Bioretention Area (BA)

Source: Department of Environmental Resources, Prince George's County, MD

Practice Description

A bioretention area is a shallow, vegetated depression incorporated into a development's landscape. The purpose of bioretention is to restore, as much as possible, an area's pre-development hydrology and provide both water quantity and water quality benefits.

Stormwater is conveyed as sheet flow to the bioretention area that temporarily stores runoff. As stormwater percolates through the bioretention area, soils and plants remove pollutants. Filtered stormwater is then directed to the conveyance system or if underlying soils are appropriate, stormwater is allowed to infiltrate to the aquifer below and provide recharge.

A bioretention area is a suitable stormwater practice for commercial, transportation, industrial, and residential developments. Applications include parking lot islands, roadway medians, roadside swales, and residential gardens positioned to collect roof and parking lot runoff. Bioretention is particularly effective on sites of 1 acre or less. Bioretention is used on larger sites with multiple bioretention areas treating sub-drainages. In general, a bioretention area is a suitable stormwater management practice for residential subdivisions and high density/ultra urban sites but not for regional-scale control. [1]

Planning Considerations

Examples of bioretention area applications are illustrated in Figure BA-1.

A bioretention area is designed with one of the two basic configurations: (1) with an underdrain connected to a stormwater collection system; or (2) without an underdrain ("no-underdrain") and infiltration into a permeable soil profile, providing groundwater recharge. The underlying soil is the main factor determining which configuration is used. [2] The no-underdrain design is a better choice when feasible because of aquifer recharge. However, the underdrain design is likely to be more appropriate over much of Alabama because of the occurrence of clayey soils.

A typical underdrain bioretention area consists of (1) grass/gravel filter strip at the entrance, (2) ponding area, (3) native vegetation selected for tolerance to wet and dry conditions, (4) hardwood mulch layer, (5) planting soil layer amended to promote infiltration, (6) pea gravel diaphragm, (7) underdrain with outlet, and (8) overflow structure.[2] Premanufactured bioretention boxes are also available.

Properly designed, constructed and maintained bioretention areas have demonstrated excellent pollutant load removal. However, pollutant removal drastically declines when poorly designed or not sufficiently maintained. Information on pollutant removal by bioretention areas may be found in the National Pollutant Removal Performance Database, 2nd Edition (www.cwp.org) and the National Stormwater Best Management Practices (BMP) Database (www.bmpdatabase.org).

Native vegetation is preferred for use in bioretention areas. Ideally, native plant species should require less maintenance and provide better wildlife habitat than introduced species. Exotic invasive species should never be used and should be removed during annual maintenance.

Bioretention areas should be finished "last" during the construction phase to minimize sediment delivery to the bioretention facility.

Design Criteria

Drainage Area

The drainage area contributing runoff to a bioretention area should be at maximum 5 acres and preferably between 0.5 and 2 acres. [1]

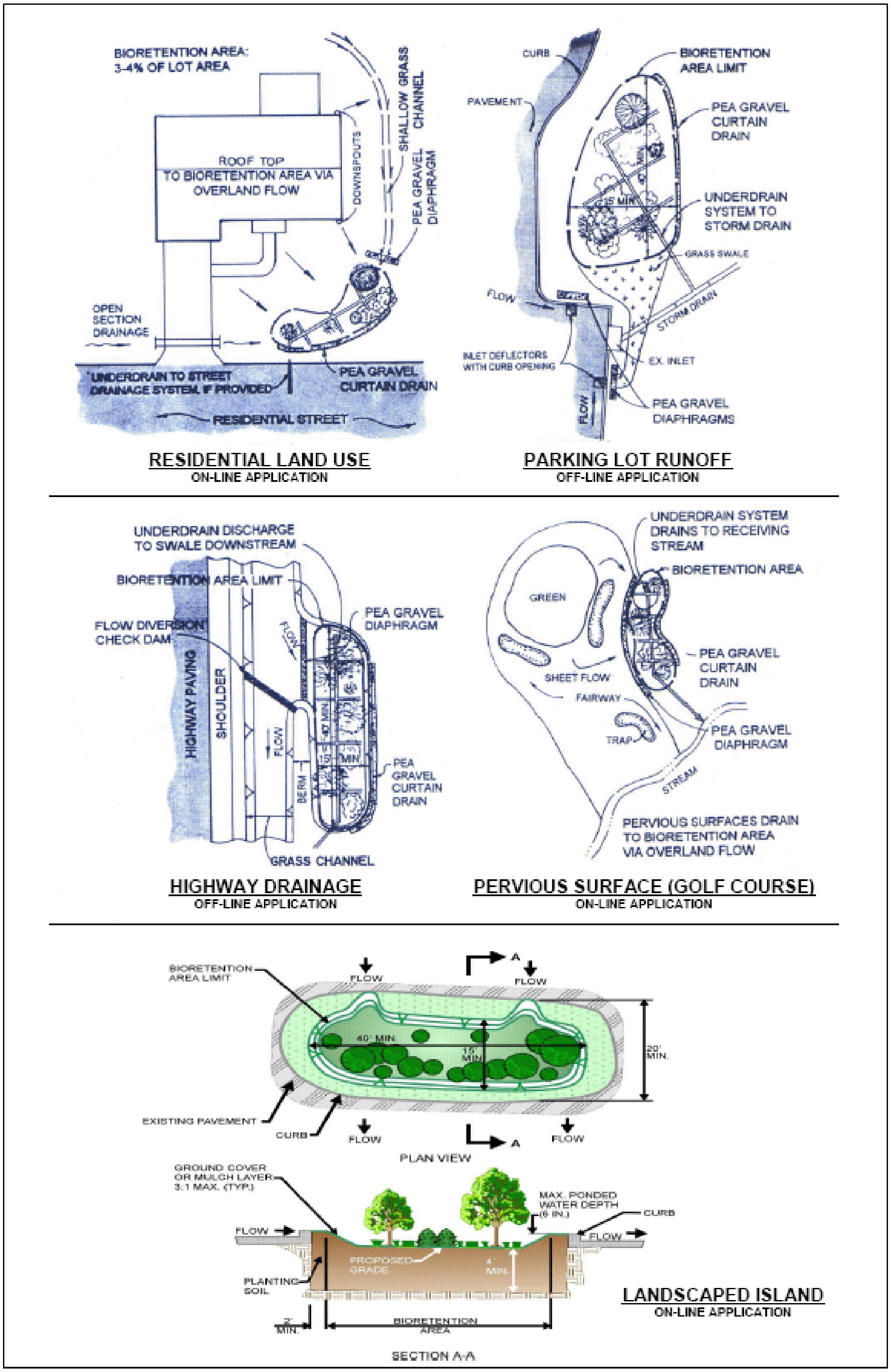

Figure BA-1 Applications of Bioretention Areas
(Source: Claytor and Schueler. 1996. Center for Watershed Protection.)

Slopes

Slopes in the bioretention area should be flatter than 6%. [1]

Space Required

A bioretention area requires approximately 5% of the impervious portion of its drainage area. A minimum area of 200 ft^2 (10 ft. x 20 ft.) is recommended for small sites. [1]

Water Table

A distance of 2 feet between the bottom of the bioretention basin and the seasonal high water table is recommended. If a bioretention area is installed at a potential stormwater pollutant hotspot, e.g. gas station or in karst topography, an impermeable liner should be installed to prevent runoff from potentially reaching and polluting an aquifer. [1]

In-situ Soils for No-Underdrain Design

In-situ soils should have an infiltration rate greater than 1" per hour for a no-underdrain bioretention area design. [2]

Soil Mixtures

The volumetric soil mixture for the bioretention area should consist of 30% planting soil, 20% organic (mulch, compost or peat moss) and 50% sand (the combined mixture should never be over 10% clay).

The planting soil for the bioretention soil mixture should be loamy sand or sandy loam. Soil testing is recommended to determine fertilizer and lime needs. Proper soil fertility and pH is essential to support vigorous plant growth and to enhance pollutant removal.

Plant Materials

Plants should be tolerant of both extreme wet and dry conditions. Publications, such as Residential Rain Garden Handbook [4] by the Alabama Cooperative Extension System provide a listing of adapted species used in the region. The Alabama Cooperative Extension System specialists trained in bioretention technology can also provide plant selection guidance.

Facility Specifications

Minimum dimensions of a bioretention area are 10 feet wide by 20 feet long. Wherever possible, sites should have a minimum length to width ratio of 2:1.
The planned ponding depth above the facility bottom should be 6 inches.
The planting soil layer should have a minimum depth of 4 feet.
Runoff should be pretreated before entering the facility by providing a grass filter strip with a gravel diaphragm (see Figures BA-2 and BA-3)
The recommended organic mulch layer is 2 to 4 inches of double shredded hardwood bark.

Stone for the diaphragm should be ASTM D 448 coarse aggregate size No. 6 or No. 57.

The underdrain system is 6-inch diameter perforated plastic pipe or tubing such as that conforming to ASTM F 405 (corrugated PE tubing) or ASTM F 758 (smooth wall PVC underdrain pipe). Perforations for PVC pipe should be 4 rows of 3/8-inch diameter holes, with holes spaced at a maximum of 6 inches along the row. Perforations should be located in the lower ½ of the pipe circumference. The minimum grade of the pipe is 0.5%. Underground pipes should be spaced at a maximum of 10 feet on center. See Figures BA-2, BA-3 and BA-4 for schematic representations of designs.

Outlet Structures

An outlet pipe should connect the underdrain system to a storm sewer outlet. When outlets empty into a drainage structure, the outlet pipe should be positioned a minimum of 6 inches above normal flow level and covered by a minimum of 18 inches of fill.

Emergency Spillway

Overflows from a bioretention area shall be diverted by an overflow structure and a stabilized overflow channel to a stable swale or other stable waterway. The inlet of the overflow system is placed in the bioretention area and is placed 6 inches above the mulch layer (see Figure BA-2). [1]

Maintenance

Bioretention areas must be kept accessible for inspection and maintenance.

Caution should be exercised during the application of fertilizers and pesticides in and around the bioretention area to prevent the possibility of surface and ground water contamination.

Landscaping

Proper attention to landscaping is vital to the performance of a bioretention area. Diversity of vegetation structure may include trees, shrubs and herbaceous vegetation. Using combinations of trees, shrubs or herbaceous vegetation is aesthetically pleasing and offers different levels of pollutant removal. Woody plants should not be placed near the facility inflow.

Design Procedures

Designs must be quite site-specific because of the variability in site conditions including soils, topography, use of the land in the drainage area, space for the facility and desired appearance of the facility. Because of these variables, no additional design procedures are provided. Instead, one should refer to other references[1, 2] for more details.

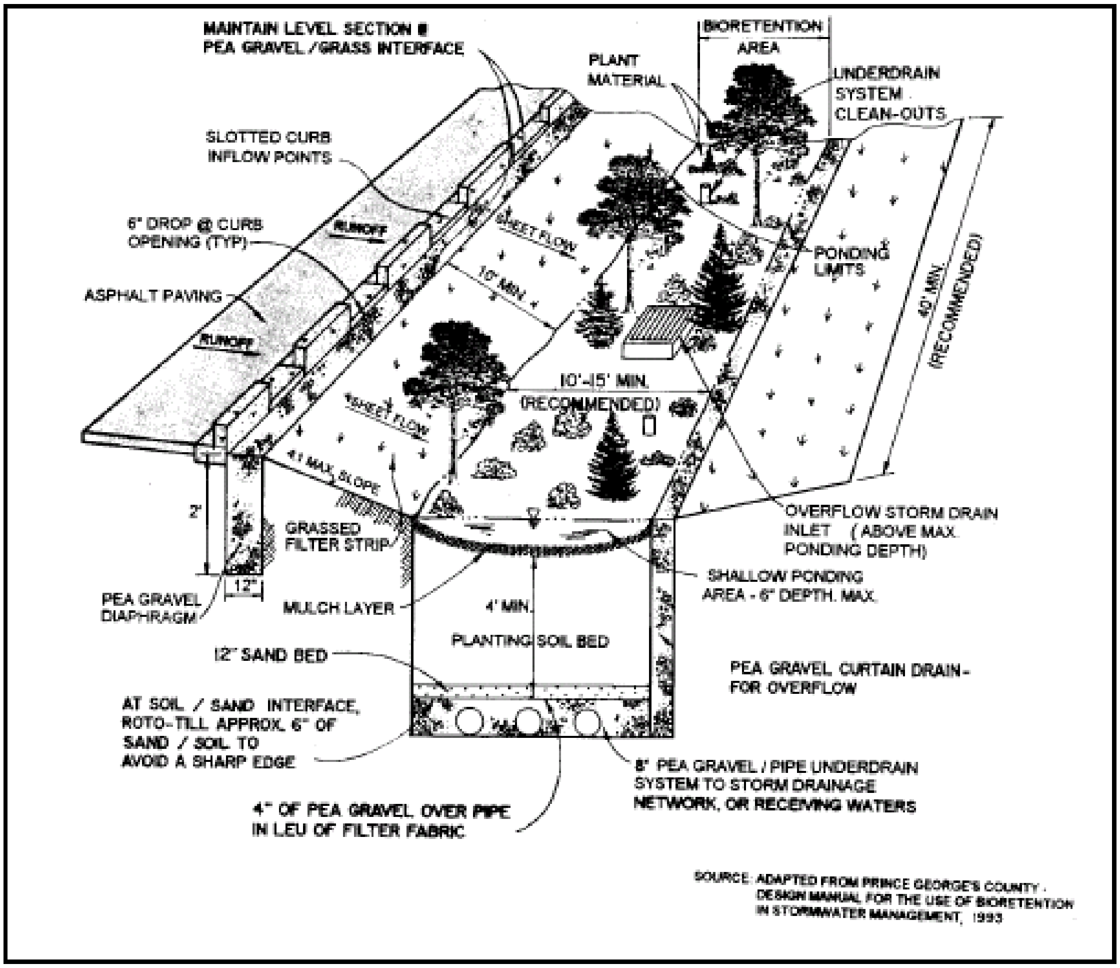

Figure BA-2 Typical Bioretention Area
(Source: Claytor and Schueler. 1996. Center for Watershed Protection.)

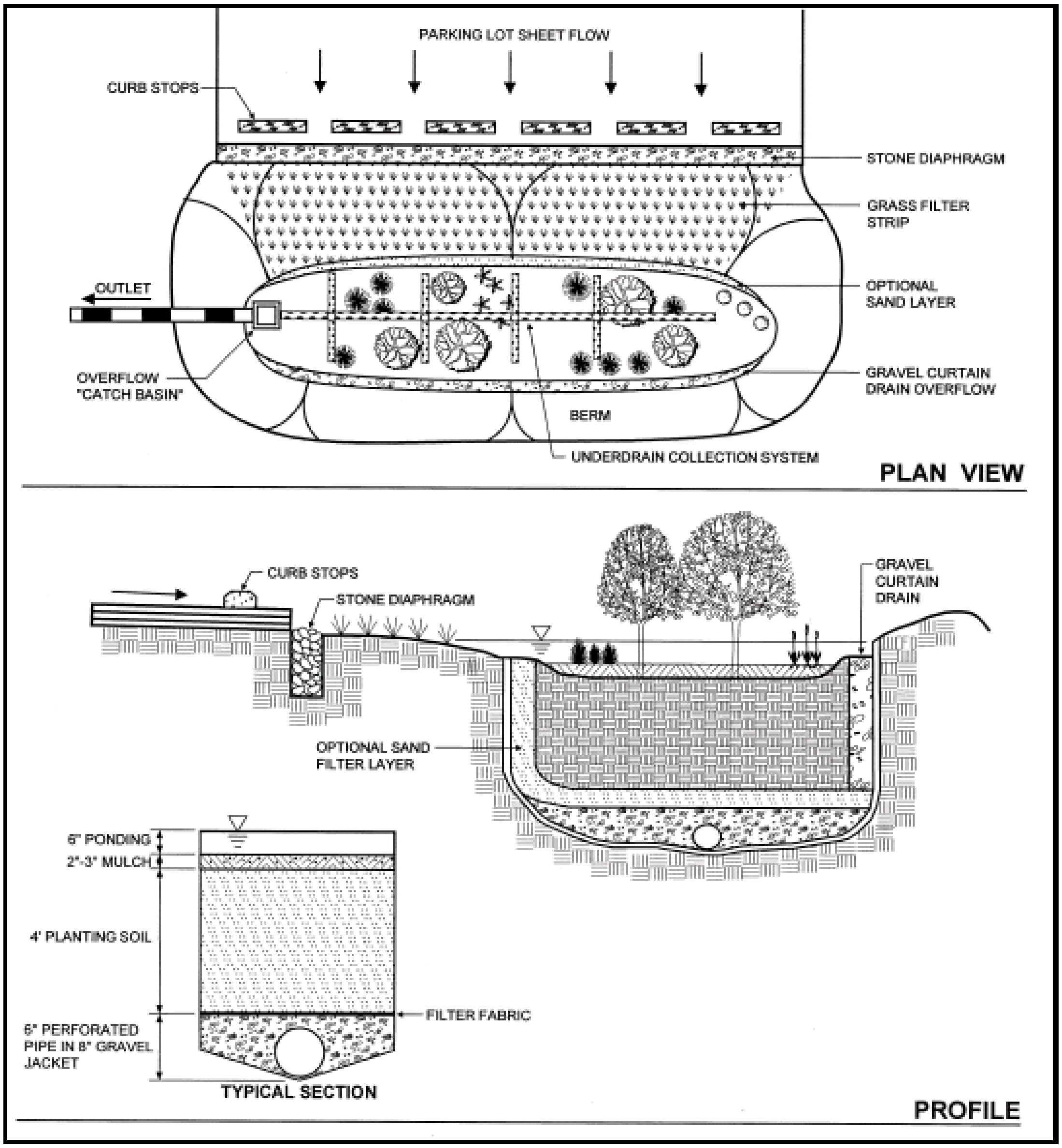

Figure BA-3 Typical On-line Bioretention Facility
(Source: Claytor and Schueler. 1996. Center for Watershed Protection.)

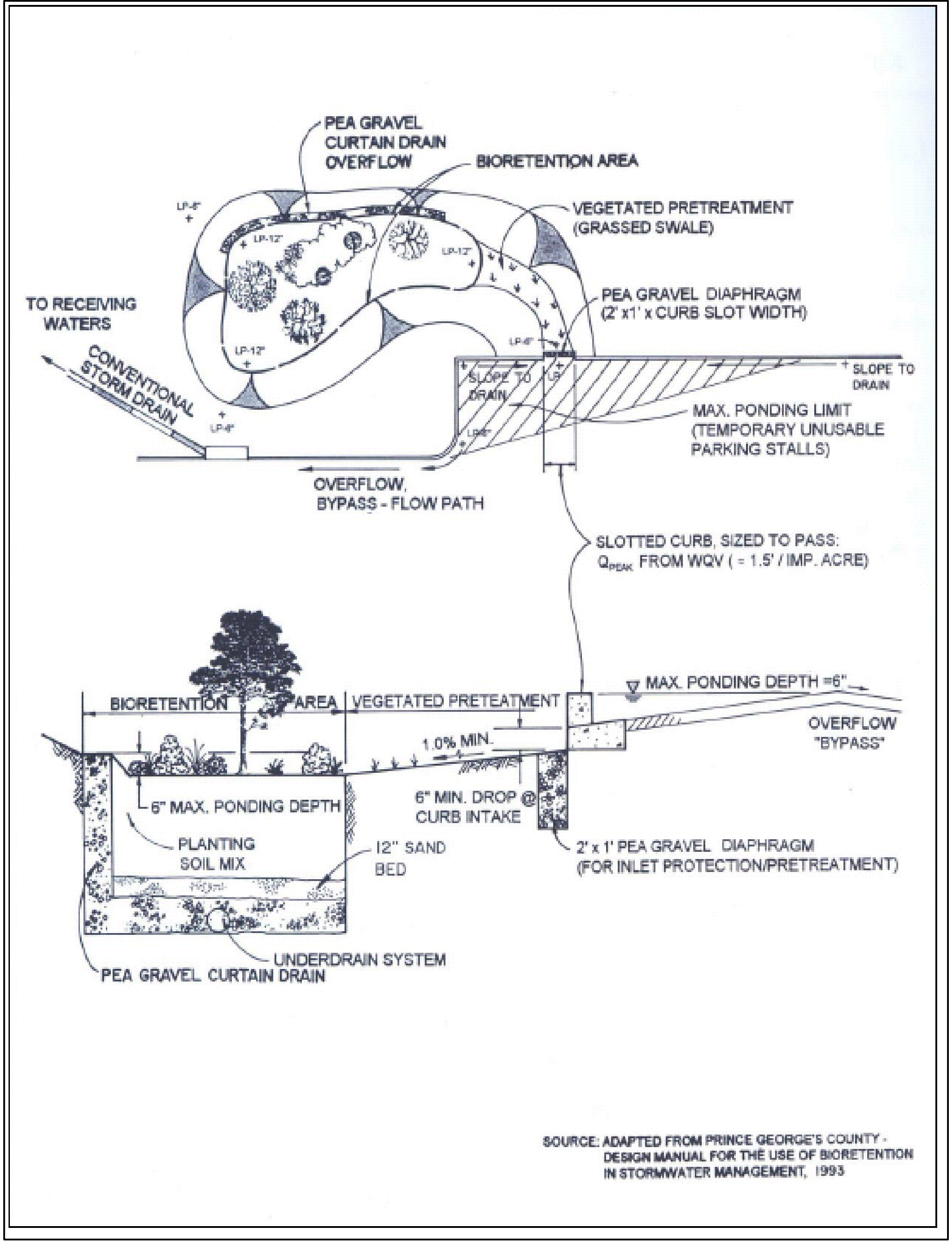

Figure BA-4 Typical Off-line Bioretention Facility
(Source: Claytor and Schueler. 1996. Center for Watershed Protection.)

References

[1] Georgia Stormwater Management Manual, Volume 2 – Technical Manual. Section 3.2.3 Bioretention Areas

[2] The Bioretention Manual. Prince George's County, Maryland

[3] Drainage-Bioretention Specifications website. Low-Impact Development Center

[4] Residential Rain Garden Handbook, Alabama Cooperative Extension System, www.aces.edu/water/mg.htm

[5] Claytor, R. and T. Schuler. 1996. Design of Stormwater Filtering Systems. Center for Watershed Protection. Ellicott City, MD.

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Porous Pavement (PP)

Practice Description

Porous pavement is a permeable load-bearing layer that reduces runoff by providing infiltration, and can be underlain by a stone reservoir for stormwater storage. The practice with a stone reservoir is designed to intercept storm runoff and allow it to gradually infiltrate into the subsoil. In addition, porous pavement may provide groundwater recharge, augment low flow in streams during dry periods, reduce downstream flooding and protect water quality. The practice is applicable for areas with low traffic, such as overflow parking lots and lightly used access roads that are on relatively gentle slopes and permeable soils.

Porous pavement falls into three different categories based on the extent of storage provide by the stone reservoir: a full exfiltration system (stores the entire design storm), a partial exfiltration system (stores a portion of the design storm) and a water quality exfiltration system (provides infiltration only or stores the first flush or some portion of a design storm and conveys the excess runoff to a conventional stormwater management facility).

Concrete grids, modular pavement, or similar products will be considered as a part of this practice.

Planning Considerations

This practice provides protection of water quality by reducing stormwater runoff through infiltration and/or storage in a buried stone reservoir. The practice is intended for areas with relatively flat slopes (less than 5%) where traffic volumes are low and the on-site soils are permeable. The practice also requires a higher degree of maintenance than normal paving materials.

When considering use of this practice the type and amount of traffic traversing the pavement must be considered. Soils and topography of the finished paving are also important. Since various levels of storage can be used, the area available for underground storage, as well as outlets for the storage area, needs to be considered in the design of the system. The seasonal high water table is an important consideration in the design of the stone storage reservoirs.

Design Criteria

Drainage Area

The drainage area contributing runoff to the stone storage reservoir should be between ¼ and 10 acres.

Slopes

Slopes in the area to receive porous paving should be flatter than 5%.

Pavement Thickness

If permeable asphalt is used the pavement thickness should be 2 to 4 inches. When using permeable concrete the thickness should be 4 to 6 inches. The thickness of concrete grids or modular pavers will be determined by the thickness of the product selected that is available from the manufacturer.

Water Table

This practice should be used in areas with deep water tables. As a minimum the seasonal high water table should be below the planned bottom of the stone storage reservoir.

Soils

Soils at the site where porous pavement is to be used should be permeable soils with combined silt/clay contents of less than 40%. Soils would generally be in NRCS hydrologic groups A, B, or C.

Stone Reservoir

The stone reservoir should be installed with a minimum of 2 feet (preferably 4 feet) of clearance between the bottom of the reservoir and bedrock. The stone reservoir should be designed so that it can be drained within 72 hours (see Figures PP-1 and PP-2).

Site Protection

Design of the porous pavement site should include measures to protect the site from being compacted by construction equipment and from erosion and sediment. Only tracked construction equipment should be used on the construction of the porous pavement subgrade. Construction traffic access routes should be routed around the site to prevent compaction by unnecessary traffic over the site. Diversions should be installed around the area to keep off-site runoff and sediment away from the site.

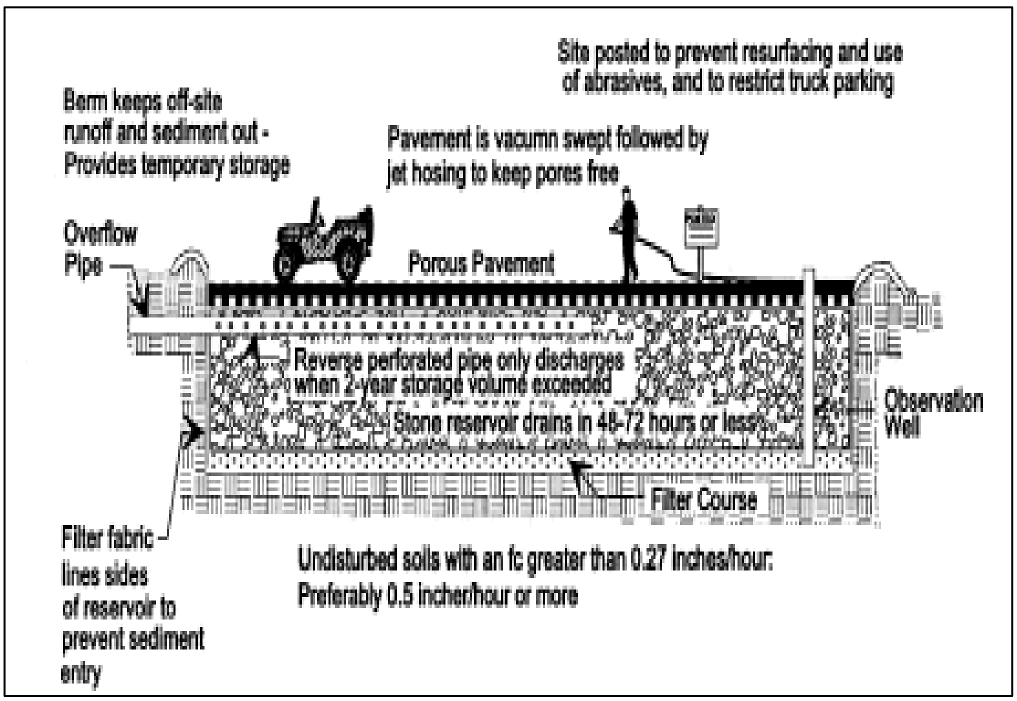

Figure PP-1 Typical Section of Porous Pavement with Buried Stone Reservoir

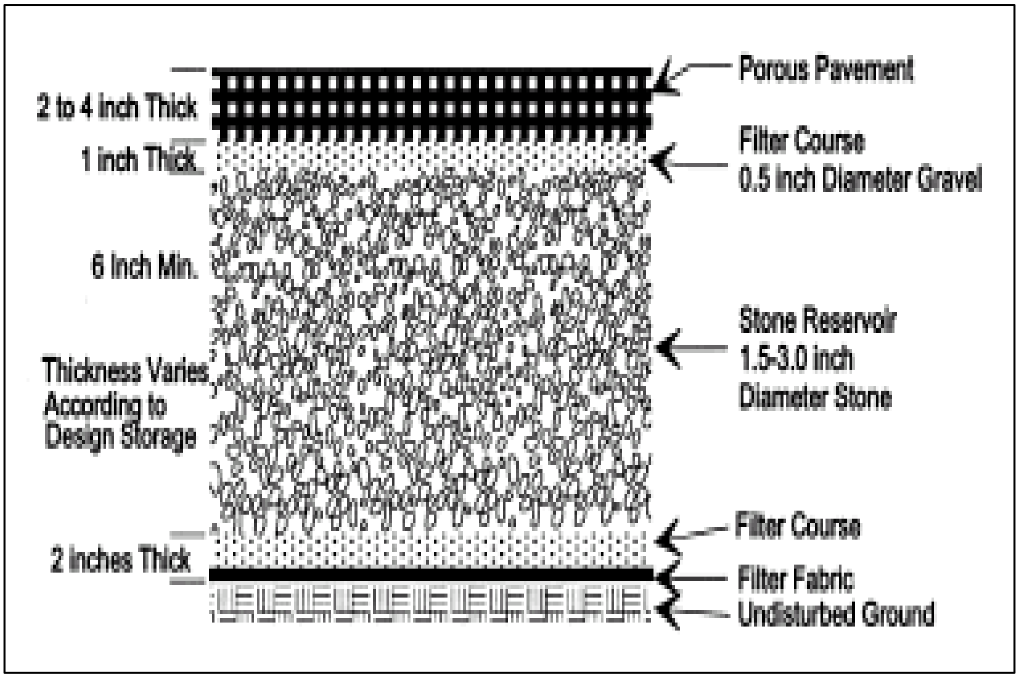

Figure PP-2 Typical Porous Pavement Design

Stormwater Detention Basin (SDB)

Practice Description

A stormwater detention basin is a dam-basin practice designed to hold stormwater runoff and release the water slowly to prevent downstream flooding and stream erosion. The practice is an extremely effective water quality and peak discharge reduction measure. Its usage is best suited to larger, more intensively developed sites. Structure life is 10 years or more. A stormwater detention basin can have a permanent pool of water or be designed to have a dry basin (typical). A detention basin can be designed to also serve as a sediment basin during the construction period.

Planning Considerations

The purpose of a stormwater detention basin is to intercept stormwater runoff and to protect drainageways, properties, and right-of-ways downstream of the structure. A qualified design professional engineer with expertise in hydrology and hydraulics should always design stormwater detention basins. This practice applies only to permanent basins on sites where:

- Failure of the dam will not result in loss of life; in damage to homes, commercial, or industrial buildings, main highways, or railroads; or in interruption of the use or service of public utilities.

- The peak release rate of stormwater runoff from the design storm does not exceed the predevelopment runoff rate for the drainage area or the rate allowed by local ordinances, whichever is less.

- The drainage area does not exceed 50 acres. The peak flow through the principal spillway normally should not exceed 50 cfs. Structures should be designed as water impoundment structures in accordance with NRCS Field Office Technical Guide Pond Standard 378 or other approved methods. Design criteria should be commensurate with the complexity of site conditions, including consideration of damages that would be caused by breaching of the embankment by overtopping.

A stormwater detention basin is appropriate where physical site conditions or land ownership restrictions preclude the installation of other stormwater measures to adequately control runoff. The basin should be maintained throughout the life of the development which produced the need for the basin.

Design Criteria

Classification

Table SDB-1 shows the recommended design and classification criteria for three types of Stormwater Detention Basins.

Table SDB-1 Stormwater Detention Basin Classification

Type [1]	Max. W/S Size (acre)	Max. Dam Ht.[2] (feet)	Minimum Principal Spillway Design Storm Frequency[3]	Minimum Emergency Spillway Design Storm Frequency[3]	Freeboard [4] (feet)
1	20	7	5-yr 24-hr	10-yr 24-hr	1.0
2	20	10	5-yr 24-hr	10-yr 24-hr	1.0
3	50	15	10-yr 24-hr	25-yr 24-hr	1.0

[1] Type 1 basins may be used where site conditions prevent the construction of an emergency spillway on residual earth.

[2] Height is measured from the top of the dam to the low point on the original centerline survey of the dam.

[3] Runoff should be determined by NRCS methods or other methods accepted by local ordinances. Soil and cover conditions used should be based on those expected during the construction period.

[4] Vertical distance between basin water surface at maximum flow through the emergency spillway and top of dam.

Location

Locate the stormwater detention basin to obtain the maximum storage benefit from the terrain and for ease of cleanout of trapped sediment. It should be located to minimize interference with construction activities and construction of utilities. Whenever possible, locate detention basins out of floodplain areas and never in flowing streams. Detention basins can be an excavated basin type as well as an earthfill dam type or a combination of the two.

Entrance of Runoff into Basin

Protect the entrance points of surface runoff into the basins to prevent erosion of the basin walls. Install riprap check dams, grade stabilization structures, or other water control devices at main points of inflow to ensure direction of runoff and protect the points of entry into the basin. Locate points of entry so as to ensure maximum travel distance of runoff water through the basin to the point of exit from the basin.

Erosion and Sedimentation Control

Conduct construction operations in such a manner that erosion and sedimentation will be minimized. Comply with state and local laws concerning pollution abatement.

Safety

Stormwater detention basins should comply with any state laws related to Dam Safety.

Stormwater detention basins are attractive to children and can be very dangerous. Local ordinances and regulations must be adhered to regarding health and safety. The developer or owner should check with local building officials on applicable safety requirements. If fencing of basins is required, the location of and type of fence should be shown on the plans.

Storage

The minimum capacity of a stormwater detention basin below the crest of the principal spillway pipe should be ½ inch per acre of the potential disturbed portion of the drainage area plus the runoff volume from a 2-year frequency, 24-hour duration storm for the developed conditions.

Shape of the Basin

Design the stormwater detention basin to have a flow length to width ratio of 2:1 or greater, where flow length is the distance between the point of inflow and the point of outflow.

When the basin is used as for sediment control during construction, design the sediment storage portion of the basin to meet the requirements in the *Sediment Basin* practice.

Principal (Pipe) Spillway Design

Layout

The spillway should consist of a vertical riser joined at its bottom to a conduit (barrel) which extends through the embankment. Connections should be watertight.

Capacity

The maximum capacity of the pipe spillway should not exceed the peak rate of runoff from the drainage area in its pre-developed condition for all rainfall events up to and including the principal spillway design storm frequency. The minimum inside diameter of the barrel should be 8 inches. The diameter of the vertical inlet riser should be a minimum of 1.5 times greater than that of the barrel to ensure full barrel flow. Size the pipe to remove at least 50% of the runoff volume of the design storm within a 3 day period.

Inlet Data

The vertical inlet (riser) may be one of the following:

- A full round pipe.
- A half round pipe fitted for flashboards.
- A box-type riser fitted with flashboards.

Set the crest of the riser inlet at an elevation to provide the minimum storage requirement (runoff from a 2-year 24-hour storm for developed conditions and ½" sediment storage for the disturbed acreage). The riser should have a base (ballast) of sufficient weight to provide a 1.5:1 safety factor against flotation. Install an approved trash rack and anti-vortex device securely on top of the riser.

Anti-seep Collars

Install anti-seep collars around all conduits through earth fills according to the following criteria:

- Collars should be placed to increase the seepage length along the conduit by a minimum of 15 percent of the pipe length located within the saturation zone.
- Collar spacing should be between 5 and 14 times the vertical projection of each collar.
- All collars should be placed within the saturation zone.
- All anti-seep collars and their connection should be watertight.

A properly designed drainage diaphragm may be utilized in lieu of anti-seep collars.

Outlet

Provide protection of the barrel pipe outlet where needed to prevent outlet scour. Design outlet protection measures according to the *Outlet Protection* Standard.

Dewatering the Basin

Stormwater detention basins can serve a dual purpose as a sediment basin during construction and a stormwater detention basin after construction (See Figure SDB-1). Basins that serve only for the purpose of stormwater detention can be designed as either a dry pool (typical) or a wet pool (See Figures SDB-2 and SDB-3).

For basins designed to also serve as a sediment basin, dewatering the sediment basin volume (½" runoff for the disturbed acreage plus ½" runoff for the total drainage area) is best accomplished with a skimmer designed according to the *Sediment Basin* practice design criteria. Dewatering of the 2-year developed condition runoff above the sediment basin volume can be accomplished with a small 4 inch orifice (installed with trash protection) in the riser at the sediment storage elevation. After disturbed areas contributing runoff water to the basin have been stabilized, the skimmer dewatering device can be removed to allow the basin to operate only as a stormwater detention basin. If the purpose of the basin is to also treat the "first flush", the skimmer can be left as a permanent treatment measure. Any accumulation of sediments that would reduce stormwater detention storage should be removed and disposed of in a proper manner.

Dry basins that serve only as stormwater detention can be dewatered with a 4" orifice at the base of the riser.

Emergency spillways

Layout

Install earth emergency spillways for Type 2 and 3 basins only in undisturbed earth. Emergency spillways for Type 1 basins may be located on compacted earth fill selected for erosion resistance qualities. Other erosion control measures such as rock riprap may be required to ensure stable emergency spillways. Each spillway should have a longitudinal level section at least 25 feet long at its crest and a straight outlet section for at least 25 feet or ½ the base width of the embankment fill.

Capacity and Design

Spillways should be trapezoidal in cross section with minimum bottom widths of 10 feet and side slopes of 3:1. The elevation of the emergency spillway crest will be determined through routing procedures of the principal spillway design storm. The capacity of the emergency spillway should be adequate to pass peak discharges of the emergency spillway design storm, taking into account the discharge through the principal spillway and the available storage. As a minimum, the designer should consider at least 0.5 foot of stage for flow through the emergency spillway. Spillways should be designed to pass designed discharges at non-erosive velocities for the types of protection used.

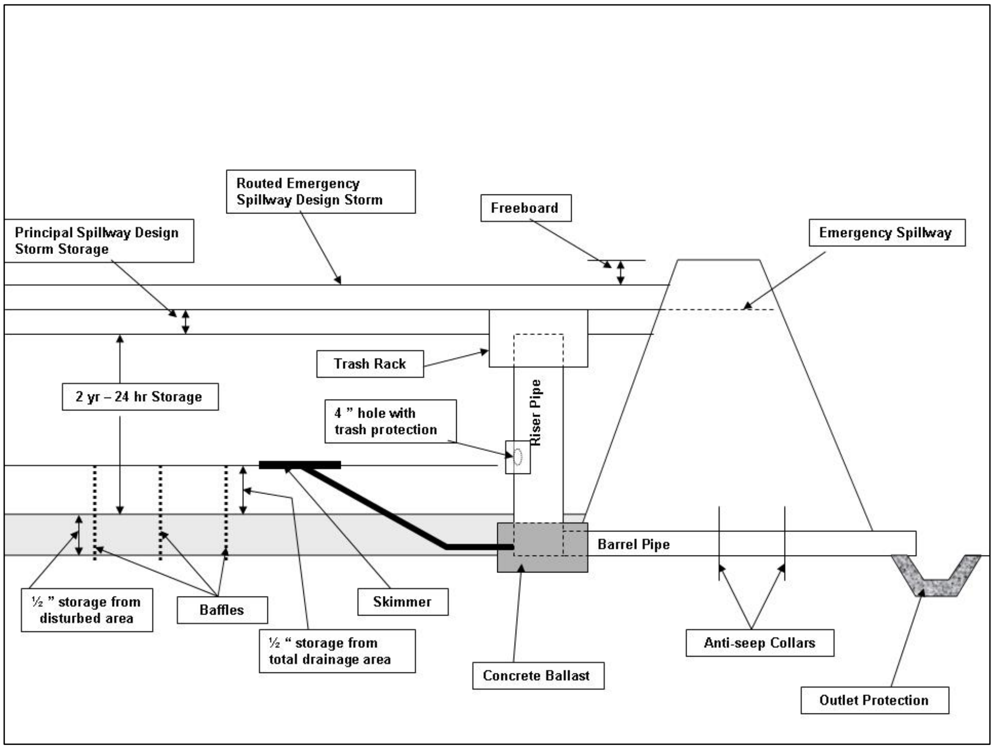

Figure SDB-1 Typical Stormwater Detention Basin / Sediment Basin Components.

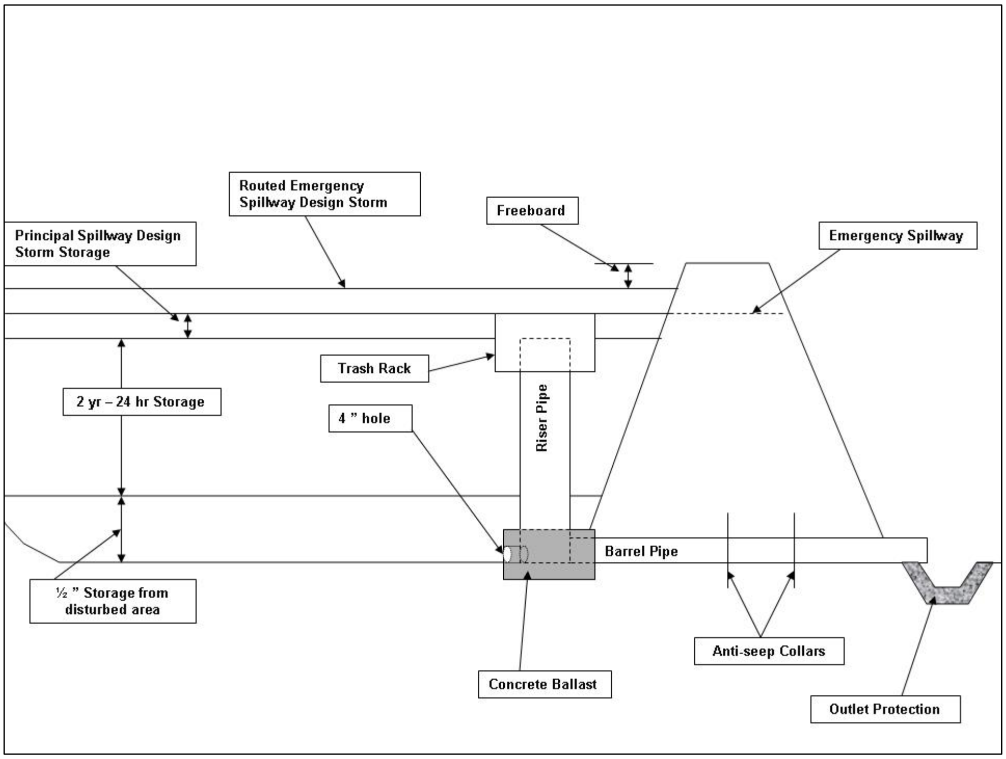

Figure SDB-2 Typical Dry Stormwater Detention Basin Components.

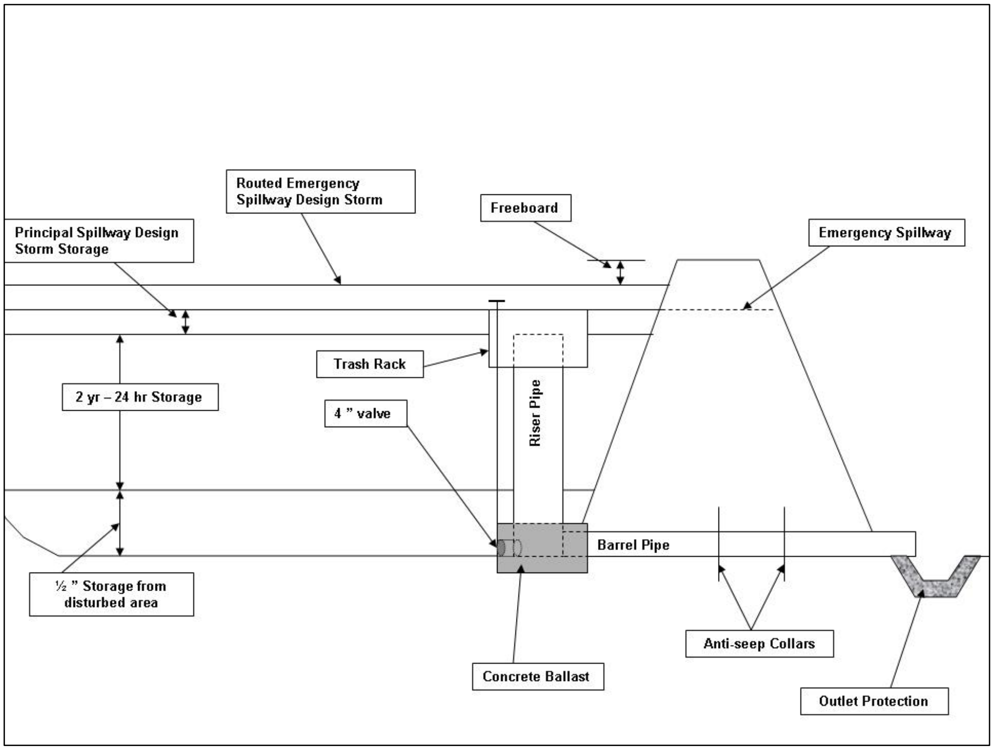

Figure SDB-3 Typical Wet Stormwater Detention Basin Components.

Embankment

The minimum top width should be 8 feet. Side slopes should be no steeper than 2½:1 (mowable surfaces should be 3:1 or flatter). On sites where relatively impermeable material (clay) is not available for a core, the downstream side slope should be increased to 4:1. Construct a keyway along the centerline of the dam. It should be at least 8 feet wide, have 1:5:1 or flatter side slopes, and should extend at least 2 feet below the normal ground surface. The core of the embankment should be at least 8 feet wide and consist of the most impermeable material available at the site. Extend this core from the bottom of the keyway to the crest of the emergency spillway.

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