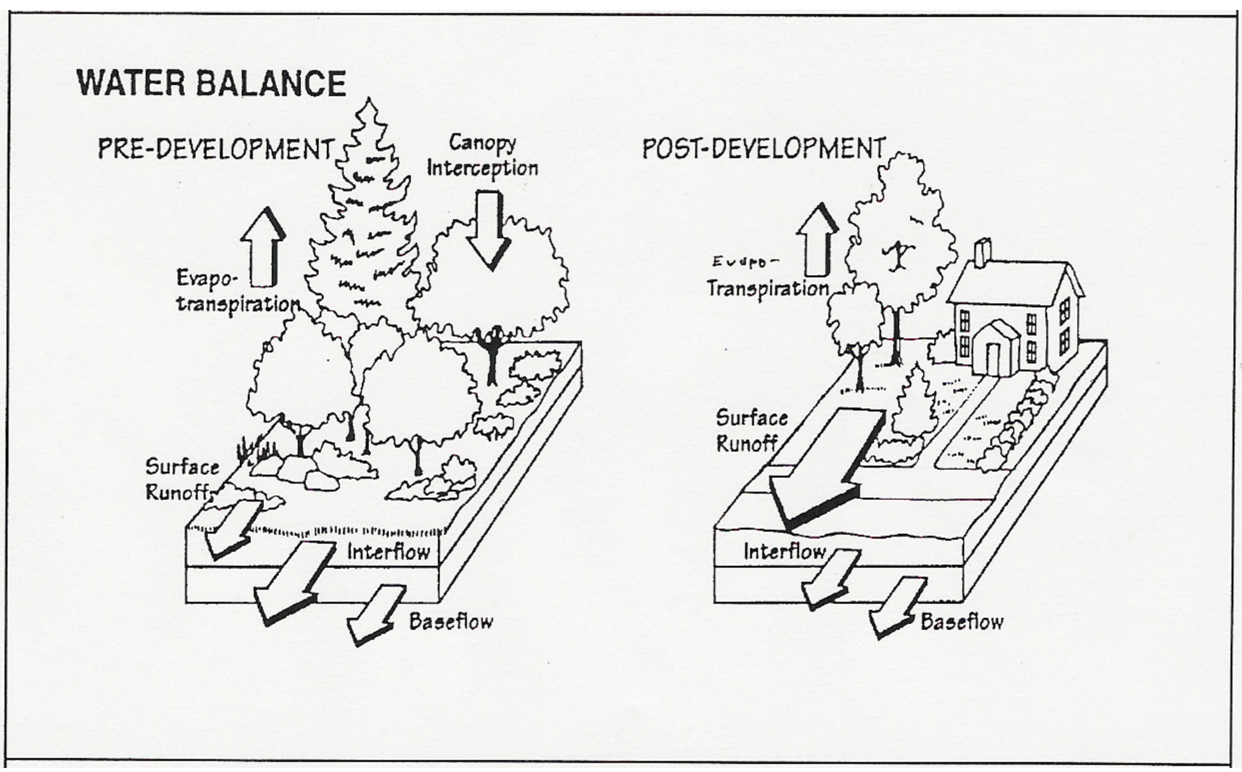


A simplified portion of the cycle of water.

In land development, the vegetation and natural topography are replaced with homes, roads, and graded sites, necessarily decreasing the amount of surface area capable of absorbing precipitation. As a result, stormwater management structures must be utilized to control the increased amount of surface runoff. The following diagram demonstrates the adverse affects of land alteration on stormwater runoff that must be addressed by applying appropriate BMPs. While this document applies to all projects in the state, those persons constructing facilities in karst areas should employ more stringent BMPs.



Earth-disturbing activities, such as land development, impacts not only surface water, but groundwater as well. The following diagram demonstrates how the flow is shifted before and after land development.



Stormwater management structures include, but are not limited to: wet and dry detention basins, wetlands, swales, and dry wells. These are intended to capture and treat a portion of the runoff by allowing it to infiltrate into the soil, recharging the aquifers.

The subject literature contains valuable guidance on the design, construction and maintenance of management structures for the capture and detention of stormwater runoff. This guidance document will give the user some insight into the type of criteria that is employed by the WVDEP in approving temporary or permanent stormwater detention structures.

Stormwater recharge of groundwater is a primary concern, especially in situations where long-term drought conditions have lowered the groundwater table to critical levels. Groundwater in many areas of the State is critical to economic growth and the well being of its citizens. Equally important is protecting the existing quality of the groundwater in order to continue to provide a clean and reliable source of drinking water to more than half of the state's rural population and a third of its municipal water supplies.

Please Note: If there is a discrepancy between federal, state, and/or local regulations, then the more stringent regulations shall apply.

Chapter 1

Site Selection and Unified Stormwater Sizing Criteria

A. Site Selection. Site selection is critical for a stormwater management structure to function properly; it is also the most difficult and important part of the design process. An infiltration structure must be located at the lowest point in the drainage basin, sufficient area must be available to allow for the construction of the structure, and adjacent structures and land use must be compatible with the installation. For example, infiltration trenches are typically employed for drainage areas of up to 10 acres, making them suitable for parking areas and commercial lots. Infiltration *basins* may be used for drainage areas of 5 to 50 acres making them suitable for municipal installations, housing developments, and transportation facilities.

Site selection is conducted in two phases:

1) Initial or preliminary site screening
2) Final site determination

A Professional Engineer (PE) and geotechnical engineer should be employed as part of both the initial and final site selection teams; the PE should also be part of the design team.

Caution: The development of a site prior to determining the subsurface characteristics of that site may preclude the use of these design criteria for infiltration structures and ultimately require installation of an impervious structural liner and the obtaining of a permit for the surface discharge.

1. Initial or Preliminary Screening

a. Available Area. A suitable site that allows for sufficient area to construct the stormwater management structure must be located. The surface area design volume criteria for the management structure (trench or basin) will be calculated based on the drainage basin area. Management structures are typically designed to intercept the "first flush" volume, generally obtained from the first one-half inch of runoff. Many constituents in stormwater runoff do not exhibit "first flush" characteristics of high contaminant concentrations relative to volume. This must be taken into consideration when determining the design volume of the management structure. It may be more cost effective to design the management structure to intercept the one to three year average storm event, thereby capturing most of the stormwater runoff other than excess from the more rare events. However, given the uncertainty of potential contaminants in stormwater runoff that may lead to groundwater contamination and the various design criteria available, it may be advisable to design the management structure to intercept larger runoff volumes, although infiltration structures designed to intercept runoff from a storm with a larger return period than one year may not be economical.

Surface area for the management structure may be calculated by multiplying the design rainfall runoff volume by the drainage basin area. Knowing the depth of the management structure, the surface area may then be computed. Typically, trench depths should be ten feet or less to allow for ease of construction and maintenance; basin depths should be three feet or less for safety purposes. Given these maximums, a minimum required surface area can be calculated, and the site suitability determined. Sufficient area adjacent to the site must be available to allow for maintenance, as a ten-foot maintenance road or shoulder should be provided around management basins. Management trenches should be set back from the property line on a 1:1 slope from the bottom of the trench. Additionally, potential pollutants may necessitate pretreatment, thus increasing the required available area to include any associated facilities (see 1.c.).

b. **Lowest Drainage Point.** The site must meet the drainage criterion of lowest point in the drainage basin.

c. **Potential Pollutants.** Also, potential sources of pollutants must be identified and the land uses that cause the pollutants must be sited in a manner that minimizes the exposure of the pollutants to rainfall and runoff. Stormwater runoff is a non-point source of pollution that comes from a variety of land uses, most of which are human activities.

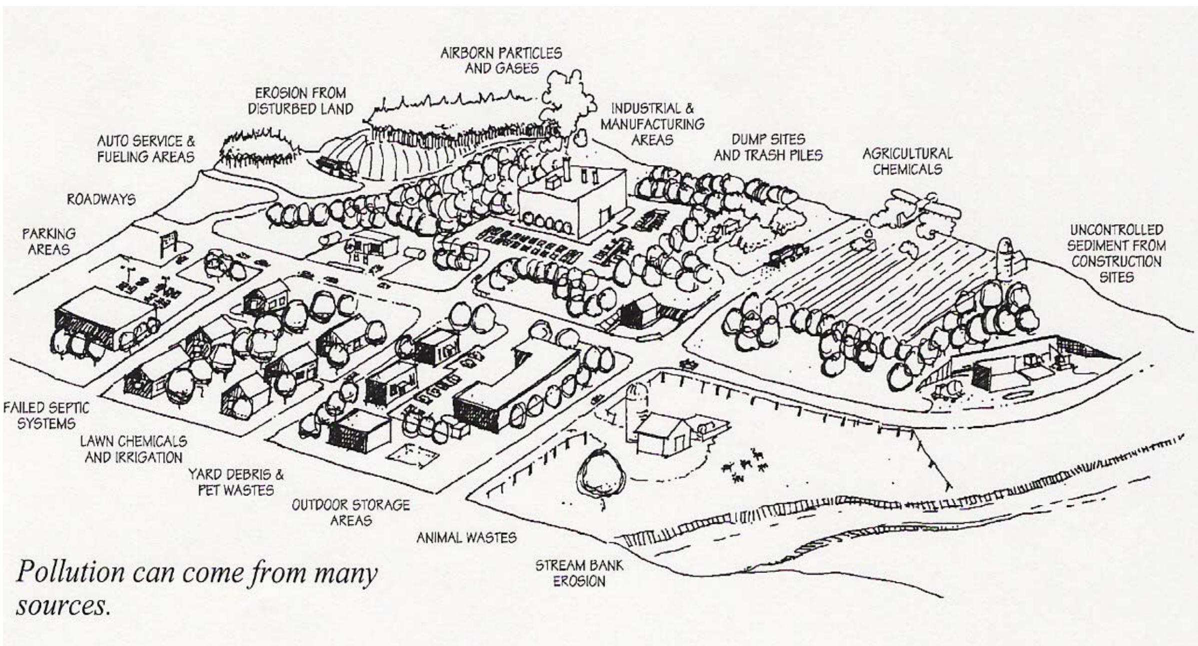
Some examples are:

- Salt deposited on roads
- Fertilizers and pesticides
- Fluids from vehicles (e.g. oil, gasoline, etc.)
- Piles of construction soil and debris
- Service stations
- Commercial and industrial areas
- Poorly constructed streets (especially unpaved)
- Sewage systems
- Agricultural activities

Stormwater recharge to groundwater is acceptable only when the impacts to groundwater quality can be minimized to comply with the Groundwater Protection Standards set forth in Title 46, Series 12, “Requirements Governing Groundwater Standards” as established by the West Virginia Environmental Quality Board and authorized by the Groundwater Protection Act, Chapter 22, Article 12 of the West Virginia Code.

Pretreatment is recommended where moderate to high sediment loads are expected or where such treatment may be beneficial in removing constituents that could contaminate groundwater. Pretreatment generally includes biofiltration, either through the use of swales or strips, but may also include detention ponds. Management basins may employ the use of a sediment forebay to intercept the coarse sediment fraction as a pretreatment option.

Typically, infiltration structures are not effective for runoff containing large volumes of particulates.



Pollution can come from many sources.

d. Soil Type. Soil maps should be consulted to determine the soil type. Natural Resource Conservation Service (NRCS) soil types C and D are not suitable candidates for infiltration structures because the infiltration rates for these soils fall below the recommended minimum.

Only NRCS soil types A and B may be considered suitable for infiltration structures.

Note: Exposed bedrock (or boulders, cobbles, etc,) in the management structure floor or walls is **STRICTLY PROHIBITED**.

e. Proximity to water wells (private or public). Management structures must be sited at least 100 feet from private or public wells to avoid contamination of potable water supplies.

Additional measures and monitoring may be required to ensure that existing or potential drinking water supplies are adequately protected. Although the recommended set-back distance of an infiltration structure is 100 feet, it may be inadvisable to site such a structure so close to a private or public drinking water supply, given the variety and unpredictability of potential contaminants in stormwater runoff and their mobility in groundwater. The 100-foot minimum criterion is acceptable in a "best case" scenario.

f. **Proximity to building foundations or other structure foundations.** Infiltration structures should be located at least 100 feet from a building or other permanent structure. This recommended set-back distance may be reduced after a detailed geotechnical investigation. The concern is potential seepage under foundations. A geotechnical engineer will be able to assess this potential and recommend whether the 100-foot set-back may be reduced at a given site.

g. **Proximity to highway, road, or street pavements.** Management structures can impact highway pavements. Infiltration structures located adjacent to highway pavements may discharge to the pavement subgrade drainage system, adversely affecting pavement integrity and resulting in ineffective stormwater disposal.

h. **Proximity to slopes.** Infiltration structures should not be located adjacent to slopes where seepage or slope stability problems may result. Again, a geotechnical engineer will be able to determine the optimum set-back from a particular slope.

2. **Final Site Determination**

Once a potential site has passed the preliminary screening, a more detailed geotechnical investigation is necessary.

Site specific surveys are recommended rather than NRCS soil surveys; therefore, local heterogeneity in soils may render a site unsuitable for infiltration.

Permeability tests are recommended for all site evaluations. A simple test can be conducted at the site of the proposed infiltration structure by drilling a hole and performing a field permeability test. Laboratory permeability tests may be performed but the field test permeability values should be used in the design of the infiltration structure.

For example, a permeability test can be performed in a "test zone" of a 4" diameter well. If the depth to groundwater is known, the depth of the bore need not be deeper than several feet past the test zone. The bottom of the test zone should be approximate with the constructed floor of the proposed trench or basin. A 4" diameter PVC threaded pipe is inserted into the borehole. The PVC pipe is slotted to ensure that the permeability of the pipe exceeds the expected permeability of the surrounding soils. The bottom of the hole is backfilled with hydrated bentonite chips; medium clean sand or other suitable filter pack is used in the annular space around the pipe within the test zone. Bentonite chips are then used to seal the top of the well. The borehole is pre-saturated to loosen sidewall cake and saturate the soils for a minimum of one day prior to testing. Permeability is calculated by taking several water level measurements in a given period of time and using equations found in the Bureau of Reclamation Groundwater Manual (U.S. Dept. Interior, 1985) and in most groundwater texts.

Permeability will determine the infiltration rate. Published minimum rates vary from 0.27 in/hr. to 0.5 in/hr. The WVDEP recommended minimum infiltration rate is 0.5 in/hr.

B. Unified Stormwater Sizing Criteria. Once the infiltration rate is determined, design of the facility can proceed. The principle variable is the infiltration drain time. A drain time (ponding time) of 72 hours or less is required to preclude vector control problems and the formation of algae that may clog the soils. However, the drain time should be long enough to adequately filter sediments and contaminants.

1. Volume

The management structure's volume is determined through selection of a design storm. As discussed previously, a one to three year return interval is suggested to compute the design storm volume. This capture volume is larger than is generally recommended in the literature, but is advised due to the uncertainties associated with groundwater infiltration from both technical and regulatory perspectives. Other design storm volumes may be stipulated in NPDES permit conditions or local ordinances. It is possible that by-pass runoff capture capacity (by-pass runoff is runoff from events more rare than the design storm) will be required to meet Water Quality Standards.

Once the total design rainfall is known, the runoff volume may be estimated by selecting an appropriate runoff coefficient based on the type of land use in the drainage basin. The NRCS has available a well-documented rainfall-runoff depth list or a small area hydrograph may be used.

2. Surface Area

The management structure's surface area is calculated using an assumed depth, the calculated design volume, and the maximum drain time. The depth for a management basin should not exceed three feet unless precautions are taken for public safety that include positive barriers to exclude pedestrian or vehicle traffic. The maximum depth of an infiltration trench should be determined by such factors as available surface area, depth to bedrock and the location of the water table. Drain time may be calculated from the equation.

$$T = d/f$$

Where T is drain time
d is design depth (in)
f is soil infiltration rate (in/hr)

Note: Many references recommend a safety factor of two when using the above equation. This is generally a good practice given that the performance of the structure is likely to degrade over time.

The volume of a management trench is calculated using the trench dimensions and assuring a void ratio of approximately 30% for the rock media used to fill the trench. The volume of an infiltration basin is calculated using standard earthwork methods and allowing an extra foot for free board.

WVDEP Recommended Design Criteria for Stormwater Management Structures

Design Element	Recommended Criteria
Ponding Time	72 hrs
Drainage area	
Infiltration Basin	50 Acres
Infiltration Trench	10 Acres
Infiltration Rate	0.5 in/hr
Design Storm	1 to 3 year storm
Depth	
Infiltration Basin	3 feet
Infiltration Trench	10 feet
Lining	Vegetation

Caution: A vegetated lining may not be appropriate in all situations. Before planning to construct a stormwater management structure, contact the West Virginia Department of Environmental Protection at:

West Virginia Department of Environmental Protection
Division of Water and Waste Management
Groundwater Program
Attn: Rick Shaver
601 57th St., S.E.
Charleston, WV 25304
Phone: (304) 926-0499 ext. 1052

3. Depth to Groundwater

Stormwater management structures should completely dewater between stormwater events. The verified separation distance from the management structure to the water table is important for groundwater protection and is dictated by regional conditions. The literature indicates values from 3 to 10 feet with minimum standards of 2 to 4 feet for areas of a high groundwater table. In areas with a deeper groundwater table the minimum adopted standard is 10 feet. It would be imprudent under any circumstances to use a minimum separation distance wherein groundwater mounding from the water table would access the infiltration structure. The determination of depth must be based on the characteristics of the uppermost aquifer, depth to bedrock or cavern, and the constituents of concern in the runoff.

4. Maintenance

Care must be taken during the designing stage to ensure that the structure does not become a jurisdictional wetland, that vector control (and possibly abatement) is achieved, and that maintenance is facilitated. Long term viability of the structure depends upon maintaining the design infiltration rate. Maintenance of the structure necessarily includes removal of accumulated sediments, excess vegetation, and debris.

5. Excess Runoff

Management structures may be constructed as either off-line or in-line. Off-line construction is generally preferred because, once the design capture volume is within the basin, further runoff is passed from the facility into the subsurface. In-line construction intercepts all flow regardless of the magnitude, discharging surplus through a spillway or outlet. Nevertheless, in-line construction may be advantageous since the goal of the management basin is to intercept more frequent events as opposed to relatively rare events.

Caution: Discharges from a stormwater management structure may require a permit (Construction Stormwater/NPDES General Permit or Stormwater UIC Permit) from the WVDEP. Information regarding these permits can be obtained from:

West Virginia Department of Environmental Protection
Division of Water and Waste Management
Permitting Section
Attn: Belinda Beller or Randolph Ramsey
601 57th St., S.E.
Charleston, WV 25304
Phone: (304) 926-0499 ext. 1047 or 1092

West Virginia Department of Environmental Protection
Division of Water and Waste Management
UIC/Groundwater Program
Attn: Don Criss
601 57th St., S.E.
Charleston, WV 25304
Phone: (304) 354-0474

Chapter 2

Wet Detention Basins

Wet detention basins are the most common stormwater management structures. They are designed to maintain a steady pool of water between rain events as well as temporary storage of stormwater during heavy rainfall. Wet detention basins are frequently used because of their efficiency in removing Total Suspended Solids (TSS). Some studies have shown that TSS removal varies from 50% to 90%, depending on the size and depth of the wet detention basins. Additionally, wet detention basins are effective in reducing downstream erosion.

Most wet detention basins are designed with a forebay. This is a smaller basin through which water flows prior to entering the larger stormwater storage basin. The forebay allows most of the TSS to settle so that the larger basin requires less frequent dredging. The forebay may be lined with a hard material such as concrete to facilitate dredging.

It is required that some wet detention basins to be lined to the top of the permanent pool level with an impermeable clay and/or geotextile liner. In a commercial/industrial area, an oil/water separator is needed between the facility and basin. The oil/water separator can be constructed immediately before the lined forebay, in the lined forebay, or after the lined forebay. The following chart shows the minimum forebay/basin lining requirements. Typically a Stormwater UIC permit would not be required if the stormwater management structure liner meets the following requirements.

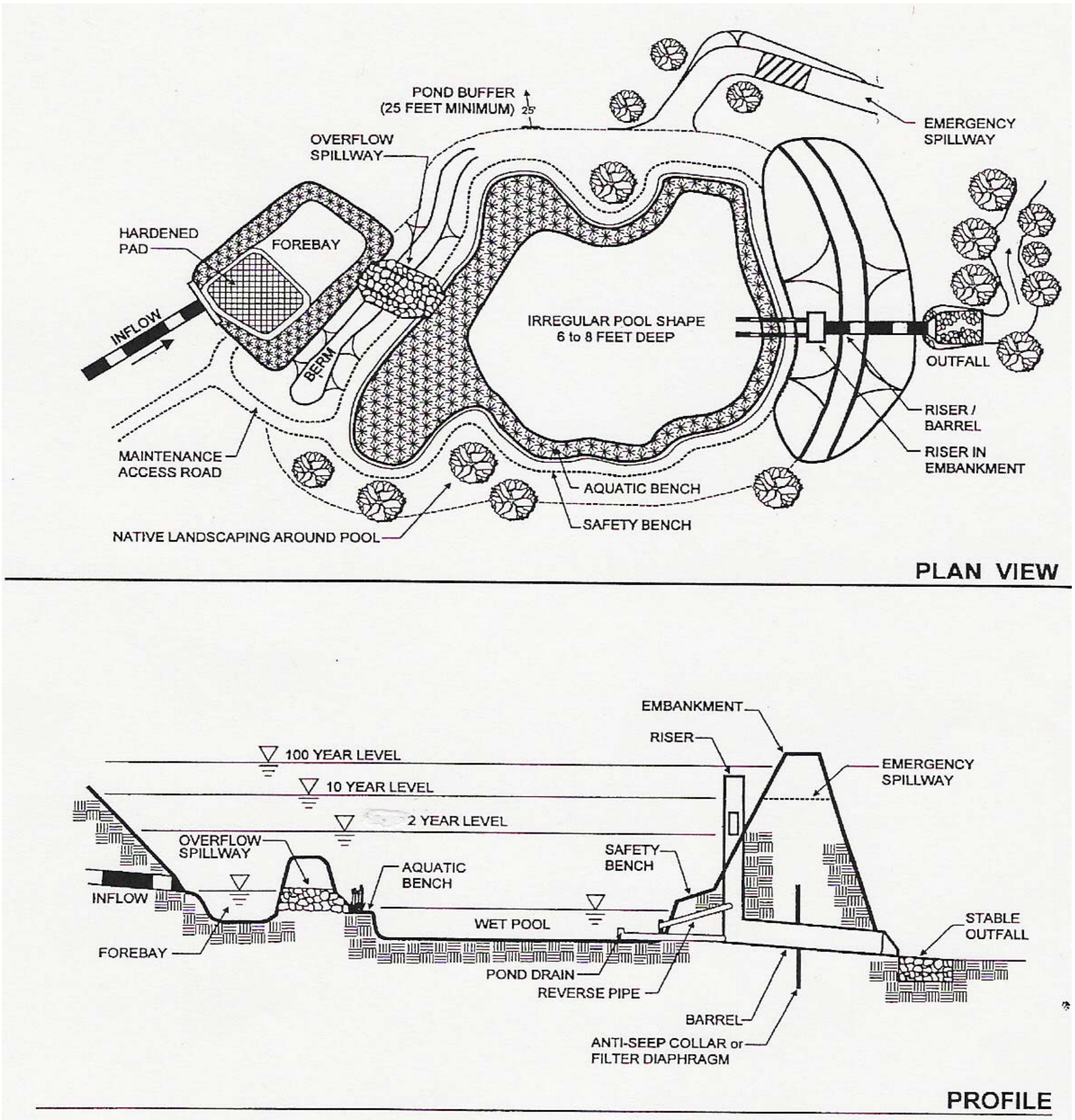
Required Stormwater Management Groundwater Protection Measures for a Wet Detention Basin

KARST AREAS	NON-KARST AREAS
Pond Not Excavated to Bedrock: 24 in. Soil – Maximum Hydraulic Conductivity 1 X 10^{-5} cm/sec.	**Pond Not Excavated to Bedrock:** 24 in. Soil – Maximum Hydraulic Conductivity 1 X 10^{-4} cm/sec.
Pond Excavated to Bedrock: 24 in. Clay – Maximum Hydraulic Conductivity 1 X 10^{-6} cm/sec	**Pond Excavated to Bedrock:** 24 in. Soil – Maximum Hydraulic Conductivity 1 X 10^{-5} cm/sec
Pond Excavated to Bedrock within Well Head Protection Areas, in recharge area of domestic well area or spring, or in known faulted or folded area: 24 in. Clay – Maximum Hydraulic Conductivity 1 X 10^{-7} cm/sec and a synthetic liner with minimum thickness 60	**Pond Excavated to Bedrock within Well Head Protection Areas, in recharge area of domestic well area or spring, or in known faulted or folded area:** 24 in. Clay – Maximum Hydraulic Conductivity 1 X 10^{-6} cm/sec or Approved Composite Liner System

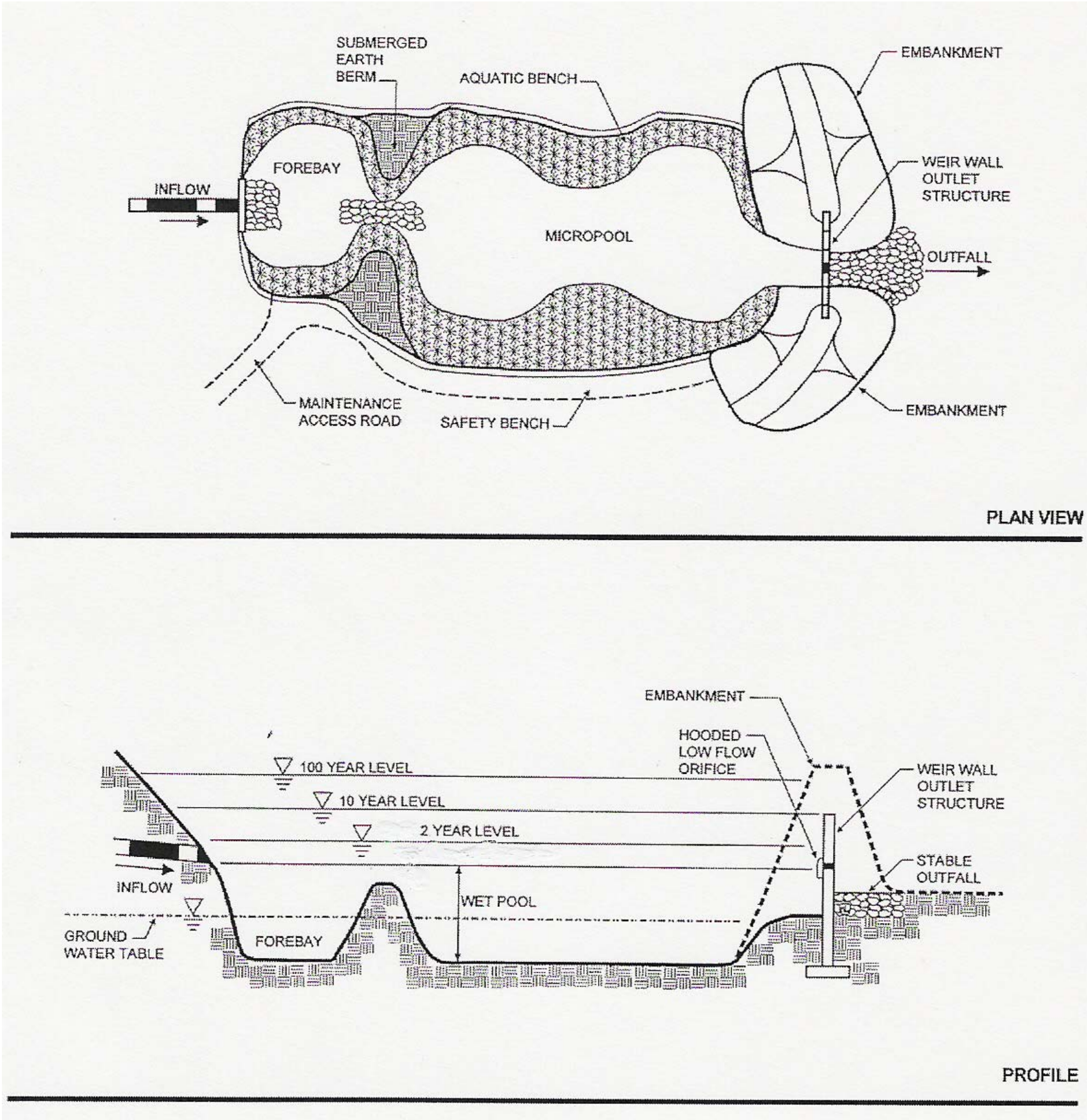
mil. Oil/water separator between facility and infiltration basin in commercial/industrial areas.	

There are several wet detention basin designs that can be utilized depending upon the site characteristics. Some examples are: standard wet detention basins, micropool wet detention basins, multiple basin systems, and pocket basins. The following diagrams are examples of different wet detention basins that are typically utilized.

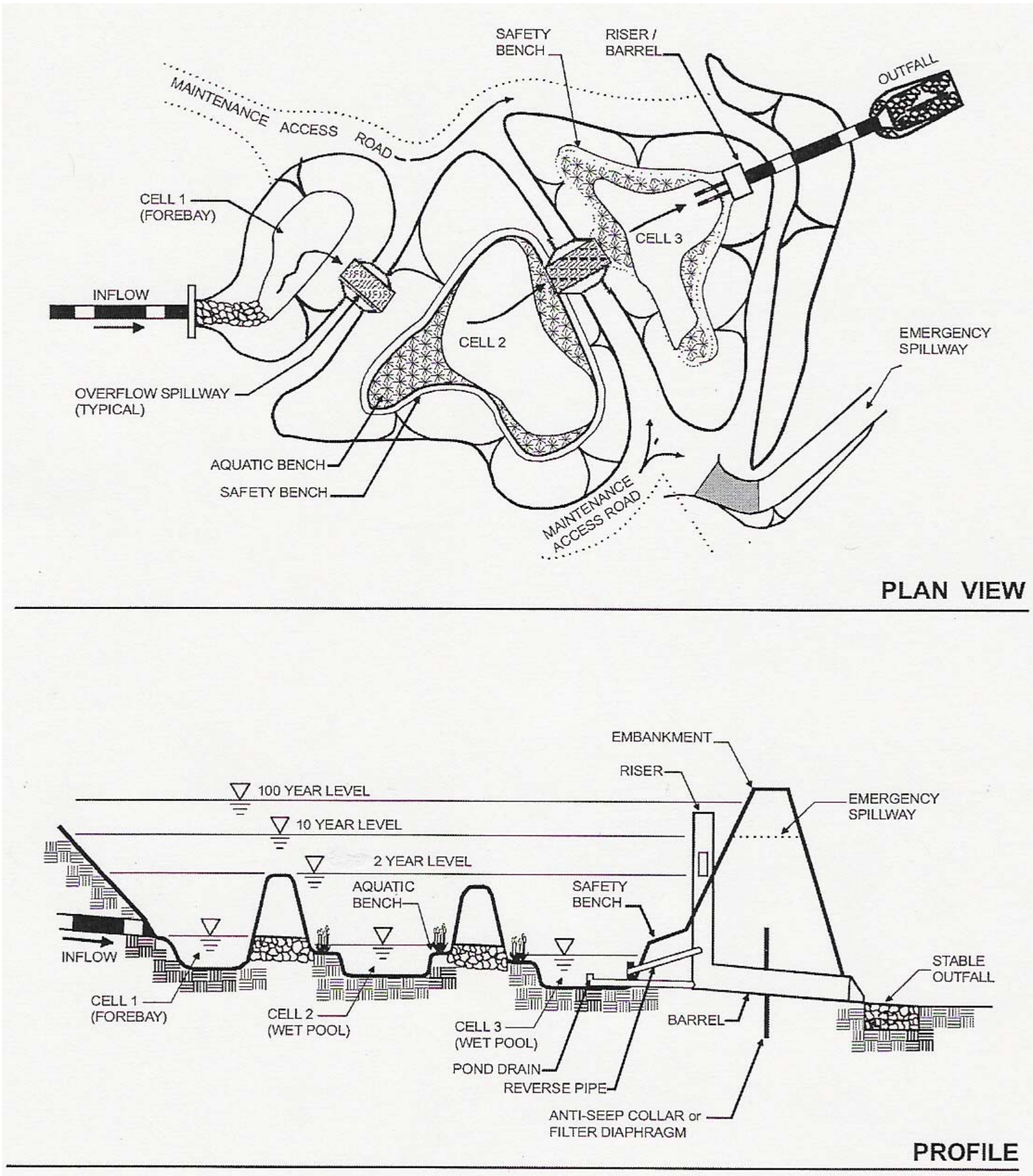
Example of a Standard Wet Detention Basin



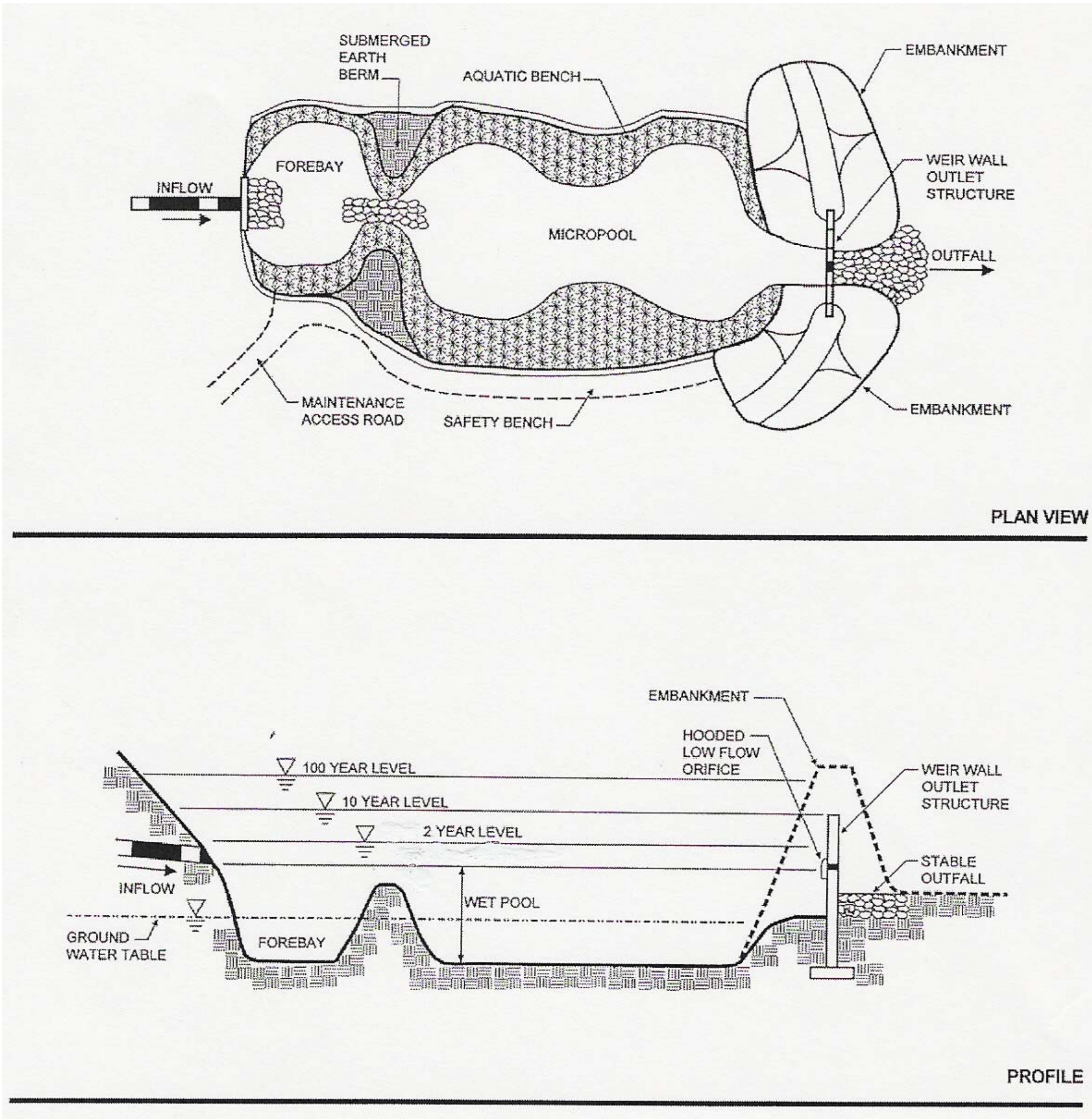
Example of a Micropool Wet Detention Basin



Example of a Multiple Basin System



Example of a Pocket Basin



The constant depth of the wet detention basin is a key element of the design. The mean depth should remain between three and six feet, as this is the optimum depth for TSS settling. Wet detention basins that are intended to support fish and other aquatic life should have a constant depth of six to eight feet. If the basin is less than three feet deep, algal blooms and resuspension of deposited material can occur. Wet detention basins in excess of eight feet deep can produce thermal stratification and anaerobic conditions near the bottom, which could cause contaminants such as metals and phosphorus to be released into the overlying water. Furthermore, wet detention basins that have release valves should release water from the bottom of the basin to prevent adverse effects on aquatic life downstream due to abrupt thermal changes.

In addition to a mean depth of three to eight feet, the wet detention basin should have a minimum drainage area of 25 acres and a surface area of 0.25 acres. A drainage area of at least 25 acres will permit the basin to receive sufficient water to maintain a pool that is environmentally sound, able to support aquatic life, and effectively manage stormwater.

An overflow must be incorporated into the design of the wet detention basin to safely discharge the excess runoff in the event of a major storm event. It must be designed to minimize adverse impacts to downstream areas.

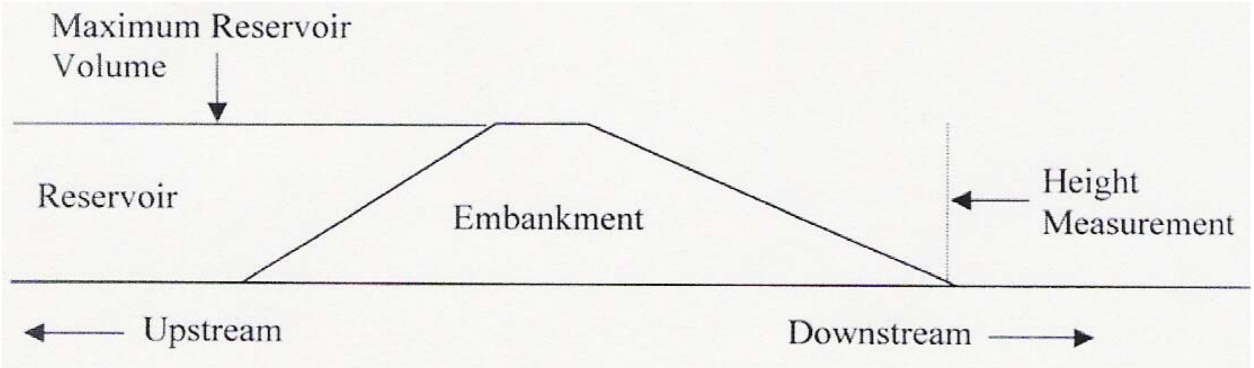
Caution: If the wet detention basin falls under the definition of a "dam", it must be in compliance with the *Dam Control and Safety Act*, 22 CSR 14.3(e) and with *Dam Safety Rules*, Title 47, Series 34.2.10. The legal definition of a dam is "an artificial barrier or obstruction that impounds, or will impound water." The law establishes that regulated dams must be:

- 25 feet or more in height* and impound 15 or more acre-feet (4,917,420 gallons) of water volume**, or
- six feet or more in height* and impound 50 or more acre-feet (16,391,400 gallons) of water volume**

* Height is the vertical distance from the natural streambed at the downstream toe of the dam to the crest of the dam.

** Water volume is measured to the crest of the dam, not to normal reservoir level. "Water" means any liquid, including any solids or other matter, which may be contained therein, which is or may be impounded by the dam.

The following diagram demonstrates where measurements are to be taken.



Any other questions regarding dam safety regulations and criteria can be directed to the WV DEP Dam Safety Section. There contact information is:

WV DEP
Dam Safety Section
601 57th St., S.E.
Charleston, WV 25304
Phone: (304) 926-0495

Caution: Wet detention basins cannot be constructed within jurisdictional waters, including wetlands, without obtaining a Section 404 permit under the Clean Water Act from the U.S. Army Corps of Engineers. The two district offices for West Virginia are:

U.S Army Corps of Engineers
Huntington District
520 Eight St., Room 6422
Huntington, WV 25701-2070
Phone: (304) 399-5710

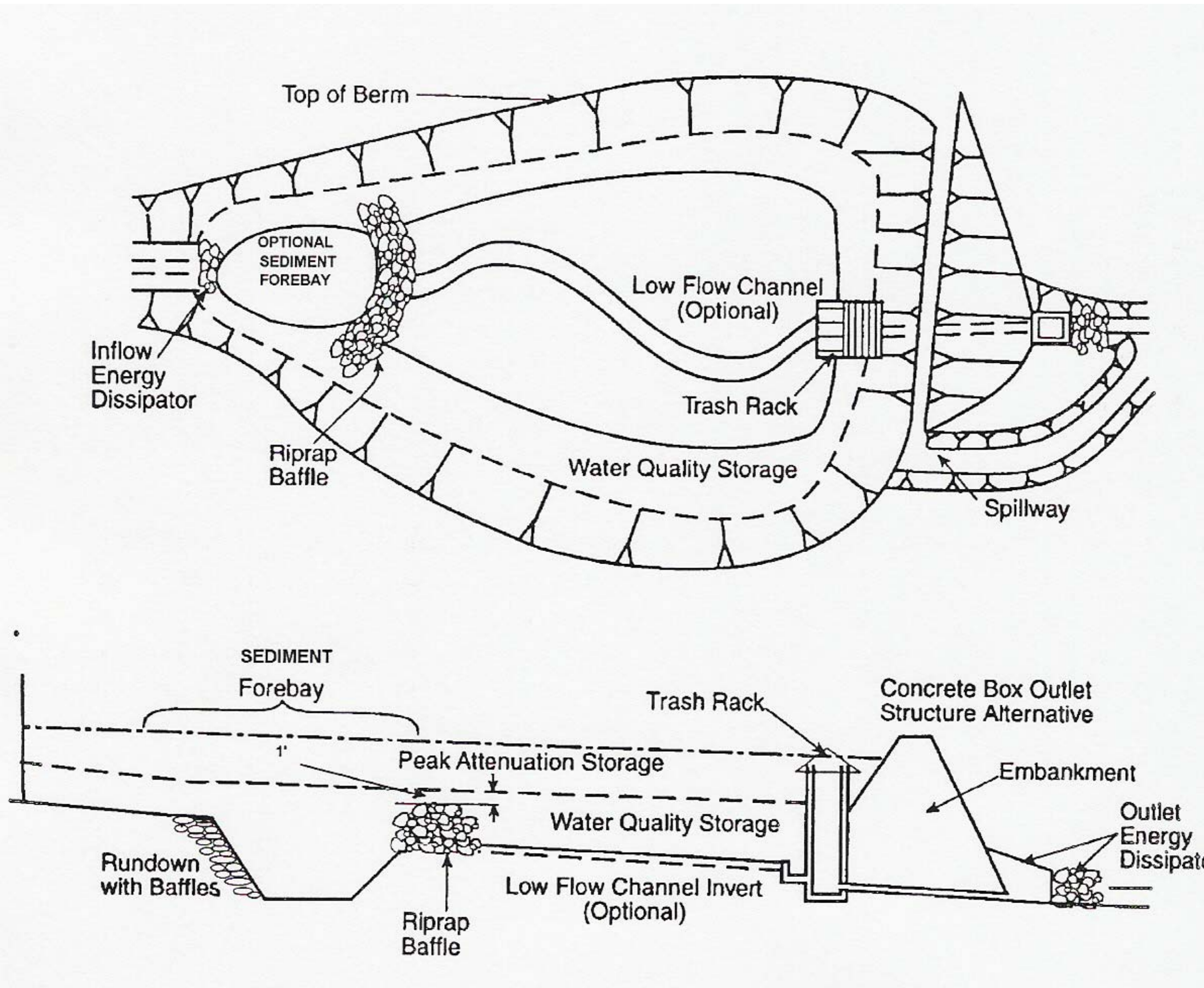
U.S. Army Corps of Engineers
Pittsburgh District
1000 Liberty Ave.
Pittsburgh, PA 15222-4186
Phone: (412) 395-7152

Chapter 3

Dry Extended Detention Basins

Dry extended detention basins are comparable in appearance and function to a wet detention basin, except that the basin remains dry between rain events. They are capable of achieving TSS removal rates from 40% to 60% if properly designed and maintained.

The following diagram is an example of a typical dry extended detention basin.



Dry extended detention basins are very effective stormwater management structures and will benefit the groundwater supply if the correct soils are utilized in construction. The collected stormwater must infiltrate completely within 72 hours or at a rate of 0.5 in/hr.

NRCS Type A and B soils are the most efficient soils for proper infiltration. A soil thickness of 24 to 36 inches with a hydraulic conductivity of 1 X 10^{-4} cm/sec to 1 X 10^{-5} cm/sec typically meets these criteria.

In karst areas, stormwater must be pretreated prior to entering the dry extended detention basin. Groundwater contamination can readily occur in karst areas due to rapid infiltration and groundwater flow. Stormwater pretreatment also extends the life of the basin and improves its efficiency. Some types of pretreatment systems are forebay, vegetative strip, or commercially manufactured system. In a commercial/industrial area, an oil/water separator is needed between the facility and basin. The oil/water separator can be constructed immediately before the lined forebay, in the lined forebay, or after the lined forebay. Typically a Stormwater UIC permit would not be required if the stormwater management structure liner meets the following requirements.

Required Stormwater Management Groundwater Protection Measures for a Dry Detention Basin

KARST AREAS	NON-KARST AREAS
Basin Not Excavated to Bedrock and Located in a USGS Designated Karst Area: 24 in. Soil – Maximum Hydraulic Conductivity 1 X 10^{-5} cm/sec or Approved Composite Liner System	**Basin Not Excavated to Bedrock:** 24 in. Soil – Maximum Hydraulic Conductivity 1 X 10^{-4} cm/sec or Approved Composite Liner System
Basin or Forebay Located in a USGS Designated Karst Area, within a Wellhead Protection Area, in a recharge area for domestic well(s) or spring(s), or in a known faulted or folded area: 24 in. Clay – Maximum Hydraulic Conductivity 1 X 10^{-7} cm/sec or Approved Composite Liner System	**Basin Excavated to Bedrock:** 24 in. Soil – Maximum Hydraulic Conductivity 1 X 10^{-5} cm/sec or Approved Composite Liner System If basin is not excavated to bedrock, soil must meet the above-mentioned thickness and hydraulic conductivity.
Commercial/Industrial Facility Basin or Forebay within a Well Head Protection Area, in a recharge area for domestic well(s) or spring(s), or in a known faulted or folded area: 24 in. Clay – Maximum Hydraulic Conductivity 1 X 10^{-7} cm/sec and a synthetic liner with minimum thickness 60 mil. Oil/water separator between facility and infiltration basin in commercial/industrial areas.	**Basin Excavated to Bedrock within Well Head Protection Areas, in recharge area of domestic well area or spring, or in known faulted or folded area:** 24 in. Clay – Maximum Hydraulic Conductivity 1 X 10^{-6} cm/sec or Approved Composite Liner System If basin is not excavated to bedrock, soil must meet the above-mentioned thickness and hydraulic conductivity.

Safety is also a concern with dry extended detention basins. The basin must be designed such that the first stormwater outlet allows the water level to rise no more than three feet in depth and such that the bottom of the basin is at least two feet above the seasonal high water table or bedrock. This prevents standing water, which causes objectionable odors and may become a breeding ground for mosquitoes and other insects. Also, rip rap needs to extend across the width of the high flow channel to protect the liner during high flow events.

Chapter 4

Extended Stormwater Wetlands

Extended stormwater wetlands are comparable to wet detention basins except the wetlands maintain a constant depth of only one to three feet. They are effective in removing pollutants while remaining aesthetically pleasing and providing natural habitats. Extended stormwater wetlands can be more effective than wet detention basins if designed properly. The wetland and its plantings are capable of removing 85% of TSS by slowing stormwater flow, allowing settling, and promoting biological uptake.

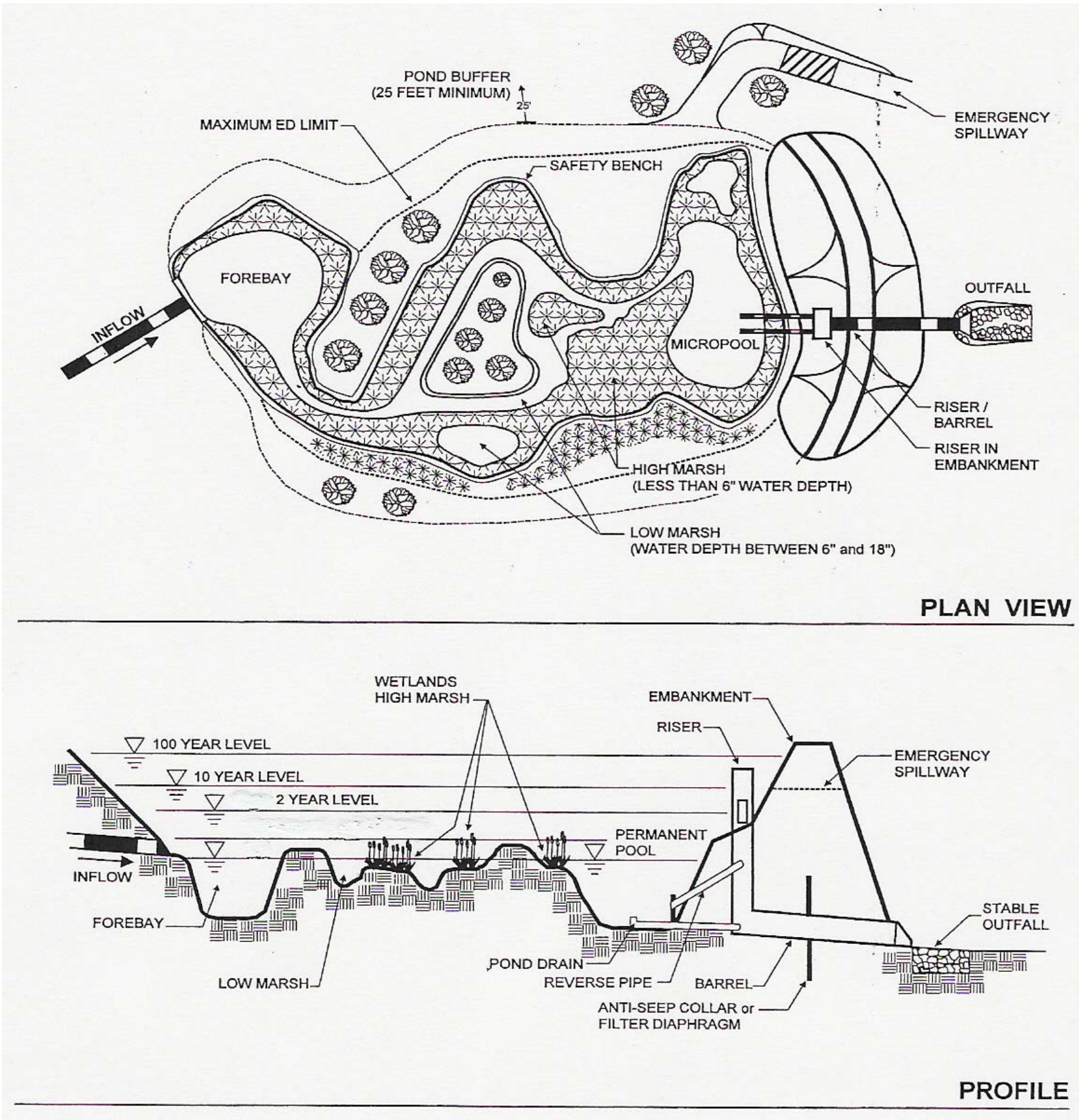
One of the major factors making the extended stormwater wetlands so efficient at removing TSS and nutrients is the vegetation. Generally, the best source of a diverse group of plants for the designed wetland is a commercial aquatic plant nursery. The experts there can advise which plants are best suited for the environmental conditions of the proposed wetland. At least five to seven species of aquatic plants should be used. Of those species, at least three should be "aggressive colonizers."

Another major factor is the capability of the wetland to maintain a depth of at least three feet of water for a drought at least thirty days duration. Sufficient water must be available to sustain aquatic plant life all year round. The wetland must be constructed in an area of 20 acres minimum to provide sufficient drainage to maintain a constant water level. In some instances, an aerator may be necessary to keep the water from becoming stagnant during low flow periods.

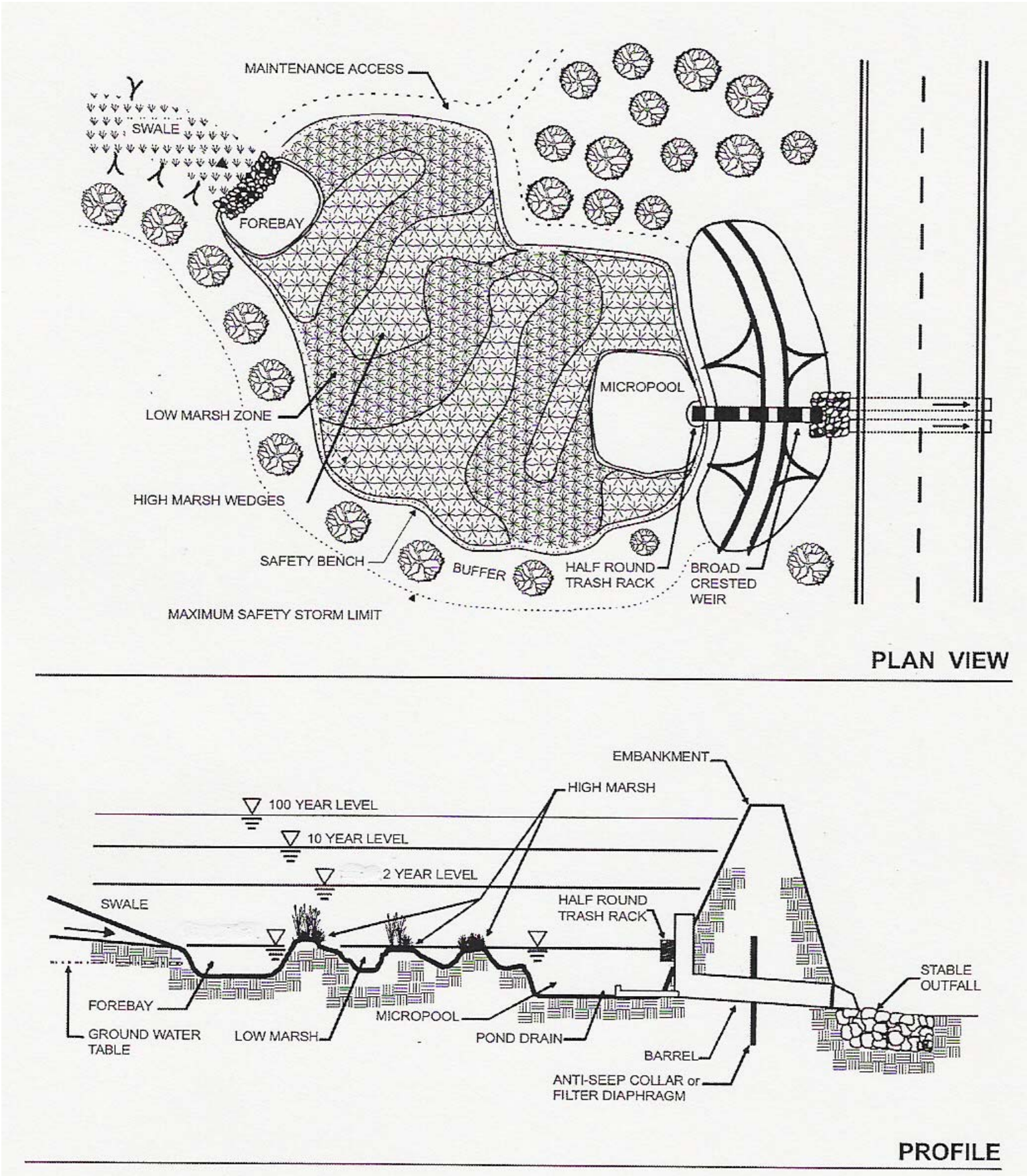
Forebays and micropools should be constructed to reduce TSSs and prevent choking the aquatic plant life and to reduce the frequency of having the wetland dredged. The forebay may be lined with a hard material such as concrete to facilitate dredging. A micropool should be constructed at the outlet of the wetland to prevent vegetation from obstructing flow. The depth of the micropool must be at least three feet to prevent plant life from growing in it.

The following diagrams are examples of typical extended stormwater wetlands.

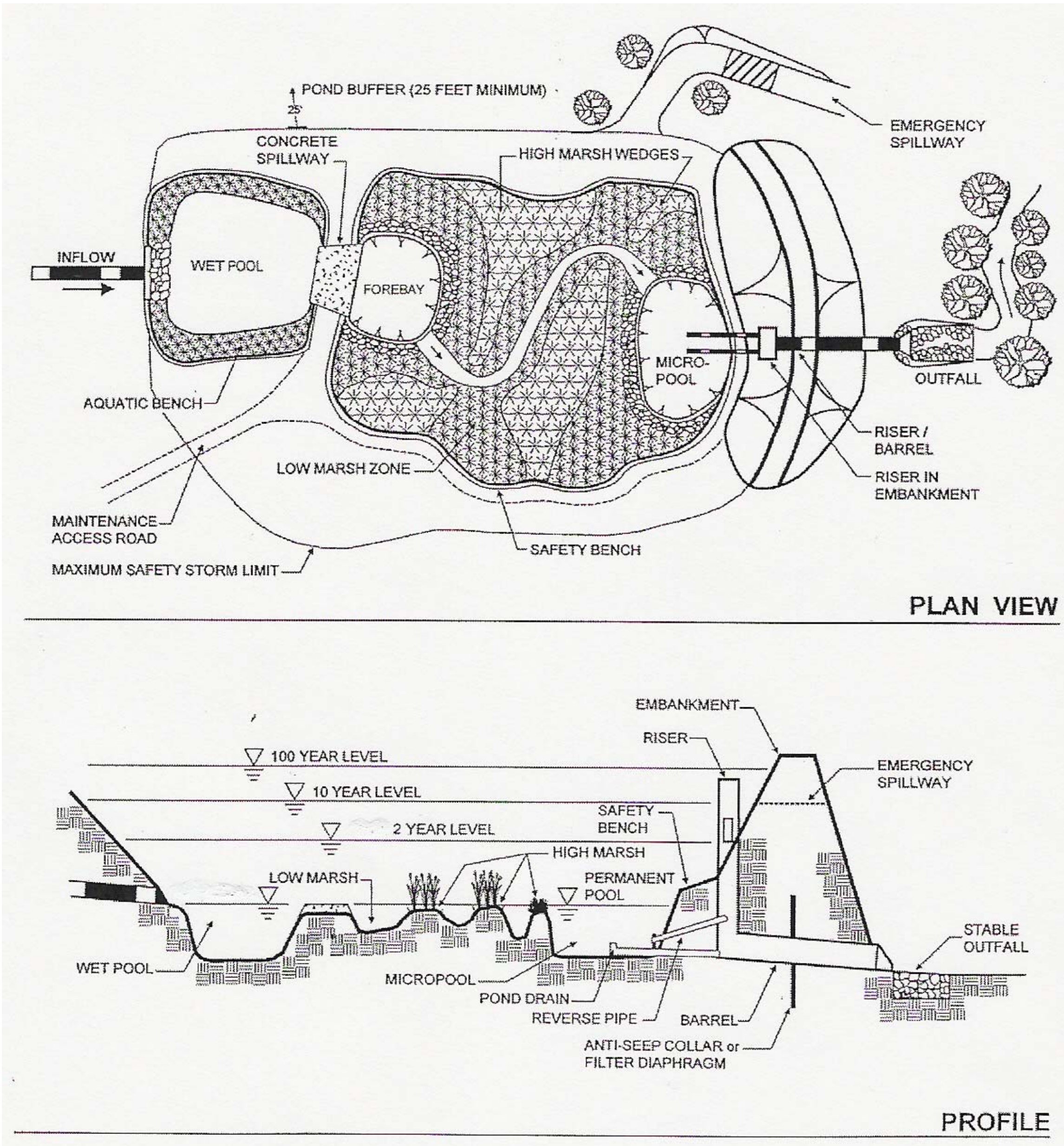
Example of an Extended Stormwater Wetland



Example of a Stormwater Pocket Wetland



Example of a Pond/Wetland Combination



Caution: Stormwater wetlands cannot be constructed within jurisdictional waters, including wetlands, without obtaining a Section 404 permit under the Clean Water Act from the U.S. Army Corps of Engineers. The two district offices for West Virginia are:

U.S Army Corps of Engineers
Huntington District
520 Eight St., Room 6422
Huntington, WV 25701-2070
Phone: (304) 399-5710

U.S. Army Corps of Engineers
Pittsburgh District
1000 Liberty Ave.
Pittsburgh, PA 15222-4186
Phone: (412) 395-7152

Chapter 5

Bioretention Areas

Bioretention areas, sometimes called rain gardens, are manmade landscape designs used to treat stormwater runoff in developed areas. They also restore a natural forest-type setting to the developed landscape. Bioretention areas are frequently used where space or topography does not allow wet detention basins, dry extended detention basins, or extended stormwater wetlands. While bioretention areas are able to manage a maximum runoff area of only five acres with relatively shallow slopes, they are quite effective at removing TSS, oil and gas drippings, metals, and nutrients if properly designed.

The following table shows typical pollutant removal percentages.

Typical Pollutant Removal Rates of Bioretention Systems

Pollutant	Pollutant Removal (%)
TSS	81
TP	29
TN	49
NOx	38
Metals	51-71

Bioretention areas offer several solutions when other stormwater management structures are contraindicated. In addition to their practicality when space is limited, they can be used at sites where the soil does not allow infiltration or where a wet detention basin or wetland cannot be sustained. They can also be made aesthetically pleasing while able to effectively remove a number of groundwater and surface water contaminants.

Unfortunately, bioretention areas do not use an insignificant amount of space. The area should be 5% to 10% of the size of the impervious area it is intended to manage. At a minimum, the bioretention area should be 20 feet wide and 40 feet long to manage sheet flows, allow proper dispersal of plant life, and allow for sufficient stormwater storage.

Bioretention areas are constructed of six major components: vegetative filter strips, ponding area, planting soil, sand bed, organic layer, and plant material. The combination of these six components is what makes bioretention areas so effective at removing contaminants from stormwater.

The vegetative filter strips limit the velocity of the stormwater runoff, reducing erosional activity and allowing TSS to settle.

The ponding area provides storage for the “first flush” of the stormwater, allowing more TSS to settle prior to infiltrating and/or evaporating. This area must be capable of retaining six inches of stormwater until it has infiltrated.

The organic layer is usually constructed of mulch. This is the top layer of materials that provide a stimulating environment for microorganisms. The microorganisms biodegrade the hydrocarbons, solvents, and other pollutants that are deposited in the bioretention area.

The planting soil is the next layer below the organic layer. This provides nutrients and holds water to sustain the plant life in the bioretention area. Additionally, metals, hydrocarbons, nutrients, and other contaminants adsorb to the soil particles to prevent groundwater contamination. This layer should be at least four feet deep to ensure that plant life is sustained and to efficiently adsorb contamination.

The sand bed is the largest part of the bioretention area structure and lies beneath the planting soil. This is where stormwater drainage and soil aeration occurs. This layer allows infiltration, dispersement of water throughout the bioretention area, and receives the plant roots for the uptake of water and any contaminants that may be present. This section must also be at least two to three feet above the seasonal high water table. Also, there must be at least four feet of soil below this layer in karst areas for added groundwater protection.

The plant material is the final component of the bioretention area. This is the step that restores the area to a forest-type setting while enhancing stormwater management and preventing possible groundwater contamination. The role of the vegetation is to reduce erosional activity, perform phytoremediation, and conduct evapotranspiration. The vegetation should be native plant material as much as possible.

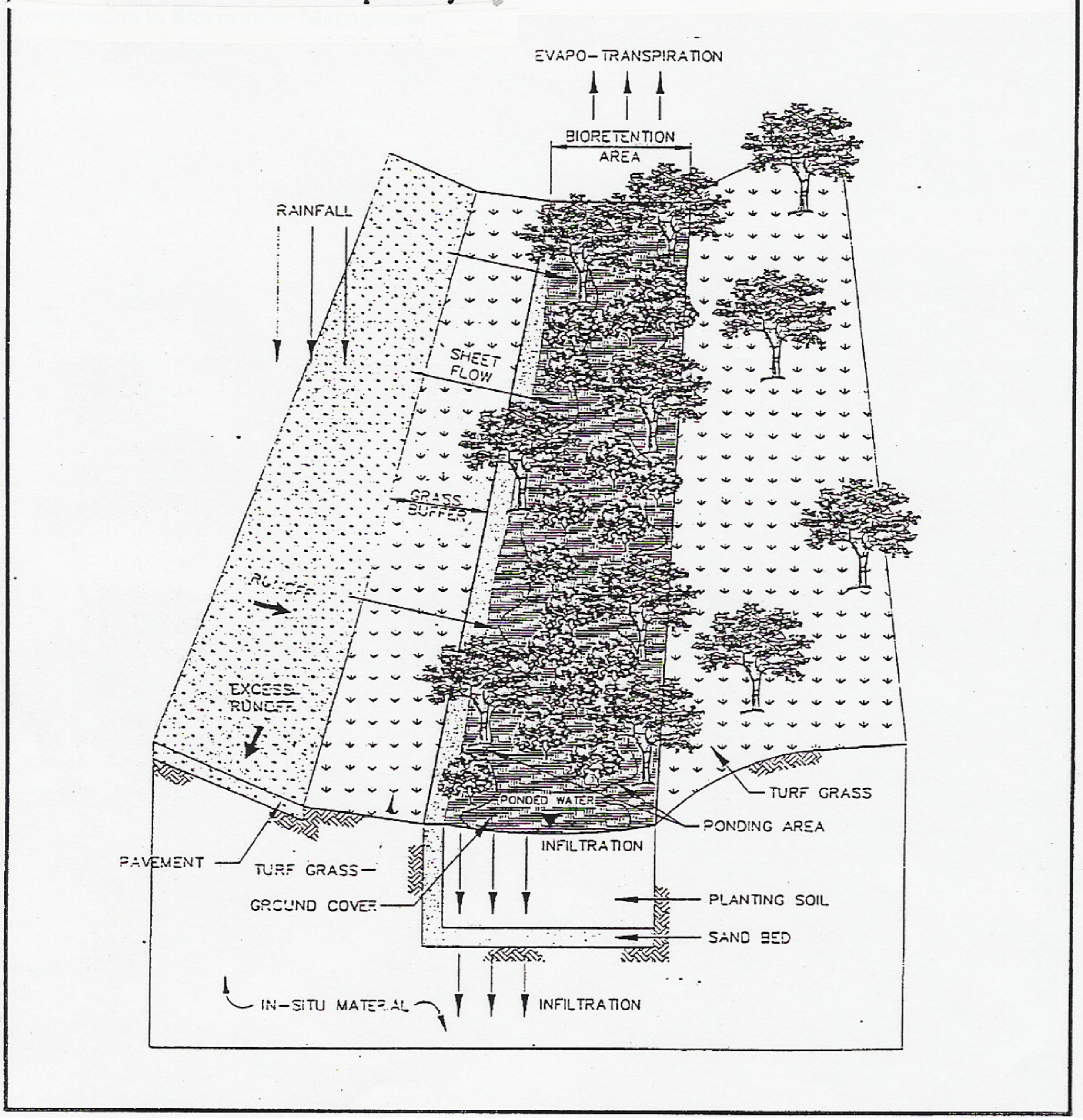
Upon completion, the bioremediation area should simulate a forest-shrub environment. Typically, trees should be located around the perimeter of the structure, while shrubs are located in the basin area in the wetter environment.

For the bioretention area to function properly there should be approximately 1,000 plants per acre with trees being 12 feet apart and shrubs being 8 feet apart. It is recommended that a plant nursery be consulted for the selection to ensure that the appropriate types of plants are being used. The experts there can advise which plants are best suited to the environmental conditions of the area.

After completion, the bioretention area must be able to drain completely within 72 hours. This is essential to allow plant survival and to prevent mosquitoes from breeding in the pooled areas. Additionally, the basin must be cleared of sediment and debris between rain events. This maintenance must be conducted when the bioretention area is dry to prevent damage.

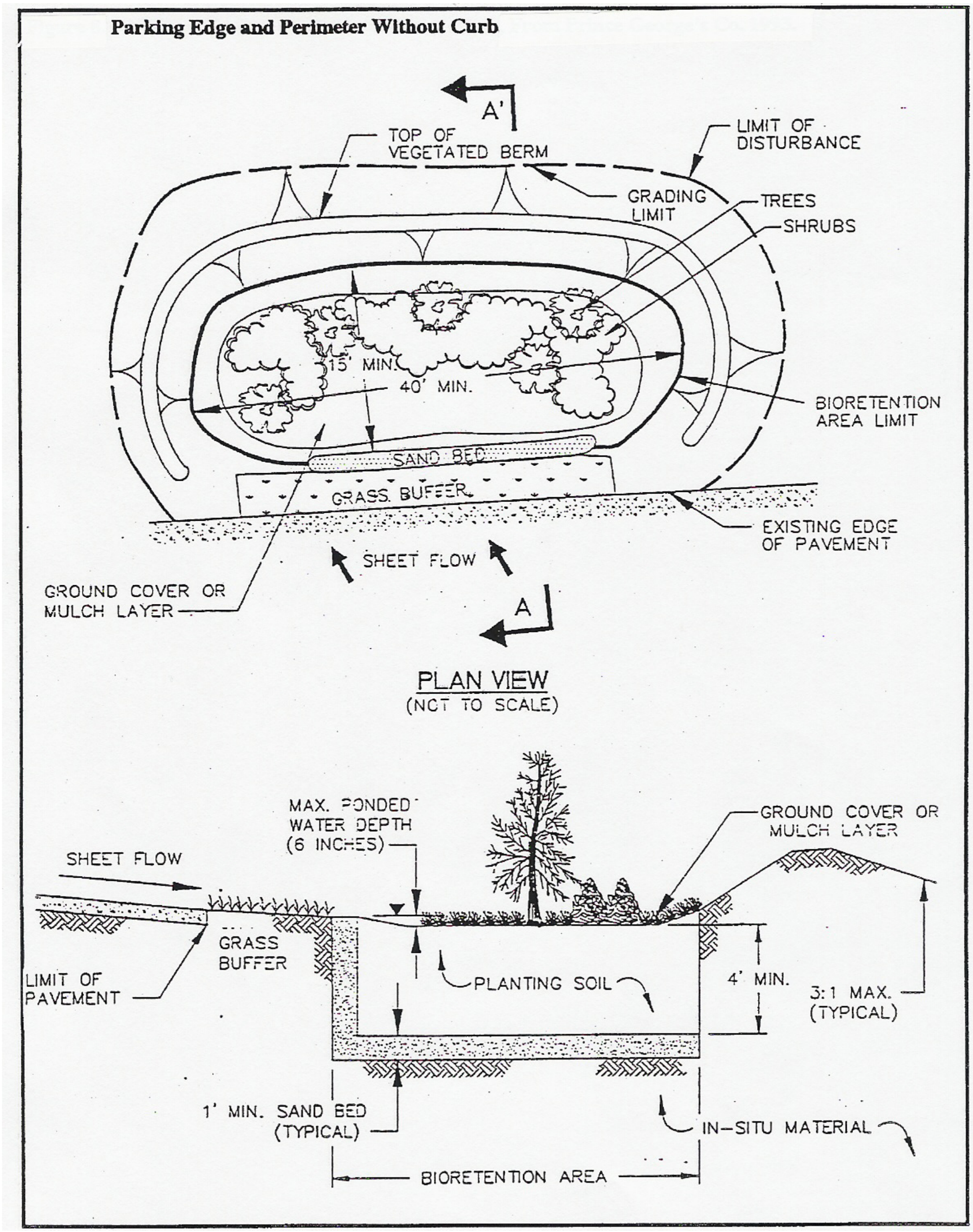
The following diagrams are examples of bioretention areas.

Example of a Bioretention Area

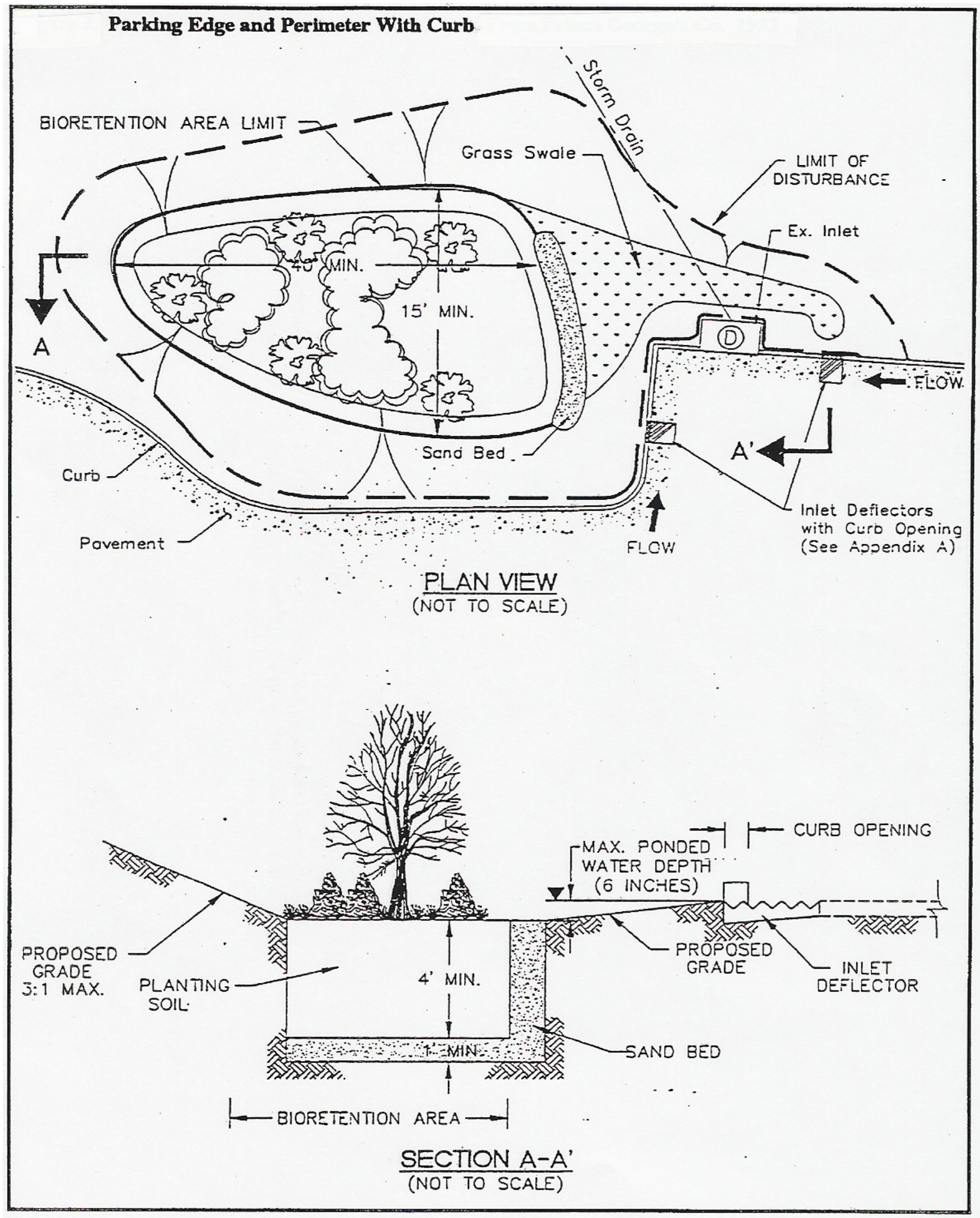


Bioretention Area Conceptual Layout

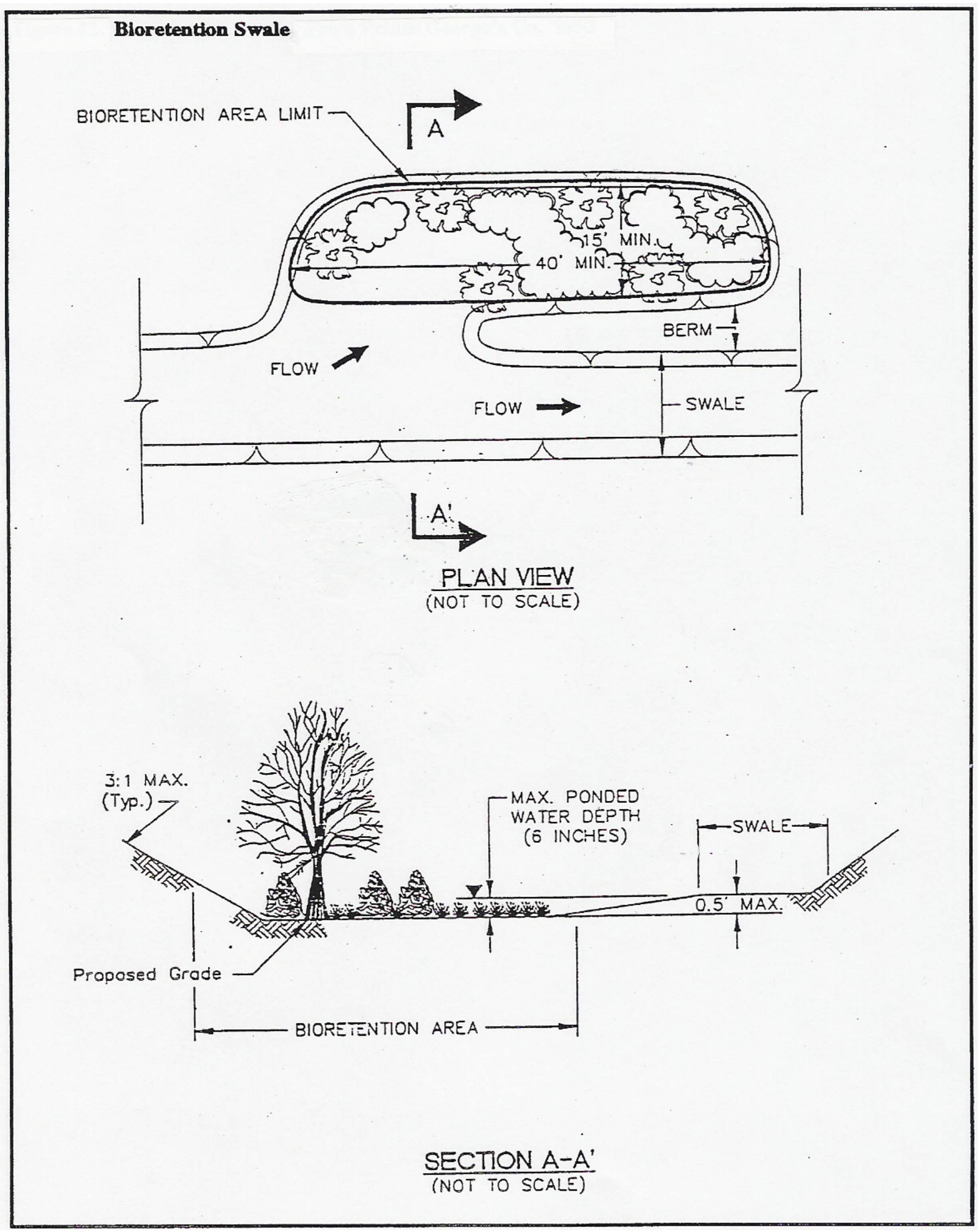
Example of a Bioretention Area in a Parking Lot Without Curb



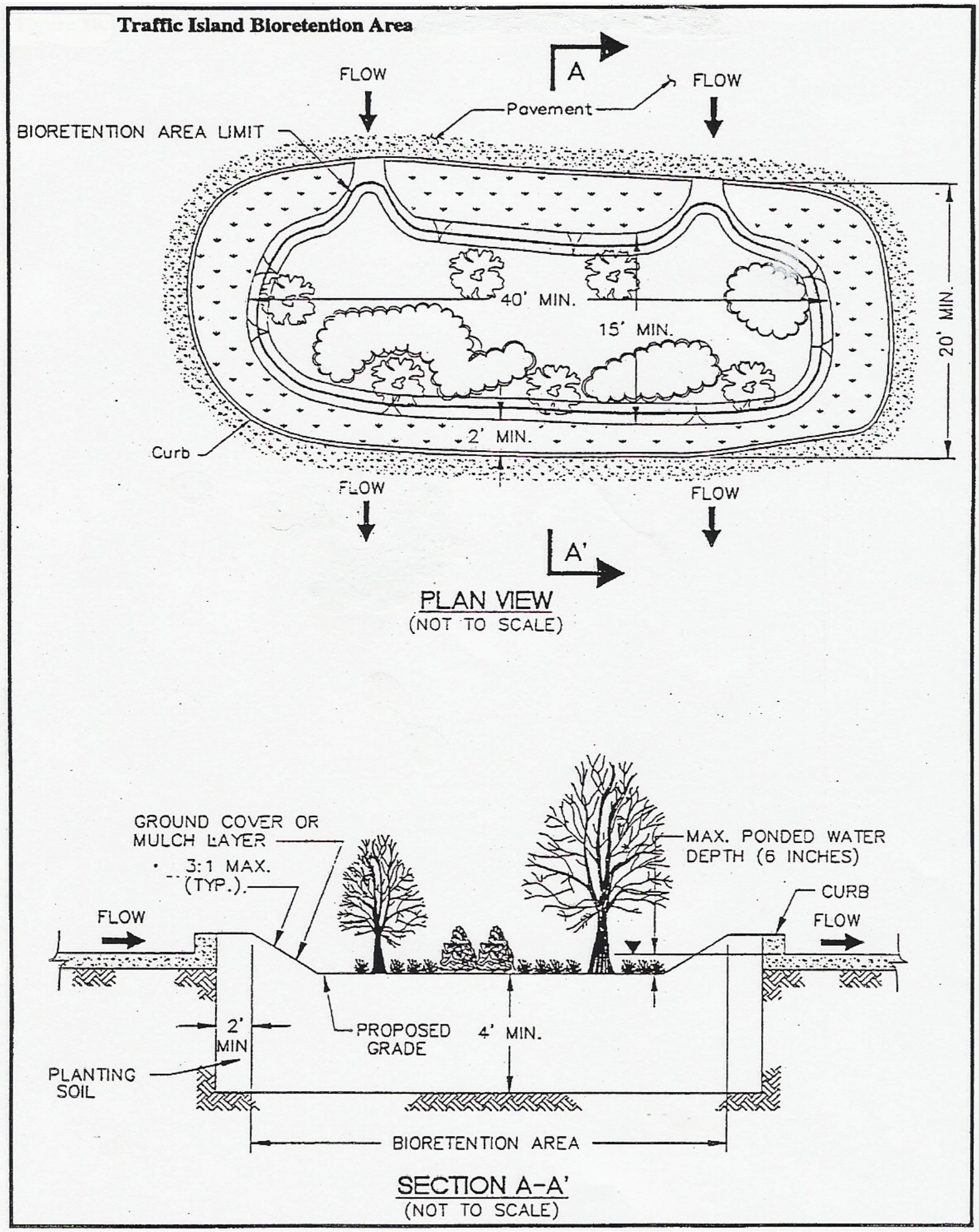
Example of a Bioretention Area in a Parking Lot With Curb



Example of a Bioretention Swale



Example of a Traffic Island Bioretention Area



Chapter 6

Grassed Swales

Grassed swales are open channels that are vegetated to reduce TSS. Although they are not the most effective stormwater management structure if used alone, they can remove some TSS and treat some of the stormwater runoff through vegetative filtering and infiltration through underlying soil.

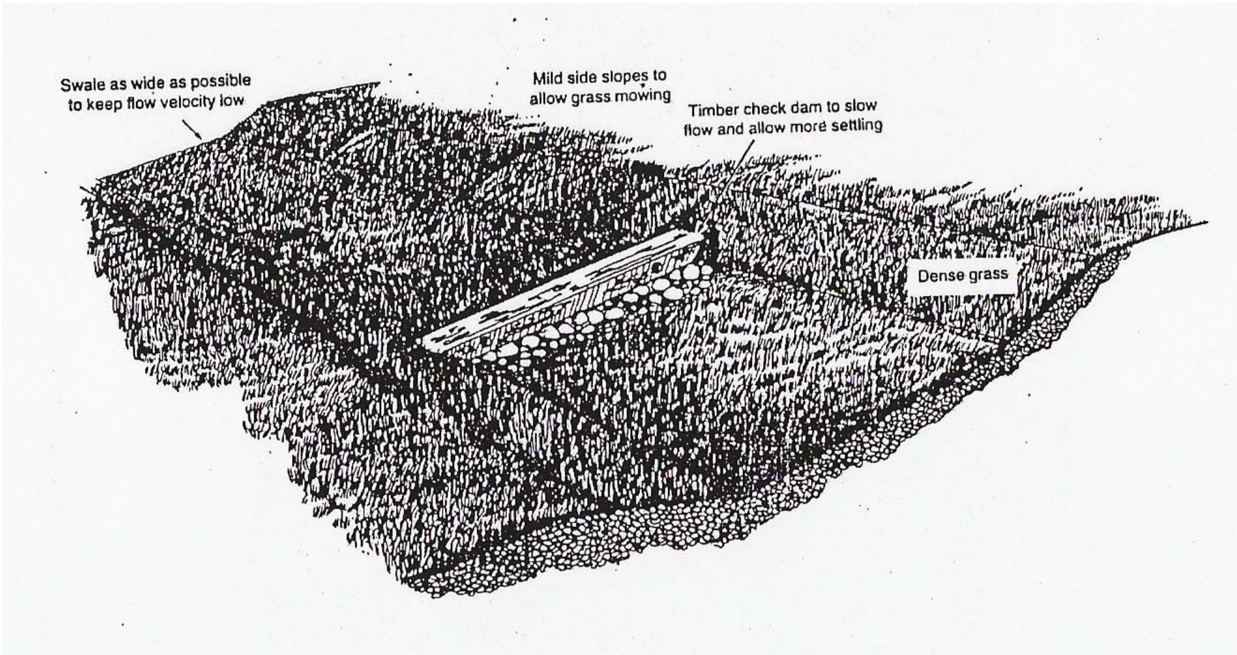
Grassed swales are frequently used in conjunction with other stormwater BMPs, reducing both TSS loading in the others and the amount of flow to them.

Grassed swales are often constructed in lieu of curbs and gutters because they are less expensive and more aesthetically pleasing. They are used extensively along roads, drainage culverts, and residential areas because they can be easily constructed parallel to them. Unfortunately, grassed swales require large areas to function properly. This is because they have very low sides and longitudinal (along the axis) slopes of no more than 2% to 4%. If the longitudinal slope exceeds 4%, check dams should be constructed to reduce the flow velocity to approximately 2 feet per second (fps). This allows for the settling of TSS, prevents stream braiding, and keeps erosion to a minimum. The side slopes should be no steeper than 3:1, horizontal to vertical. The shallow slopes allow more contact area with the stormwater and helps decrease velocity, allowing greater infiltration.

Effective management of excessive runoff from a 10 year storm event requires a minimum of 100 feet of grassed swale area for each acre of runoff area.

The following diagram is an example of a grassed swale.

Example of a Grassed Swale with a Check Dam



Chapter 7

Vegetative Filter Strips

Vegetative filter strips are constructed areas between the stormwater runoff areas and either the receiving surface water or next stormwater management structure. They are composed of grasses, planted shrubs and trees, and indigenous forest, and they help remove TSS and contaminants through sedimentation, filtration, adsorption, infiltration, and biological uptake. However, vegetative strips alone are not completely effective at removing a large amount of TSS and contaminants, but they are an excellent addition to other BMPs in managing stormwater from the same area. If designed and constructed properly, vegetative filter strips can remove 35% of TSS and 40% of contaminants.

There are three factors that must be taken into consideration when designing vegetative filter strips: slope, plant types, and soil types.

Slope must be both gradual and uniform and must be 2% to 6%. If less than 2%, ponding can occur. If greater than 6%, the flow velocity would exceed 2 feet per second (fps) allowing insufficient time for sedimentation and infiltration. Uniform slope is necessary to maintain a sheet flow, minimizing erosional activity. A gravel trench (level spreader) must be incorporated into the design to ensure that the stormwater runoff is spread evenly over the entire vegetative filter strip. This pretreats the runoff by allowing some TSS to settle immediately, and helps prevent clogging the vegetated area with sediment.

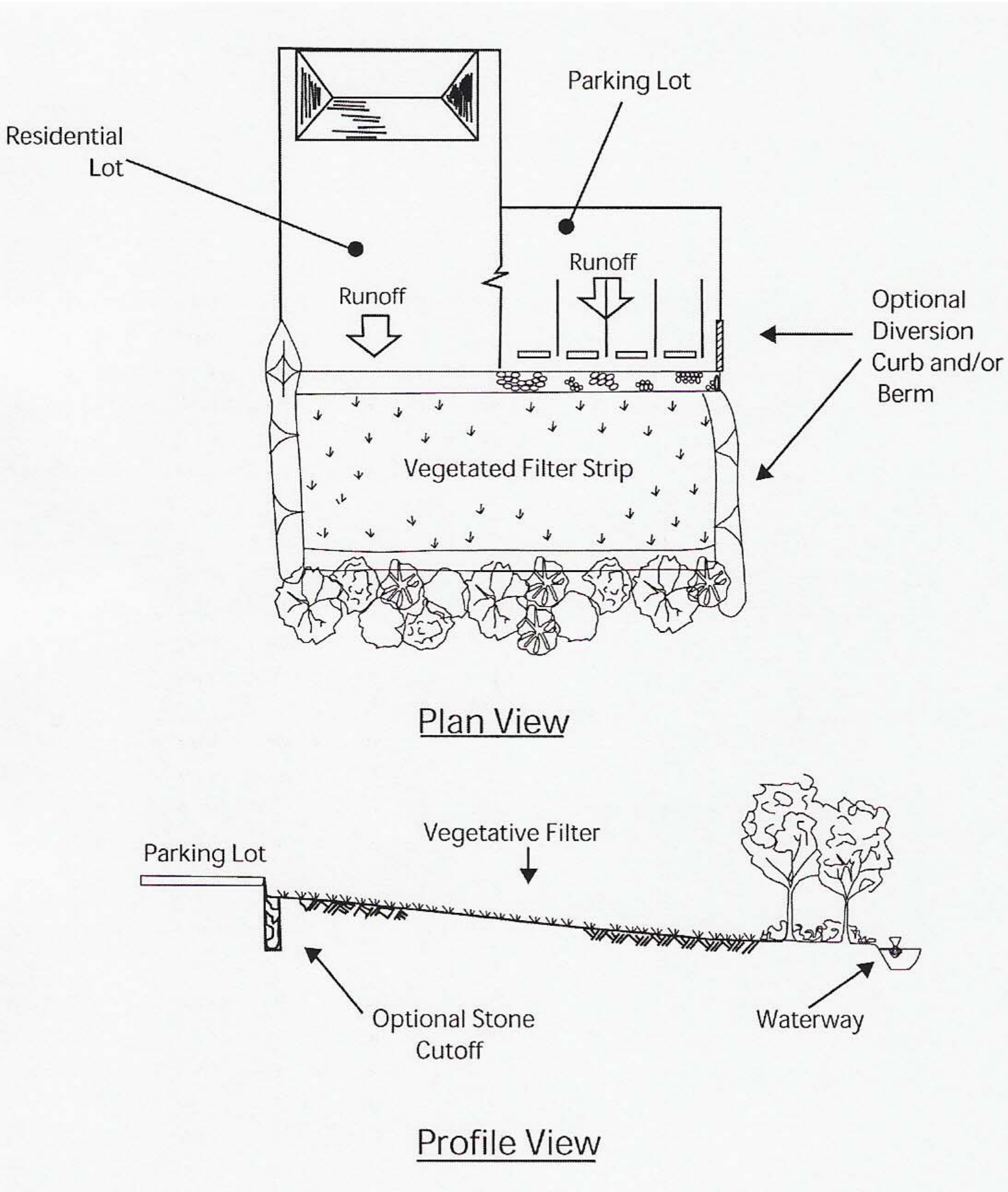
Plant types are selected according to the amount of TSS and contaminants to be removed from the stormwater runoff. The most effective vegetative filter strips are natural, forested areas that are undisturbed. The next most effective vegetative filter strip is planted trees and vegetation. In addition to removing TSS and contaminants, trees help maintain riparian zones along streams by reducing stream bank erosion. They also provide wildlife habitat, help shade streams, and protect the aquatic ecosystem. The least effective filter strip is grasses alone. To maximize the effectiveness of the planted grasses, they must be very dense and capable of surviving very wet and dry periods. A plant nursery should be consulted to ensure that the appropriate types of plants will be incorporated into the design and are best suited to the environmental conditions of the area.

Soil type is important to the rate of infiltration. The best soils to use are *in situ* and are classified as NRCS A and B type soils. Unfortunately, the majority of West Virginia has NRCS C and D type soils. However, vegetative filter strips can be utilized regardless of soil type, but there must be some groundcover overlying the soil in the forested areas of the strip. If grasses cannot be maintained in the forested area, a one inch layer of natural ground cover, such as leaves, or three inches of mulch must be present.

The width of the vegetative filter strip must be 50 feet long in the direction of flow and must be 100 feet wide for each one acre of area. It should not receive stormwater for an area larger than five acres. Concentrated flows exceeding 2 fps could result, which would decrease effectiveness and cause erosion. Also, the strip must be at least two to three feet above the seasonal high water table to allow for soil adsorption before the infiltration reaches the water table.

The following diagram is an example of a vegetative filter strip.

Example of a Vegetative Filter Strip



Chapter 8

Infiltration Structures

Infiltration structures are comparable to dry extended detention basins, but they manage stormwater runoff by receiving it and allowing all of it to infiltrate into the ground instead of discharging onto the surface. These can be excellent structures that aid in recharging aquifers with clean water while temporarily storing stormwater; nevertheless, they must be properly designed and maintained because they are susceptible to failing.

There are two basic infiltration structure designs: infiltration basins and infiltration trenches. Infiltration basins are the larger of the two and can be designed to accommodate stormwater for an area of no more than five acres. Infiltration trenches are smaller and can easily be incorporated into sites with limited space, such as urban areas.

Neither infiltration structure can be used in an area having a slope greater than 15%.

To function properly, infiltration structures must be constructed on areas with permeable soil types, although, construction on fill material is prohibited.

The bottom of the infiltration structure must be at least two feet above the seasonal high water table or bedrock. To remove the majority of TSS, there must be at least four feet of soil below the infiltration structure in karst areas to prevent possible groundwater contamination.

The infiltration structure must have a grass channel and a stilling basin prior to the stormwater entering the structure. Clogging from TSS is the primary cause of infiltration structure failure. Other pretreatment devices are recommended as cost and space allow.

Infiltration basins

Infiltration basins are designed with three layers to properly filter stormwater prior to its entering the subsurface soil. The bottom layer is a minimum of six inches of clean sand. Next is a layer of clean gravel, ideally two feet thick.

Infiltration structures must be constructed on areas with permeable soil types in order to function properly. However, construction on fill material is prohibited. NRCS Type A and B soils are the most efficient soils for proper infiltration. The collected stormwater must infiltrate completely within 72 hours or at a rate of 0.5 in/hr. Soils 24 to 36 inches thick with a hydraulic conductivity of 1×10^{-4} cm/sec to 1×10^{-5} cm/sec typically meet these criteria.

The middle layer is a two inch layer of pea gravel with soil overlying it to support vegetation. The top layer (the soil) must be flat to allow the water to disperse evenly over the infiltration basin for greater effectiveness. It is recommended that the infiltration basin be constructed to cover as large an area as possible in order to keep the stormwater as shallow as possible and to decrease the infiltration time.

Infiltration Trenches

Infiltration trenches must have four components to filter stormwater effectively. After excavation is complete, the first component is geotextile filter fabric placed on the sides of the trench. Secondly, the bottom of the trench must have a minimum of six inches of clean sand. Thirdly, there must be a minimum of four feet of clean gravel on top of the sand. River gravel with rounded edges is best because it has greater pore space. Last is a two inch (minimum) layer of pea gravel on the top of the river gravel.

Both types of infiltration structures should be designed with at least one observation well so that the person in charge of maintenance can determine whether the system is functioning properly.

Caution: No infiltration structure may be constructed within 30 feet of surface water, within 100 feet of any water well, within 30 feet of a sewage disposal system, or within less than 25 feet downgradient of structures. Other types of stormwater management structures should be considered in industrial and/or commercial areas that are prone to spill contaminants that could have adverse impacts on water.

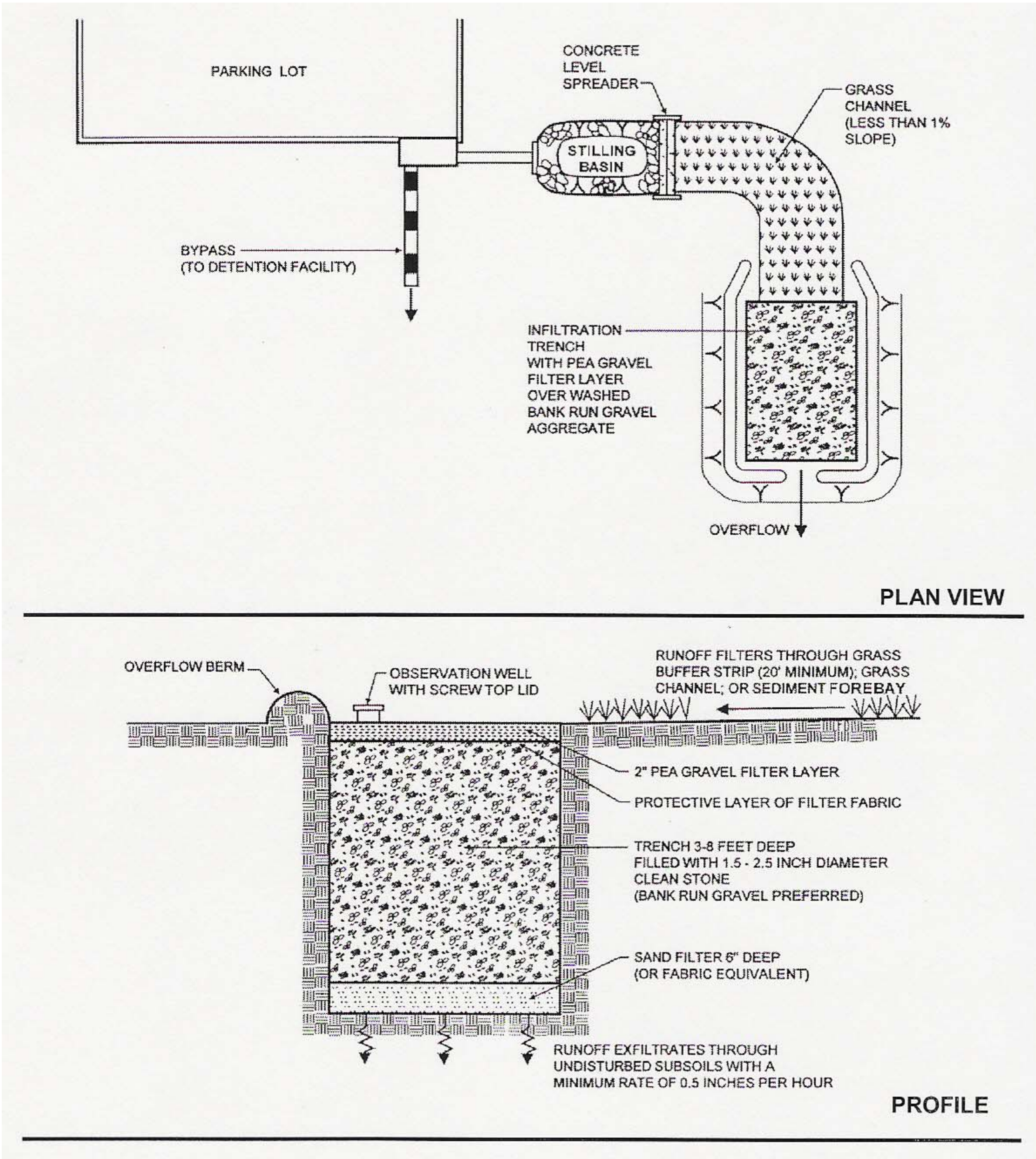
Caution: Both surface and subsurface discharges from a stormwater infiltration structure may require a permit (Construction Stormwater/NPDES General Permit or Stormwater UIC Permit) from the WVDEP. Information regarding these permits can be obtained from:

West Virginia Department of Environmental Protection
Division of Water and Waste Management
Permitting Section
Attn: Belinda Beller or Randolph Ramsey
601 57th St., S.E.
Charleston, WV 25304
Phone: (304) 926-0499 ext. 1047 or 1092

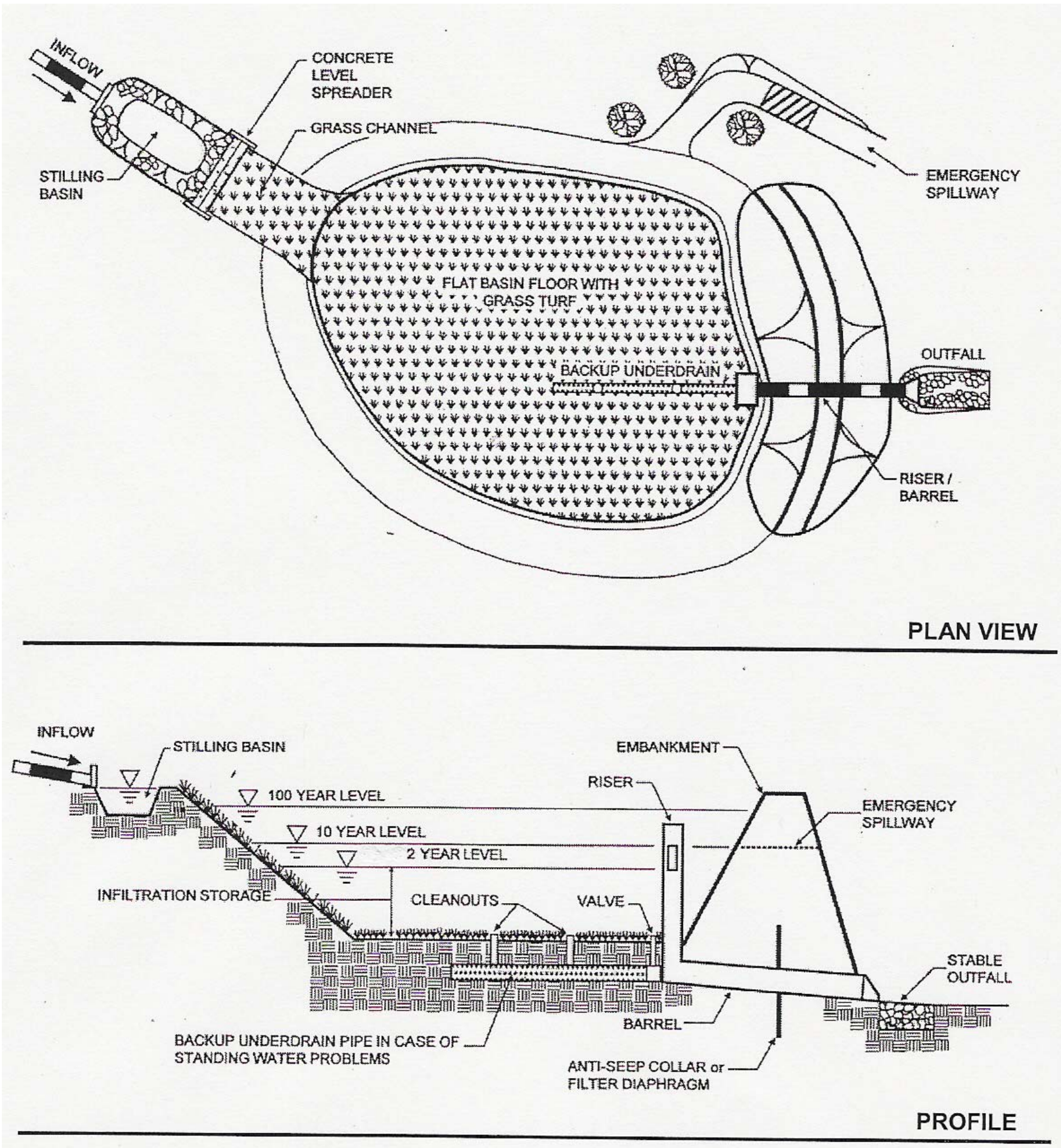
West Virginia Department of Environmental Protection
Division of Water and Waste Management
UIC/Groundwater Program
Attn: Don Criss
601 57th St., S.E.
Charleston, WV 25304
Phone: (304) 354-0474

The following diagrams are examples of infiltration structures.

Example of an Infiltration Trench



Example of an Infiltration Basin



Chapter 9

Filtration Structures

Filtration structures such as sand and organic filters are typically used in highly impervious areas with spatial constraints. These are excellent stormwater management options when the geology and soil types are unsuitable for other types of structures. Studies have shown that a properly designed and maintained filtration structure can remove 80% of TSS, as well as many metals and hydrocarbons, for an area no larger than 10 acres.

There are several different filtration structure designs such as surface sand filters, underground sand filters, perimeter sand filters, organic filters. Although they are designed differently, all are required to have at least two filtering components: the sediment chamber and the filter bed.

The sediment chamber is the section where stormwater flow first enters and deposits the majority of the TSS. The sediment chamber also helps ensure that the stormwater moves as a sheetflow.

The sediment chamber must have a minimum volume of 540 ft^3 and a minimum surface area of 360 ft^2 per acre of drainage area. It must be at least 18 inches deep and conduct the stormwater to the filter bed in a sheet flow.

The filter bed removes the remaining TSS and contaminants that have been adsorbed by TSS provide an environment that can support microorganisms and maximize the biological degradation of contaminants.

The filter bed must have a minimum volume of 540 ft^3 and a minimum surface area of 360 ft^2 per acre of drainage area. It may have an outlet pipe no larger than six inches in a gravel underdrain system or have an open bottom that infiltrates directly to the subsurface.

Whether the filter bed is designed with a pipe outlet or open bottom, it must be able to drain completely within 24 hours. A pipe outlet typically discharges treated stormwater onto the grounds surface, whereas an open bottom system allows treated stormwater to infiltrate directly into underlying soil. Please note that the use of an open bottom system will require a Stormwater UIC Permit.

Due to filtration systems high susceptibility to clogging, it is recommended that pretreatment structures such as vegetative filter strips be used. This will help increase the effectiveness of the filtration structure as well as decrease the frequency of maintenance.

For stormwater runoff areas exceeding five acres, only surface filtration structures may used. Subsurface systems are typically designed for stormwater runoff areas up to two acres in size, but can be designed to accommodate areas up to five acres.

Caution: Filtration structures can be only used in areas that have been stabilized to reduce the risk of clogging.

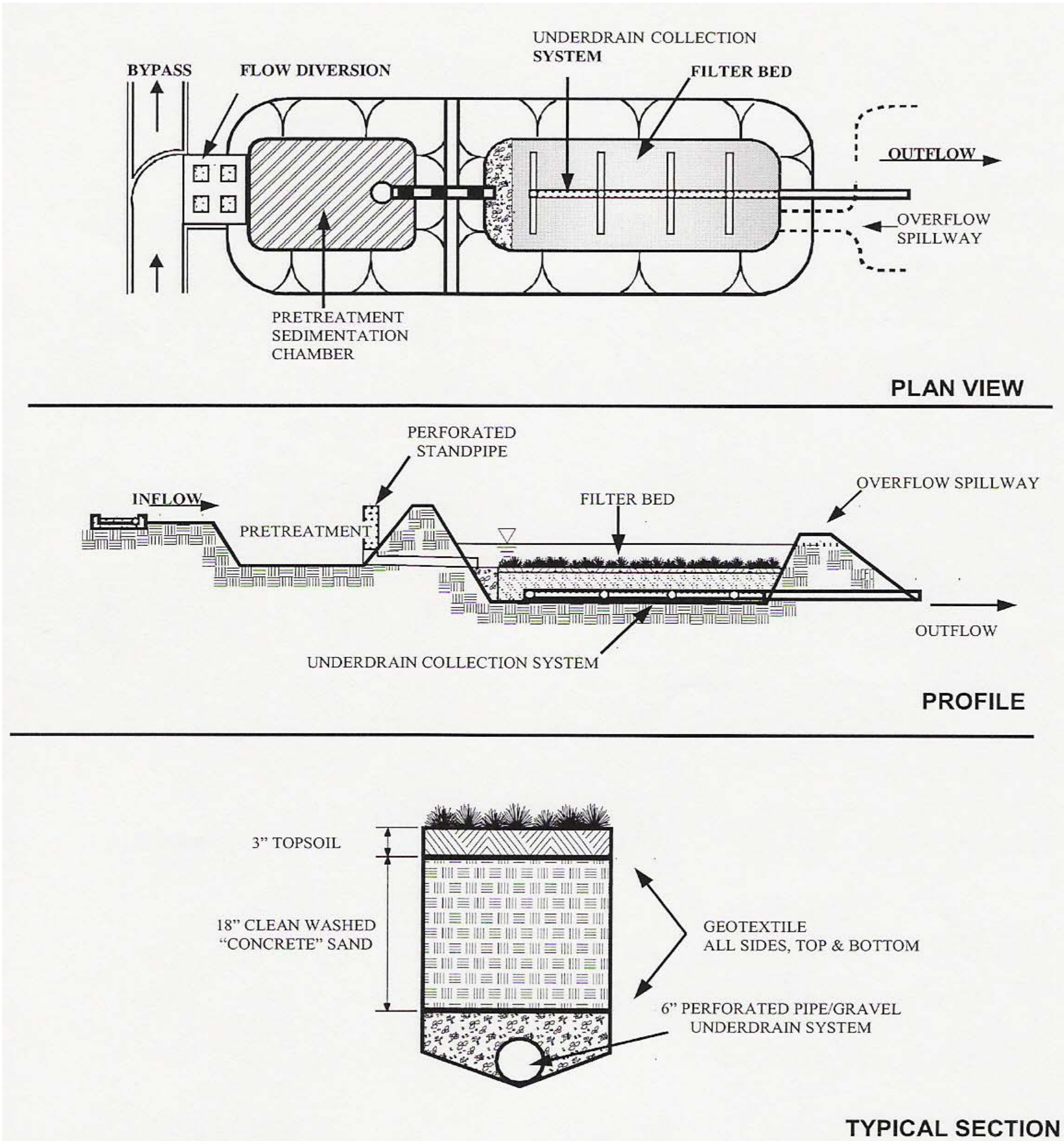
Caution: Surface discharges from a stormwater filtration structure may require a permit (Construction Stormwater/NPDES General Permit) and subsurface discharges must obtain a permit (Stormwater UIC Permit) from the WVDEP. Information regarding these permits can be obtained from:

West Virginia Department of Environmental Protection
Division of Water and Waste Management
Permitting Section
Attn: Belinda Beller or Randolph Ramsey
601 57th St., S.E.
Charleston, WV 25304
Phone: (304) 926-0499 ext. 1047 or 1092

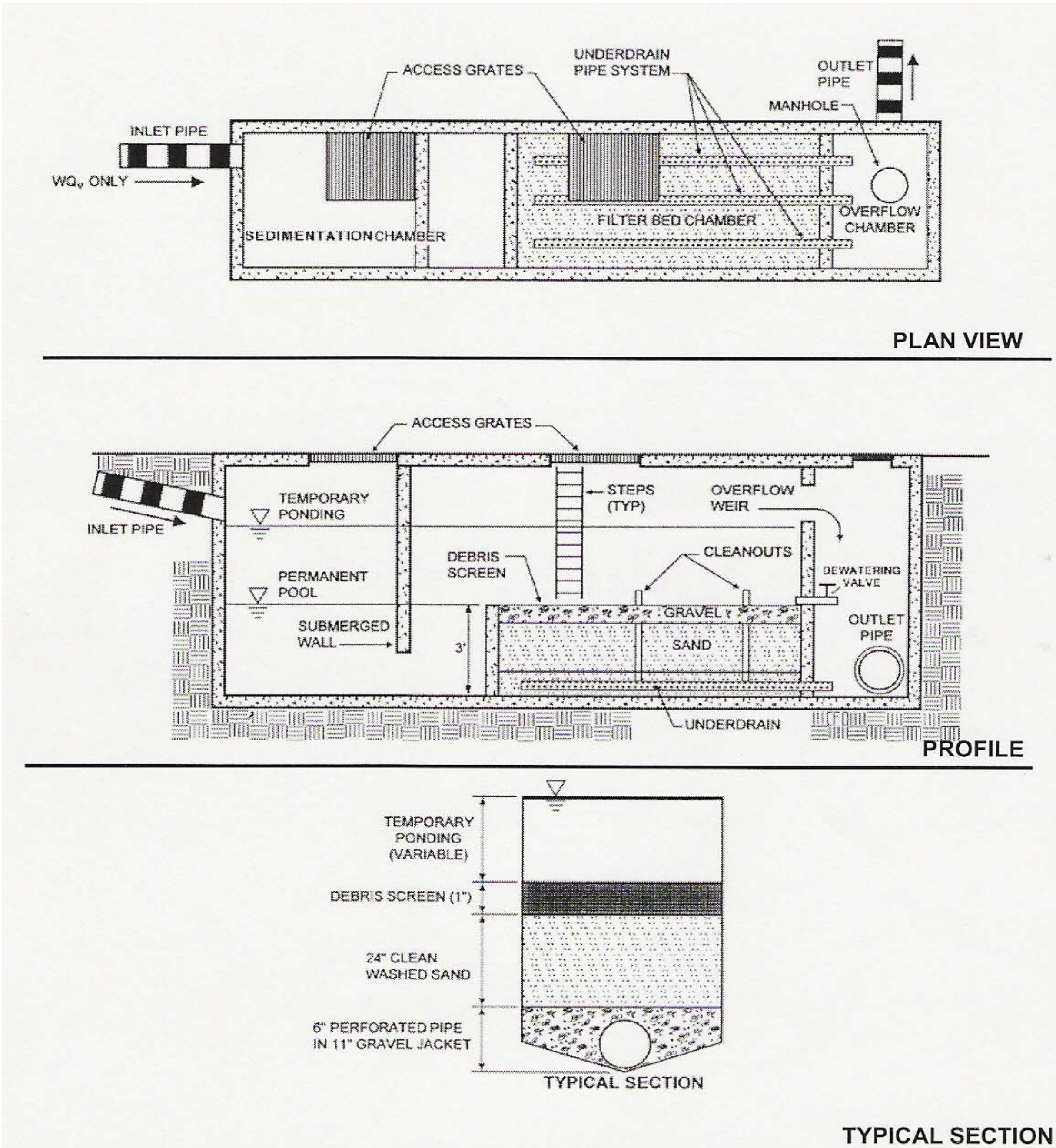
West Virginia Department of Environmental Protection
Division of Water and Waste Management
UIC/Groundwater Program
Attn: Don Criss
601 57th St., S.E.
Charleston, WV 25304
Phone: (304) 354-0474

The following diagrams are examples of filtration structures.

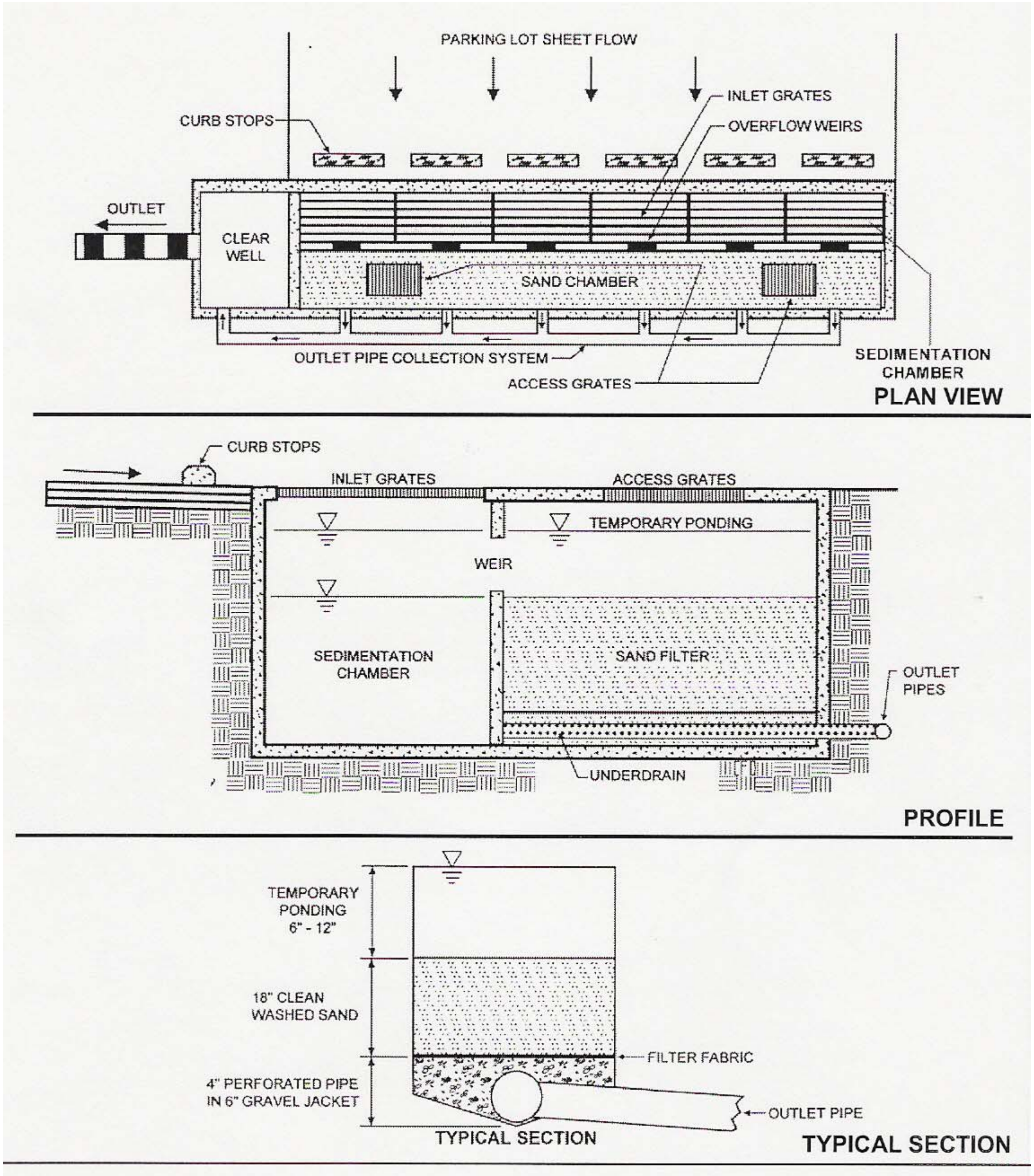
Example of a Surface Sand Filter



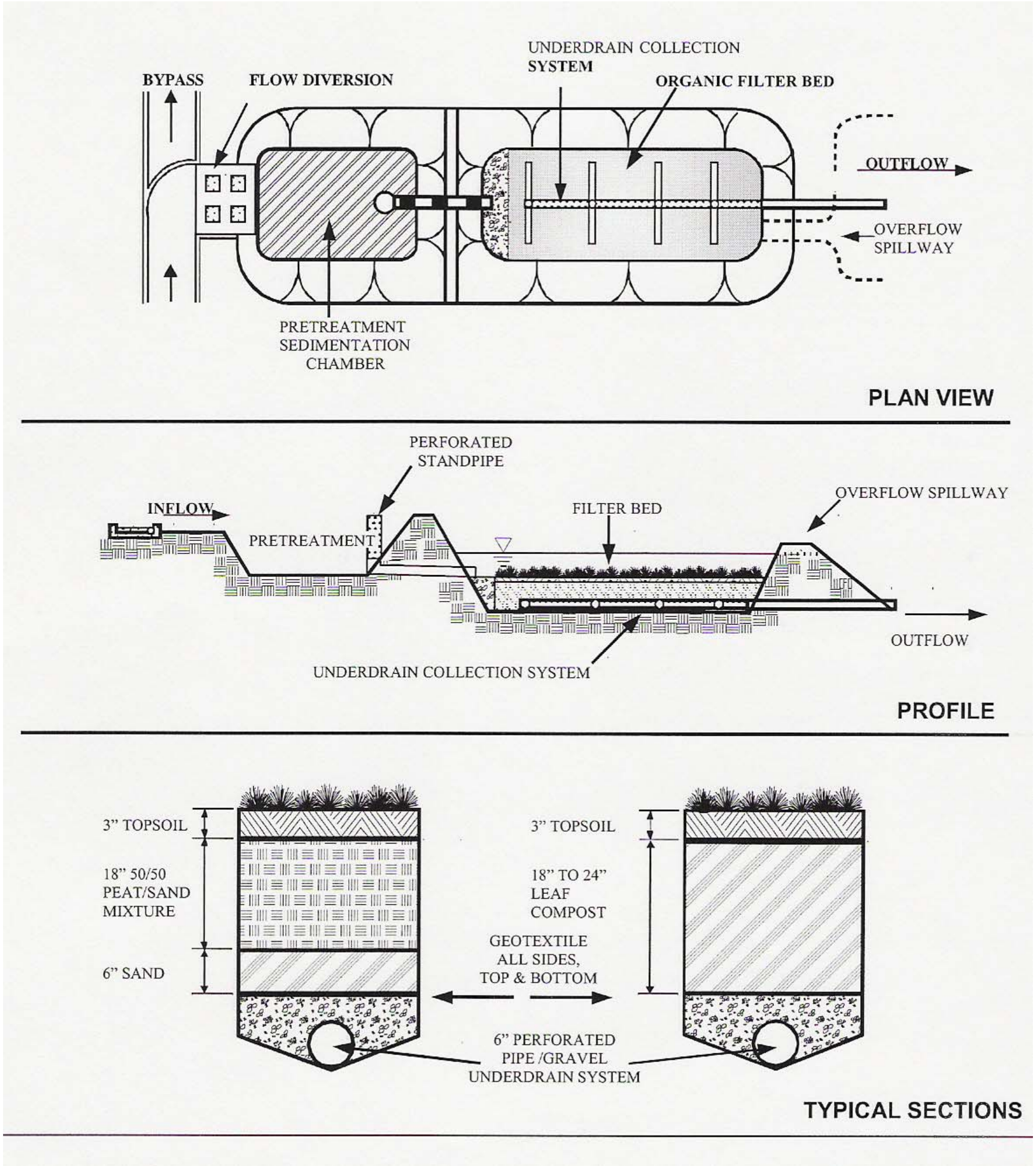
Example of an Underground Sand Filter



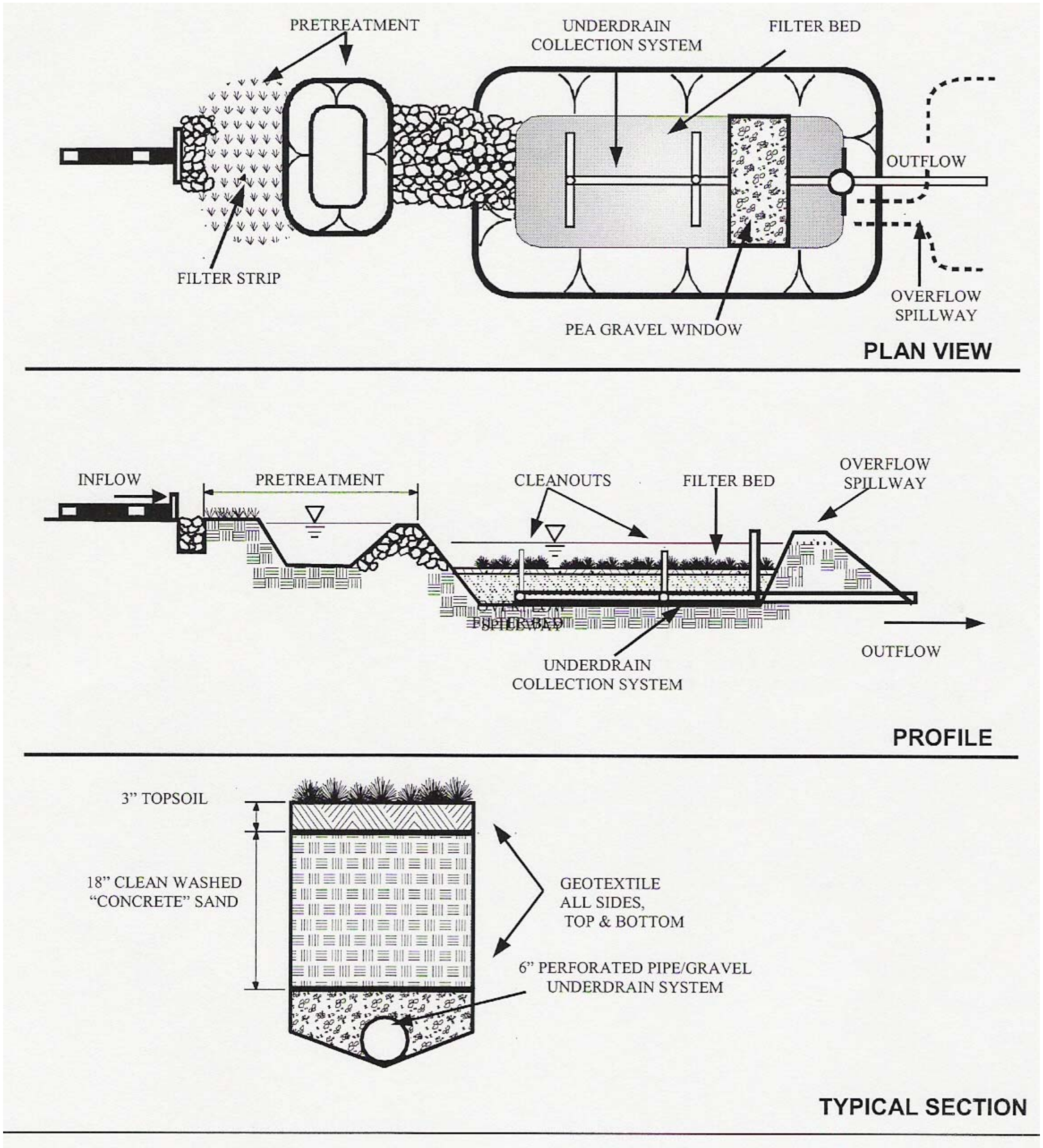
Example of a Perimeter Sand Filter



Example of an Organic Filter



Example of an Pocket Sand Filter



Chapter 10

Open Channel Systems

Open channel systems are structures that are capable of effectively managing stormwater runoff from small impervious areas and from highway runoff in relatively flat lying areas. There are two basic open channel system designs: dry swale and wet swale.

Dry swales resemble grass swales, but are designed, constructed, and manage stormwater differently.

The dry swale must be excavated and there must be at least two feet from the seasonal high groundwater table or bedrock to the bottom of the excavation with six inches of gravel over a four inch perforated underdrain. A geotextile filter fabric is then installed on top of the gravel layer. Next, a 30 inch layer of permeable soil is added for infiltration. The soil must have a minimum ponding time of one hour and a maximum time of 48 hours. Vegetation is planted on top of the soil layer, using grass that can survive both storm events and periods of drought. A plant nursery should be consulted to ensure that the appropriate types of plants will be utilized according to the environmental conditions of the area.

Stormwater pretreatment is required for all open channel systems. The dry swales should have a forebay to allow TSS to settle prior to entering and to evenly disperse stormwater over the open channel. If a forebay is not constructed, a pea gravel diaphragm must be used to spread the stormwater runoff evenly over the dry swale and reduce clogging.

The open channel system cannot have a slope greater than 3:1 and a flatter slope is highly recommended. The width of the bottom of the channel must be two to eight feet in order to spread the stormwater runoff throughout the dry swale without causing braiding or channeling in the structure. Longitudinal slopes should be constructed from 2% to 4%. If the longitudinal slope exceeds 4%, check dams should be placed to reduce the flow velocity to approximately 2 fps.

Wet swales are constructed the same as dry swales, except that the water table may be above the bottom of the channel. Also, an underdrain system cannot used.

Wet swales should be used with caution because they are usually not aesthetically pleasing, can cause objectionable odors, and may become a breeding ground for mosquitoes and other insects.

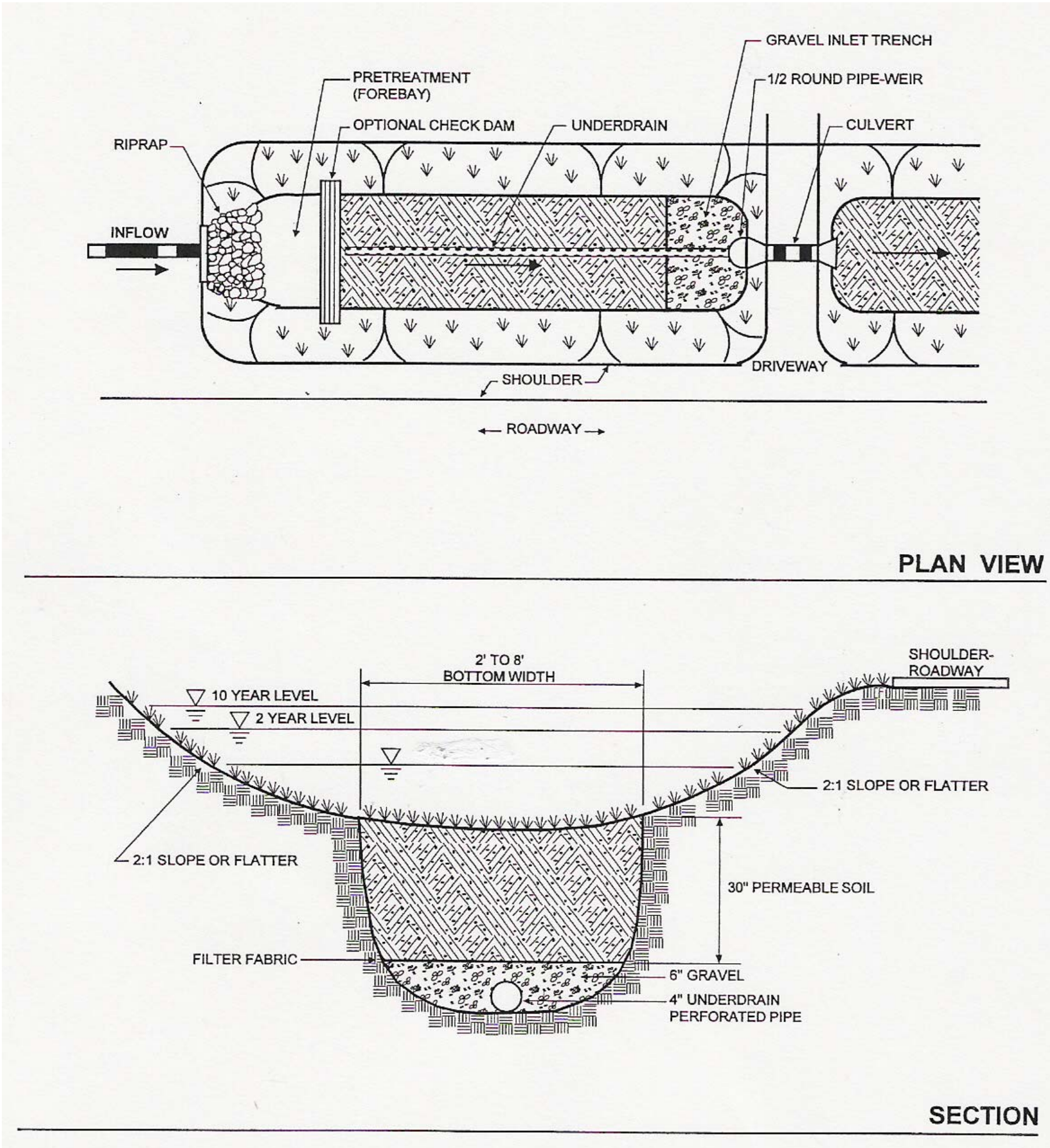
Caution: Both surface and subsurface discharges from a stormwater open channel system may require a permit (Construction Stormwater/NPDES General Permit or Stormwater UIC Permit) from the WVDEP. Information regarding these permits can be obtained from:

West Virginia Department of Environmental Protection
Division of Water and Waste Management
Permitting Section
Attn: Belinda Beller or Randolph Ramsey
601 57th St., S.E.
Charleston, WV 25304
Phone: (304) 926-0499 ext. 1047 or 1092

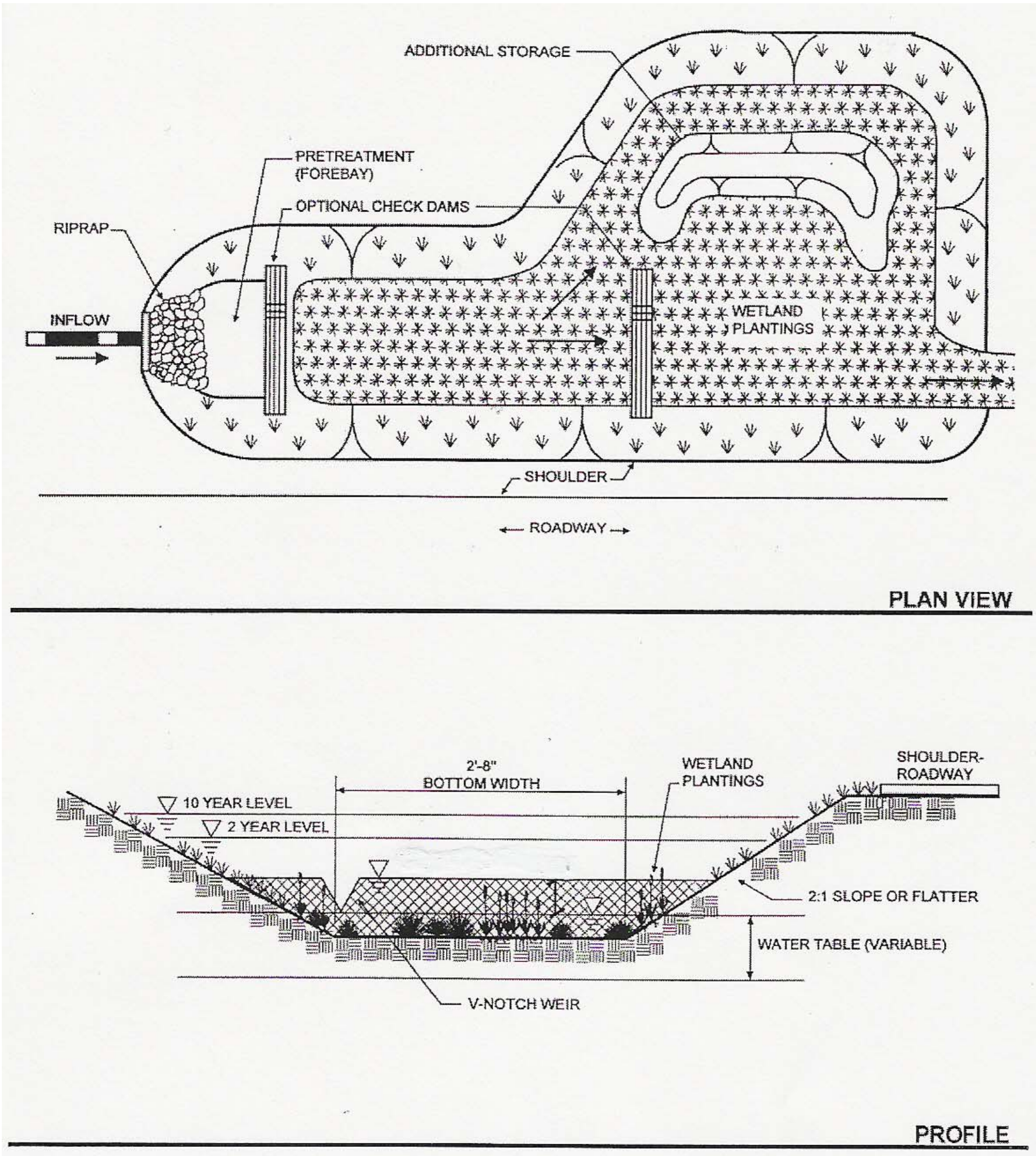
West Virginia Department of Environmental Protection
Division of Water and Waste Management
UIC/Groundwater Program
Attn: Don Criss
601 57th St., S.E.
Charleston, WV 25304
Phone: (304) 354-0474

The following diagrams are examples of open channel systems.

Example of a Dry Swale



Example of a Wet Swale



Chapter 11

Dry Wells

Dry wells are subsurface infiltration structures that are constructed vertically and/or horizontally and manage small amounts of stormwater runoff. Dry wells are the poorest choice of disposal of stormwater as they offer relatively little opportunity for mitigation of potential contaminants other than a limited ability to filter some of the total suspended solids in stormwater effluent. Additionally, the ability of drywells to filter some of the total suspended solids in stormwater effluent is limited to areas where NRCS Type A and B soils with a hydraulic conductivity are present.

Caution: No dry well may be constructed in areas where there is a potential for major sediment loading or the release of potential contaminants such as hydrocarbons of any type, metals, solvents, agricultural runoff, or contaminants from other commercial/industrial processes. No dry well may be constructed in areas where stormwater effluent from vehicle maintenance, fueling stations, or other commercial/industrial facilities that may produce potential contamination may enter into the subsurface. Also, contaminants from air deposition on roofs is a major concern. It is strongly encouraged that homeowners use structures such as splash guards or rain barrels to handle roof runoff. This would also prevent the homeowner from having to obtain a Stormwater UIC permit.

Caution: Both surface and subsurface discharges from a dry well require a permit (Construction Stormwater/NPDES General Permit or Stormwater UIC Permit) from the WVDEP. If a Stormwater UIC Permit is desired, potential permittees will be required to perform stringent sampling and monitoring of the discharged effluent to ensure protection of groundwater resources as directed by the WVDEP. Stormwater recharge to groundwater is acceptable only when the impacts to groundwater quality can comply with the Groundwater Protection Standards set forth in Title 46, Series 12, “Requirements Governing Groundwater Standards” as established by the West Virginia Environmental Quality Board and authorized by the Groundwater Protection Act, Chapter 22, Article 12, of the West Virginia Code.

Information regarding Construction Stormwater/NPDES General Permit or Stormwater UIC Permits can be obtained from:

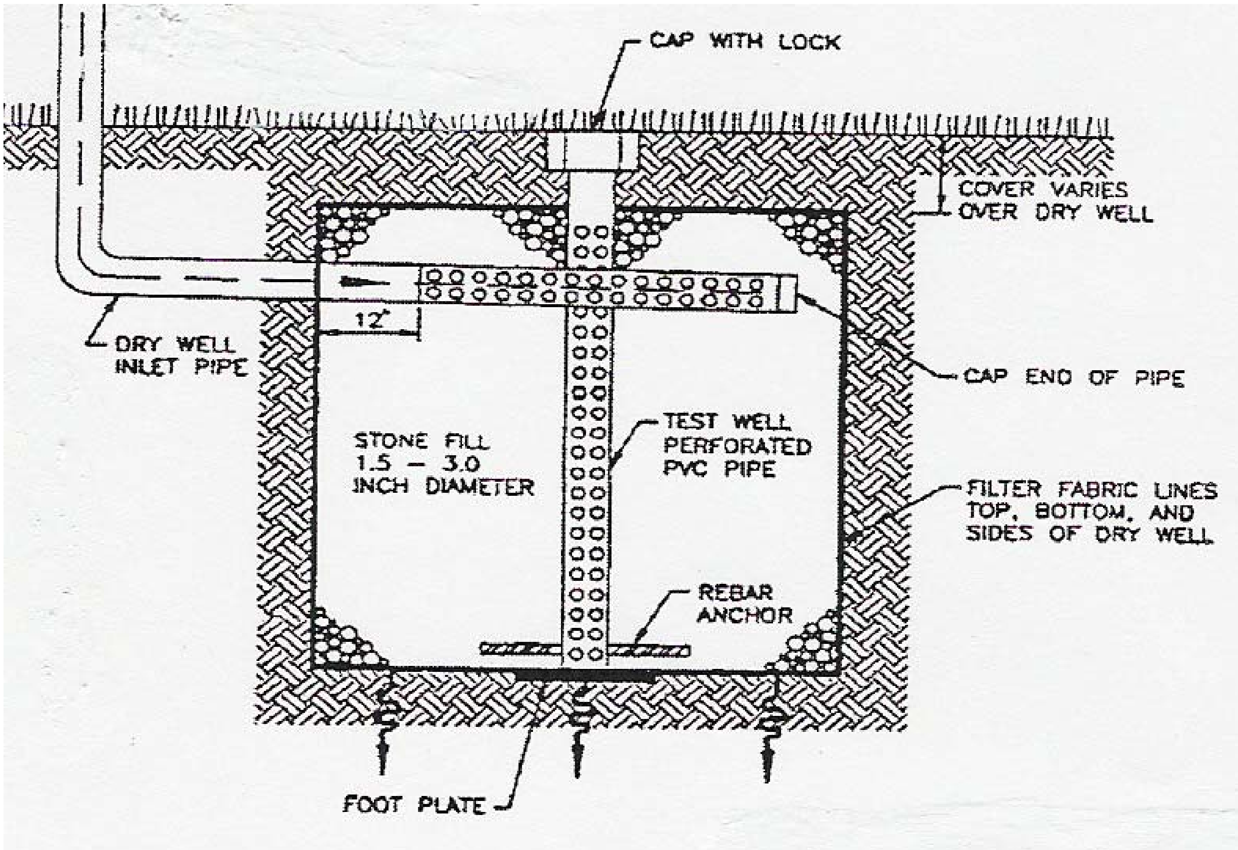
West Virginia Department of Environmental Protection
Division of Water and Waste Management
Permitting Section
Attn: Belinda Beller or Randolph Ramsey
601 57th Street, SE
Charleston, WV 25304

Phone: (304) 926-0499, ext. 1047 or 1092

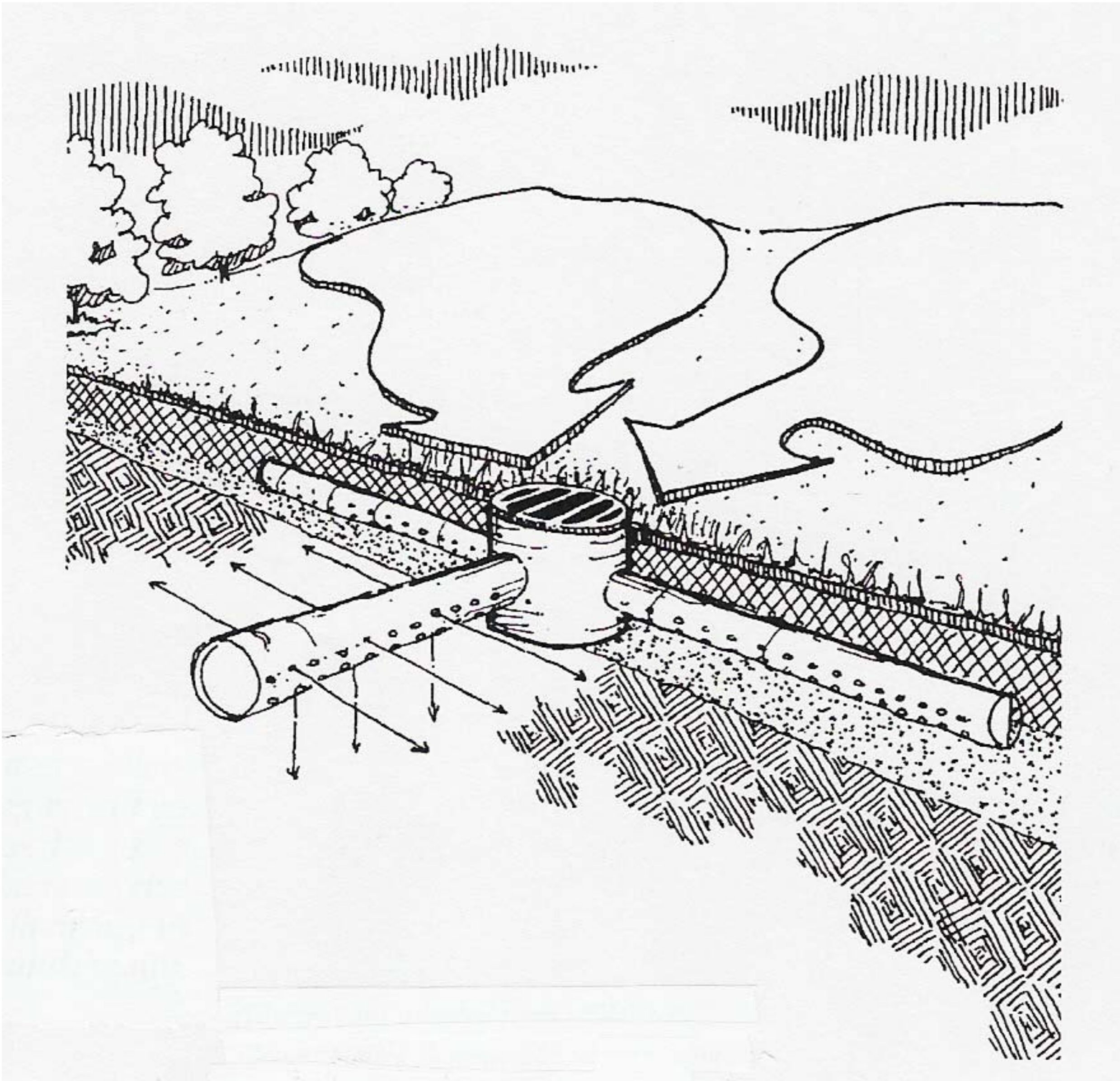
West Virginia Department of Environmental Protection
Division of Water and Waste Management
Groundwater/UIC Program
Attn: Don Criss
601 57th Street, SE
Charleston, WV 25304
Phone: (304) 354-0474

The following diagrams are examples of dry wells.

Example of a Dry Well



Example of a Dry Well



Chapter 12

Monitoring and Maintenance of Structures

The use of management structures is advantageous in that groundwater recharge is achieved, potential contaminants restricted from reaching aquifers, and they are relatively simple to construct. However, such structures may be difficult to site in areas where soils contain higher percentages of silts and clays, and sufficient distance from the seasonal high water table, wells, and structures may be unattainable.

Management structures may also function more efficiently and with less maintenance if pretreatment is used. Biofilters (swabs or strips) are highly recommended and well suited for removing settleable material prior to discharging to the infiltration structure. Tributary areas with highly stabilized pervious cover may not require pretreatment, being considered a natural mechanism to remove potential contaminants that could otherwise contaminate groundwater.

Management structures are just one of the Best Management Practices (BMPs) that can be employed to recharge groundwater and achieve groundwater and surface water quality goals. Consequently, in instances where there is significant uncertainty as to the potential for groundwater contamination by the management structure, another type of BMP may be a better solution.

Monitoring Monitoring of the stormwater management structure may be required as a part of the maintenance program to ensure that groundwater supplies are protected. The WVDEP may require such monitoring as is reasonable to fulfill its regulatory responsibilities under Title 47, Series 58, "Groundwater Protection Rules".

If monitoring is required, at a minimum one monitoring well should be installed up gradient and another down gradient of the management structure, both of them outside the maintenance area, for sampling purposes. The number and placement of groundwater monitoring wells may be adjusted relative to the type of strata, the depth to groundwater, and the beneficial uses of the groundwater in the area of the infiltration structure.

Note: The installation, construction, alteration and abandonment of all monitoring wells must be conducted according to Title 47, Series 60, "Monitoring Well Design Standards" by a West Virginia certified monitoring well driller according to Title 47, Series 59, "Monitoring Well Rules".

Maintenance Maintenance of management structures is absolutely essential for effective operation. Infiltration structures will clog over time, as indicated by increasingly long drain times from a full condition.

Maintenance Guidelines

- ❖ Sediments should be removed from infiltration basins to restore infiltration capacity when the drain time from a full structure exceeds 72 hours.

- ❖ Sediment removal should only be carried out when the structure is dry.

- ❖ The structure owner and/or maintainer must ensure that the sediment is removed without damaging the structure and is properly disposed of. The owner and/or maintainer must keep a record of the dates sediment was removed, amounts of sediment removed, and the location to which it was taken.

- ❖ Only rubber-tired vehicles should be used in the maintenance activities and the equipment should be as small and light as possible.

- ❖ Basins should be tilled annually to aerate soils, and an appropriate vegetative cover should be cultivated on the basin side slopes and floor.

- ❖ Management trenches may begin to lose storage volume as sediment accumulates in the rock matrix. Most trench designs include a layer of filter fabric approximately 1 foot below the trench surface to extend maintenance periods. However, the entire rock matrix must be removed once it becomes filled with sediment, although only the top one foot and the filter fabric must be serviced in most instances.

- ❖ Management structures should be inspected after each storm event to observe how long runoff remains in the structure. Management trenches are generally designed with an observation well for this purpose. Other inspection criteria include erosion, growth of woody vegetation, sediment accumulation, and the coverage of vegetation (basins).

- ❖ Vegetation in basins and trenches should be maintained at a height of approximately 6 inches to preclude vector control problems. A maintenance schedule is important to ensure that the structure does not become a jurisdictional wetland. The jurisdictional agencies (WVDEP and WVDNR) may require an initial agreement for the consistent maintenance of the basin. All clippings and vegetation should be removed from the basin during maintenance operations.

- ❖ Pesticide and herbicide use near the site should be limited and used only when necessary, as these are potential contaminants that could adversely affect surface water and groundwater.

- Remulching the cover in the stormwater management structure will probably be necessary between storm events. A thickness of one to three inches of cover should be maintained in structures such as bioretention areas for optimum performance.

Chapter 13

Groundwater Protection Plans (GPP's)

47 CSR 58, "Groundwater Protection Rules" Section 4.11 requires that "Each industrial establishment shall have a comprehensive Groundwater Protection Plan (GPP)." The term "Industrial Establishment" may include facilities that have, or shall be required to have, impoundments, ponds, or lagoons at any commercial, municipal, state, or federal facility on any property within the state.

Facilities that also implement a Federal Stormwater Pollution Prevention Plan (SWPPP) or Spill Prevention, Control and Countermeasures Plan (SPCC) may combine these documents with the GPP, as long as all elements required by 47 CSR 58 are included.

Section 4.12.b mandates that new facilities have a completed GPP prior to construction. The GPP requires the owner or operator of such facility to address (through an inventory review) all the potential groundwater contamination sources, including, but not limited to, impoundments, ponds, lagoons, above and underground tanks, non-containerized outside storage areas, drum storage, loading and unloading areas, and stormwater effluent.

Section 4.12.c. requires that the GPP be on site and available for inspection at all times. It also requires that the GPP be submitted and reviewed as part of any NPDES Permit application or renewal, and that the Director may review the GPP at any time. The Phase II NPDES Stormwater permit requires the submittal of a GPP prior to construction of any permanent stormwater management pond.

Section 4.12.d. states, "The Director may require modification to the GPP to assure adequate protection of groundwater. Further, the Director may, during review of a GPP, require such other information as he/she reasonably needs to evaluate the plan."

Section 5.1 states, "Where a statute, rule, ordinance, or other legal requirement (other than West Virginia Code 22-12 and rules promulgated pursuant thereto) provides authority to regulate facilities and activities which may adversely affect groundwater, and such facilities and activities are not regulated by another groundwater regulatory agency, including another office or division of the Department of Environmental Protection, the Director may require such facility or activity to comply with any or all of the requirements of this rule which the Director reasonably determines to be necessary for the implementation of West Virginia Code 22-12." A few of these facilities and activities which the Director has designated as having the potential to adversely affect the groundwater include housing developments, retail malls, short- and long-term parking lots, streets and roads, construction activities, and various commercial and manufacturing activities.

Section 5.2 states, “The Director must provide a written notification specifying which section(s) of this rule will be enforced, before compliance with this rule or any provision thereof is required from any facility or activity not included in the definition of an industrial establishment.”

Note: The NPDES Phase II Stormwater Construction permit and this guidance document serve as **written notice** from the Director to any person who builds, constructs, alters, or demolishes any structure whether permanent or temporary; be it pre or post construction, including any ancillary structures or activities associated with the building, construction, alteration, or demolition of such structures including any post construction operation of such structures shall develop and implement a Groundwater Protection Plan (GPP).

A GPP for Stormwater Management Structures is included in this guidance document (Page 71). The GPPs are also available from Rick Shaver at the Division of Water and Waste Management, Groundwater Program at (304) 926-0499, ext. 1052, Fax (304) 926-0496, TDD (304) 926-0489, or rshaver@wvdep.org.

The submittal of all Stormwater Management Structure Operation and Maintenance Phase GPPs must be directed to the West Virginia Department of Environmental Protection, Division of Water and Waste Management, Groundwater Program, Attn: Rick Shaver, 601 57th St., S.E., Charleston, WV 25304. (For Berkeley, Grant, Hardy, Hampshire, Jefferson, Mineral, Morgan, and Pendleton Counties, an **additional** copy of Stormwater Management Structure Operation and Maintenance Phase GPPs must be submitted to Twila Carr, WVDEP, at 3810 Greensburg Road, Martinsburg, WV 25401.)

Please use the following table as a guide for determining if a particular activity requires a Groundwater Protection Plan or a permit. This table is based on existing facilities and is subject to frequent revision.

POTENTIAL GPP and PERMIT SCENARIOS

Type of Property or Facility	**GPP Required**	**Permit Required**
Construction Site	YES – Construction Phase GPP	NPDES Stormwater
Industrial or Commercial Facility discharging to surface water	YES	NPDES Stormwater or Individual
Residential Site with Stormwater Management Pond	YES – Operation and Maintenance Phase GPP	NPDES Stormwater
Residential Site with Stormwater Management Structure accepting drainage from Fuel Storage or Industrial Facility	YES – Operation and Maintenance Phase GPP	NPDES Stormwater

Fuel Storage Facility with Aboveground Storage Tanks discharging to surface water	YES	NPDES Stormwater
Any Industrial, Commercial, or Residential complexes which discharge to a permanent stormwater structure	YES – Operation and Maintenance Phase GPP	NPDES Stormwater
Car Wash discharging to surface water	YES	NPDES
Car Wash discharging to groundwater	STRICTLY PROHIBITED	STRICTLY PROHIBITED
Any Facility discharging directly to groundwater	YES	UIC
Roof Runoff	STRICTLY PROHIBITED	STRICTLY PROHIBITED

GPP SECTIONS

SECTION 4.11.a. "An inventory of any and all operations that ***may reasonably be expected to*** contaminate the groundwater resources with an indication of the potential for soil and groundwater contamination from these operations."

The inventory should include a list of all processes, materials, and other activities that could contaminate groundwater. Examples are: fertilizers, aboveground storage tanks, batteries, lubricants, and parts cleaners. Stormwater management structures should be included.

The GPP should include a description of how the stormwater management structure will be used and maintained during the construction and post-construction phases (see Appendix One). A description of the use of fuel, solvents, chemical de-icers, fertilizers, and pesticides as affecting the structure should be included.

A site plan showing the structure and structure cross sections should be included with the GPP, as well as the location of any other potential sources of groundwater contamination. The site plan shall include the relative position of the potential sources of contamination in relationship to the stormwater management pond and the relative drainage areas of these potential sources of contamination.

SECTION 4.11.b. "A description of procedures designed to protect groundwater from the identified potential contamination sources, with specific attention given to the handling, transport, and storage of potential sources of contamination.

This section should describe all potential groundwater contamination sources as identified in 4.11.a above. It should also list the procedures (including operating practices and physical installations) that would prevent or mitigate groundwater contamination for each of these potential sources. These must include emergency responder contact information, spill response and cleanup procedures, and an inventory of cleanup equipment and supplies (absorbent materials, booms, etc.).

All proposed structure designs and site descriptions must be submitted and approved prior to construction. The design should also include any state or local construction requirements, e.g., the county planning commission, other local government or management entities such as a Public Service District (PSD).

Site Selection Criteria (47-CSR-58, Section 4.10) are important considerations when a facility or development intends to construct new or expand existing areas. Adequate design of the stormwater management structures must be considered in the GPP, especially when constructing or expanding in areas of karst, faulted or fractured terrains, areas of subsidence, wetlands, delineated wellhead protection areas, Source Water Protection areas as determined by the Bureau for Public Health, or other areas deemed by the Director to be vulnerable based upon geologic or hydrogeologic information.

If an existing or planned facility or development is located in or near one or more of these vulnerable areas, this must be addressed in the GPP. The facility must revise their existing GPP to address any newly delineated areas or other vulnerable areas upon notification by the Bureau for Public Health or the Director of WVDEP.

Disclaimer: The GPP is not intended to serve as construction criteria for stormwater management pond design. The GPP's intent is to serve as an inventory, evaluation, and implementation document to prevent and/or mitigate potential impacts to the groundwater from the stormwater management structure. Appendix Two provides guidance criteria that is employed by the WVDEP in approving permanent stormwater management structures.

Two Elements That Are Essential to GPP Approval Infiltration of stormwater runoff to groundwater through stormwater management structures is a critical issue to stormwater structure design in the review and approval of GPPs. The discharge to groundwater through stormwater management structures to replenish the groundwater table is desirable, especially in drought stricken areas.

Stormwater management structures can be designed to allow slow infiltration into groundwater provided that mitigating practices are employed prior to the stormwater reaching the structure. **The employment of mitigating practices to eliminate potential contaminants from reaching the stormwater management structure** is one of two essential elements in WVDEP's approval of a stormwater management structure design.

The other essential element is **a responsible management entity**. The need to properly manage the stormwater structure and to oversee the proper employment and maintenance of mitigating measures is critical to the success of such measures in minimizing or eliminating potential contaminants introduced into the structure via runoff. Typically, the property owner will need to hire a consulting firm or employ qualified personnel to properly inspect and maintain the structure(s).

There are current opportunities through existing statutory authority to establish management entities at the local governmental level or through PSDs. Local governments or PSDs, through ordinances or restrictions, can impose construction and maintenance criteria on both commercial and residential developments that would ensure the application of mitigating factors in managing stormwater runoff.

Without incorporating these two essential factors in stormwater management structure design, construction, and maintenance, it is unlikely that infiltration of stormwater into the groundwater through these structures will be approved. Stormwater structures not employing these factors will in most instances be required to install a protective synthetic liner.

Please consider the following items when designing a stormwater management structure:

1. Structures excavated to bedrock in karst or fractured limestone areas that do not employ a liner system are required to obtain an Underground Injection Control (UIC) permit from the Division of Water and Waste Management prior to construction and operations. Industrial facilities or developments, including streets and highways that discharge fluid into or otherwise direct drainage into sinkholes or any other subsurface injection system are required to obtain an UIC permit prior to any subsurface discharge.

2. Impervious areas should be kept to a minimum and vegetated areas should be employed to the greatest extent possible. Vegetated areas (*i.e.*, green areas—trees, shrubs, grassy swales) should be incorporated into all parking lot designs. These areas need to be designed to keep

sheet flow at a slow rate and should be wide with a gradual slope. Diversion structures in the swales can also diminish sheet flow velocity.

3. Structure design approval will depend largely on site characteristics (*e.g.*, loading and unloading areas, parking lots, streets and highways, roof drains, process areas, maintenance areas, storage areas, etc.) and mitigating practices (*e.g.*, grassy swales, housekeeping practices, containment areas, spill prevention, emergency response plans, and responsible entities for pond management, etc.) employed to prevent potential contaminated discharges to the structure.

4. Stormwater from parking lots should be channeled in such a way as to divert all stormwater from impervious areas through a series of grassy or densely vegetated swales before entering the stormwater management structures. Trees should be planted in conical depressions to detain small portions of the stormwater runoff. Vegetation should be employed that is conducive to the local climate, requires wet conditions, and is a natural repellent of pests such as mosquitoes.

5. Discharges to Stormwater Management Structures not included in the GPP are strictly prohibited and will subject the discharger to penalties according to Chapter 22, Article 12, Section 10, "Groundwater Protection Act."

Note: Stormwater Management Structures must be clearly marked with a sign in a visible location

STORMWATER MANAGEMENT STRUCTURE
Drinking Water Recharge Area
Do Not Dump Waste

SECTION 4.11.c. "A list of procedures to be employed in the design of any new equipment and/or operations."

All designs, construction, and operational phases must be protective of groundwater. This may include improvements made on existing protection measures. This section should describe how groundwater protection measures will be implemented during any and all phases of work, and it should specify which personnel will be responsible for insuring that the groundwater protection measures are in place and functioning properly.

The following stormwater management structure design standards are required in karst, Wellhead Protection and Source Water Protection Areas, and/or Vulnerable Groundwater Use areas to allow, where there is an acceptable management entity, surface water infiltration to groundwater while protecting the groundwater quality from spills or other contaminants.

1. If allowed by the NPDES permit, stormwater structure depth should be as shallow as possible with a horizontal bottom (no deep spots), and shall be constructed to implement the requirements set forth by the NPDES criteria,

2. Maximum stormwater structure depth of ten feet, and

3. Fully vegetated basin side slopes and bottoms.

The above are the minimum requirements for stormwater management structure design in karst, Wellhead Protection, and/or Vulnerable Groundwater Use areas. More stringent requirements may apply for certain projects (*e.g.*, industrial and commercial sites), depending upon the potential for contamination of special areas as listed above. Examples of more stringent design features include:

1. More than two feet of material between the bedrock surface and the bottom and sides of the stormwater structure, or increased compaction criteria to reduce permeability,

2. Synthetic liners,

3. Sediment sumps at stormwater inlets,

4. Off-line treatment,

5. Special stormwater system design,

6. Groundwater monitoring, and

7. Paint, solvent, or oil and water separators.

Stormwater Management Structures requiring liners will be required to provide the following information within thirty days of structure completion:

1. Specification of clay liner lift thickness.

2. Specification of clay liner compaction data.

3. Documentation of clay and synthetic liner installation.

4. P.E. certification of as-built drawings of final installation.

Stormwater management system designers who do not propose to meet at least the minimum design standards listed above may seek approval for the alternative design through the GPP approval process. However, the system designer must provide reasonable assurance that state Groundwater Protection Standards are met. Additional design criteria may be required to satisfy NPDES permit, county or local government requirements.

SECTION 4.11.d. "A summary of all activities carried out under other regulatory programs that have relevance to groundwater protection…"

List any other permits, required spill prevention and response plans, registrations (*e.g.*, UST registration), certifications or other approvals, and any regulatory agencies that regulate groundwater protection measures at the facility.

Examples include:

- NPDES
- NPDES—Stormwater
- WVDEP—DWWM—UST
- CERCLA—Superfund
- WV Voluntary Remediation—(Brownfields)
- FIFRA—Federal Insecticide, Fungicide, and Rodenticide Act
- Well Head Protection Program (WHPP)
- Underground Injection Control (UIC)
- Toxic Substances Control Act—(TSCA)
- Best Management Plans
- Management of used oil
- RCRA
- Solid Waste Landfills (municipal, industrial, C&D, etc.)

SECTION 4.11.e. "A discussion of all available information reasonably available to the facility or activity regarding existing groundwater quality at, or which may be affected by the site."

This section should include any groundwater analyses for the facility or development; a summary of the previous year's data should be included if sampling has been conducted for more than a year. This should include the data from any contamination that has originated from off site. This section should also contain any other information that is available, such as soil type, geologic formation, depth to groundwater, location of existing monitoring wells, or the results of any septic system percolation tests conducted by the county health department. Analyses of drinking water wells, monitoring wells, springs, and seeps should also be included if available, and these well locations or other sampling points should be marked on the site map.

Monitoring wells and groundwater sampling may be required by the Director for the assessment of the potential for or existence of groundwater contamination, but are not required for every GPP.

Many sites have no groundwater monitoring data and should state that in this section.

SECTION 4.11.f. "A clarification that no wastes be used for deicing, fills, etc., unless provided for in existing rule."

Only commercially available de-icing or traction-improving products may be used for ice control on streets. De-icing on streets should be kept to a minimum where runoff is collected by the stormwater management pond. The use of abrasive traction-improving material (*e.g.*, sand) is preferred where practical to minimize the salt impact to groundwater.

The GPP must contain a statement that waste materials will not be used for deicing, fill, or any other use, unless that use is provided for in some other regulation, permit, or other groundwater regulatory agency approval. A temporary construction demolition permit (D2) might allow waste to be used for fill.

SECTION 4.11.g. "Provisions for all employees to be instructed and trained on their responsibility to ensure groundwater protection. Job procedures shall provide direction on how to prevent groundwater contamination."

Summarize the instruction and training given to all personnel who are responsible for pond maintenance for groundwater protection, including frequency of training. Pond maintenance is a critical issue in protecting groundwater and public and private drinking water sources. List the name(s) of those persons responsible for pond maintenance. If the pond maintenance is the responsibility of an authorized entity, list the name of that entity and the appropriate contact person. An authorized entity could be a management company, maintenance contractor, public service district, local governmental authority, or other body. See Appendix Two for further guidance on stormwater pond maintenance.

Training should include the following:

1. A summary of 47 CSR 58, “Groundwater Protection Rule.”

2. Location of groundwater protection structures, secondary containment units, and spill cleanup equipment.

3. A summary of likely potential groundwater contaminants at this facility or development.

4. Spill notification and documentation procedures.

Note: A homeowners association will **not** be recognized as an authorized entity for the purpose of stormwater management.

SECTION 4.11.h. At a minimum, “The GPP shall include provisions for quarterly inspections to ensure that all elements and equipment of the site’s groundwater protection program are in place, properly functioning, and appropriately managed.”

A minimum of four inspections per year of the GPP elements by authorized entity personnel is required. Although four inspections are required, more frequent inspections may be warranted, depending upon site-specific characteristics. It will also be necessary to inspect after significant rain events. This will be to identify sediment that would need to be removed or erosional activity that would need to be repaired. Inspection records are not required by the rule; however, documentation of these inspections can facilitate DEP inspections or demonstrate the entity’s good faith efforts to protect groundwater. The GPP should include a description of inspection procedures and how control structures and devices are maintained. Include a copy of the facility’s inspection form, if one is used. Include a copy of the stormwater management pond maintenance schedule.

SECTION 4.12. New facilities and developments are required to have a completed GPP prior to construction. Pre-construction GPPs will be reviewed by the Groundwater Program of the Division of Water and Waste Management.

The GPP must be available on site at all times for review by WVDEP personnel. The GPP will be required to be submitted as part of an NPDES permit application, renewal, modification, registration (of general permits), or when the stormwater management pond is left in place as a permanent structure.

The Director may require modification of a GPP to assure adequate protection of groundwater. If a facility does not have adequate groundwater protection practices in place, then they may submit a compliance schedule for implementation of necessary practices along with their permit renewal application, renewal, or notification. If approved, this compliance schedule will allow reasonable time to implement the necessary practices.

ENFORCEMENT

Failure to have a completed and implemented GPP is a violation of 47 CSR 58, "Groundwater Protection Rule."

Failure to follow any practice set forth in a GPP is a violation of the 47 CSR 58.

Caution: Complying with a GPP does not relieve the facility of any obligation to comply with any other Federal, state, or local rule, regulation, or statute.
Information regarding GPPs can be obtained from:

West Virginia Department of Environmental Protection
Division of Water and Waste Management
Groundwater/UIC Program
Attn: Rick Shaver
601 57th St., S.E.
Charleston, WV 25304
Phone: (304) 926-0499 ext. 1052

West Virginia Department of Environmental Protection
Division of Water and Waste Management
Groundwater/UIC Program
Attn: Twila Carr
3810 Greensburg Rd.
Martinsburg, WV 25404
Phone: (304) 267-0173

The following pages are a sample GPP to be completed and submitted for review prior to any stormwater management structures being constructed.

APPENDIX 1
GROUNDWATER PROTECTION PLAN
FOR STORMWATER MANAGEMENT STRUCTURE SITES

A Groundwater Protection Plan (GPP) for your project is required by WVDEP. The primary purpose of the GPP is to make the construction project operator aware that groundwater, by law, must be protected. Important parts are the inventory of all operations (materials and other activities) that "may reasonably be expected to" contaminate groundwater, and a description of procedures to prevent potential contamination from occurring due to sources in the inventory.

PROJECT NAME:
PROJECT LOCATION:

The form below will be your GPP after you:

1. Read and understand each GPP Section.

2. Fill in the information required box below each GPP Section. Add extra sheets if necessary.

3. Attach a location map and a site diagram or plan showing the location of all GPP inventory items.

4. Sign and date the GPP.

THE COMPLETED GPP MUST BE AVAILABLE ON SITE AT ALL TIMES (47CSR58, Section 4.12.c.)

GPP Section	Information Required
4.11.a. A list of all operations that may reasonably be expected to contaminate groundwater.	A list of all processes, materials, and other activities that could contaminate groundwater. Examples are fertilizers, aboveground storage tanks, batteries, lubricants, and parts cleaners. Stormwater management ponds should be included.

4.11.b. A description of procedures and facilities used to protect groundwater quality from the list of potential contaminant sources above.	Examples are secondary containment for aboveground storage tanks, or pads and shelters for drum storage, fertilizers, and parts cleaners. Include the following information for stormwater management ponds: 1. Construction method and proposed design drawings. 2. Will the pond be used after construction is completed? If so, who is the responsible party for pond management? 3. A GPP along with all design criteria must be submitted for approval prior to construction. Failure to do so may result in a revision of the pond design.

4.11.c. List procedures to be used when designing and adding new equipment or operations.	This section is probably not applicable but may be if the project is expanded.

4.11.d. Summarize all activities at your facility that are already regulated for groundwater protection.	Examples would be the registration of underground storage tanks and the required groundwater monitoring, or the construction and use of a landfill and required groundwater monitoring.

4.11.e. Discuss any existing groundwater quality data for your facility or an adjacent property.	Include the most recent year of sampling data if available or data for an adjacent facility. Most projects will have no information for this section.
Attach data summary sheets if necessary.	

4.11.f. A statement that no waste material will be used for deicing or fill material on the property unless allowed by another rule.	Write an appropriate statement that this practice will not be used at your project.

4.11.g. Provisions for all employees to be instructed and trained on their responsibility to ensure groundwater protection. Job procedures shall provide direction on how to prevent groundwater contamination.	Summarize training for all employees or other persons responsible for pond management to ensure familiarity with the GPP. Specific inspection, maintenance, and cleanup procedures should be included.

4.11.h. Include provisions for inspections of all GPP elements and equipment. Inspections must be made quarterly (every 3 months) at a minimum.	State inspection frequency by foremen, maintenance company, or other management entity representatives. Include inspection form if one is used. Inspection records should be retained to verify GPP inspections.
Signature	
Date	

APPENDIX 2
GROUNDWATER PROTECTION PLAN
INFORMATION REQUIREMENTS

1. Describe Site Selection Process – What methods were used to determine the management structure location?

2. Preliminary Screening

   a. What NRCS soil types are present?
   b. What is the proposed soil thickness between the bottom of the management structure and the bedrock surface?
   c. Where are the closest domestic and public water sources (wells or springs)?

3. What is the proposed management structure set-back distance from the closest building foundation, slope, or sinkhole?

4. What is the proposed distance of the management structure from the nearest road or highway?

5.Describe the management structure's volume calculation.

6. Describe the soil permeability investigation of the management structure location. See Chapter 1 and the chart on page 9.

7. Describe maintenance practices to be employed for the management structure.

8. Describe all mitigating structures (best management practices) proposed for stormwater prior to its entering the management structure.

9. Is there a proposed overflow structure and where will the stormwater be discharged from this structure(s)?

10. Are there proposed alterations, mitigations, or closures of any sinkhole on the site?

11. Stormwater Management Structures requiring liners will be required to provide the following information within thirty days of structure completion:

   1. Specification of clay liner lift thickness.

   2. Specification of clay liner compaction data.

3. Documentation of clay and synthetic liner installation.

4. P.E. certification of as-built drawings of final installation.

Caution: Please be aware that groundwater monitoring for the management structure may be required by WVDEP.

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