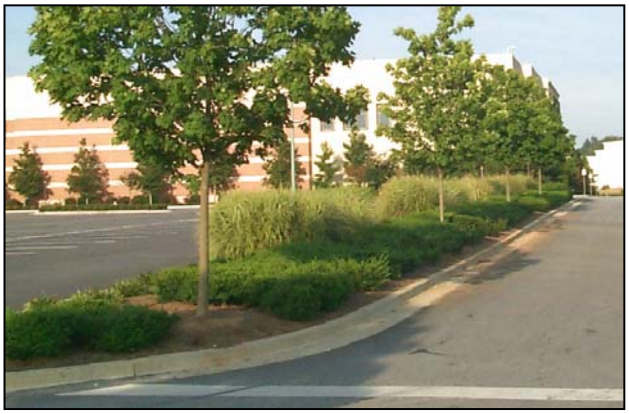
4.3.5 Bioretention Areas

General Application Stormwater BMP



Description: Shallow stormwater basin or landscaped area that utilizes engineered soils and vegetation to capture and treat runoff.

KEY CONSIDERATIONS

DESIGN GUIDELINES:

- Maximum contributing drainage area of 5 acres.
- Often located in "landscaping islands."
- Treatment area consists of grass filter, sand bed, ponding area, organic/mulch layer, planting soil, and vegetation.
- Typically requires 5 feet of elevation difference from inflow to outflow.

ADVANTAGES / BENEFITS:

- Applicable to small drainage areas.
- Good for highly impervious areas, particularly parking lots.
- Good retrofit capability.
- Relatively low maintenance requirements.
- Can be planned as an aesthetic feature.

DISADVANTAGES / LIMITATIONS:

- Requires extensive landscaping.
- Not recommended for areas with steep slopes.

MAINTENANCE REQUIREMENTS:

- Inspect and repair/replace treatment area components.

STORMWATER MANAGEMENT SUITABILITY

- ✓ **Water Quality**
- ✷ **Channel Protection**
- ☐ **Overbank Flood Protection**
- ☐ **Extreme Flood Protection**

Provides pretreatment for SPAP land uses? *Yes*
✷ in certain situations

FEASIBILITY CONSIDERATIONS

M	**Land Requirement**
M	**Capital Cost**
L	**Maintenance Burden**

Residential/Subdivision Use: *Yes*

High Density/Ultra-Urban: *Yes*

Drainage Area: *5 acres max.*

Soils: *Planting soils must meet specified criteria; no restriction on surrounding soils.*

L=Low **M**=Moderate **H**=High

POLLUTANT REMOVAL

H	**Total Suspended Solids**
M	**Nutrients** - Total Phosphorus / Total Nitrogen
M	**Metals** - Cadmium, Copper, Lead, and Zinc
No data	**Pathogens** - Coliform, Streptococci, E.Coli

OTHER CONSIDERATIONS:

- Use of native plants is recommended

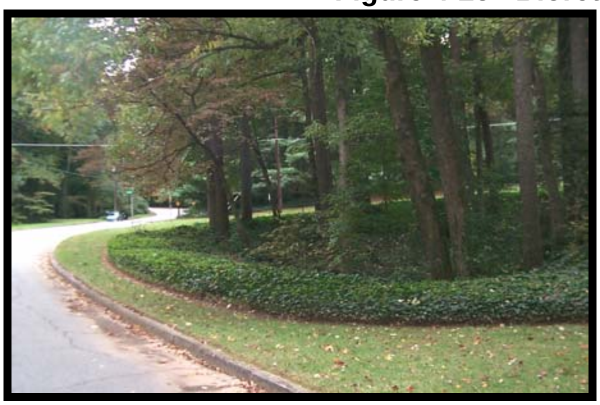
4.3.5.1 General Description

Bioretention areas (also referred to as *bioretention filters* or *rain gardens*) are structural stormwater controls that capture and temporarily store the water quality volume (WQv) using soils and vegetation in shallow basins or landscaped areas to remove pollutants from stormwater runoff.

Bioretention areas are engineered facilities in which runoff is conveyed as sheet flow to the "treatment area," which consists of a grass buffer strip, ponding area, organic or mulch layer, planting soil, and vegetation. An optional sand bed can also be included in the design to provide aeration and drainage of the planting soil. The filtered runoff is typically collected and returned to the conveyance system, though it can also permeate into the surrounding soil in areas with porous soils.

There are numerous design applications, both on- and off-line, for bioretention areas. These include use on single-family residential lots (*rain gardens*), as off-line facilities adjacent to parking lots, along road drainage swales, within larger landscaped pervious areas, and as landscaped islands in impervious or high-density environments. Figures 4-25 and 4-26 illustrate a number of examples of bioretention facilities in both photographs and drawings.

Figure 4-25. Bioretention Area Examples



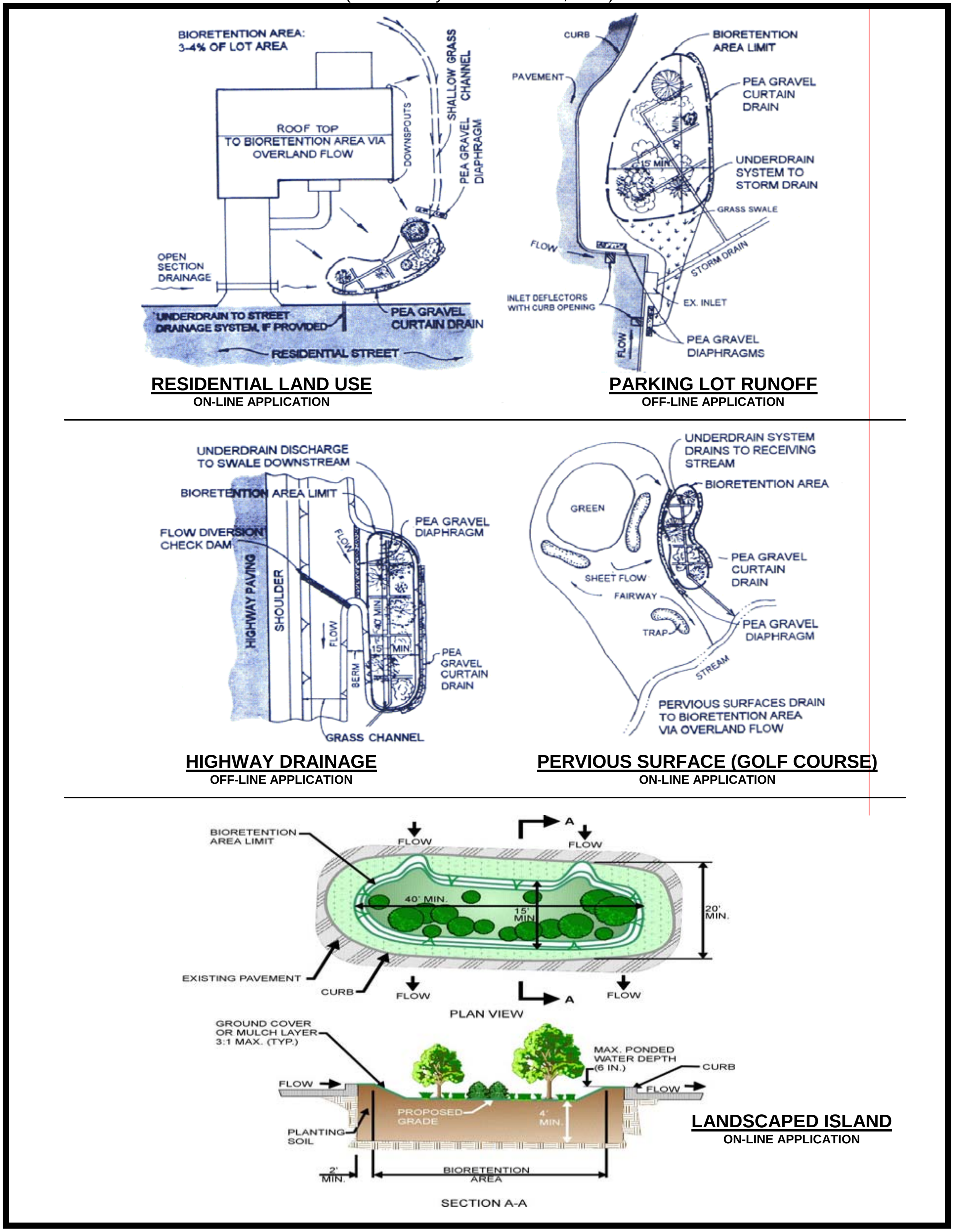
Single-Family Residential "Rain Garden"

Landscaped Island

Newly Constructed Bioretention Area

Newly Planted Bioretention Area After Storm Event

Figure 4-26. Bioretention Area Applications
(Source: Claytor and Schueler, 1996)



4.3.5.2 Stormwater Management Suitability

Bioretention areas are designed primarily for stormwater quality and can provide limited runoff quantity control, primarily for smaller storm events. These facilities may sometimes be used to partially or completely meet channel protection volume (CPv) requirements on smaller sites. However, bioretention areas will typically need to be used in conjunction with other structural BMPs to provide channel protection as well as overbank flood volume (Qp_2, Qp_{10}, and Qp_{25}) protection. It is important to ensure that a bioretention area safely bypasses higher flows.

Water Quality (WQv)
Bioretention is an excellent stormwater treatment practice due to the variety of pollutant removal mechanisms. Each of the components of the bioretention area is designed to perform a specific function (see Figure 4-27). The *grass filter strip (or grass channel)* reduces incoming runoff velocity and filters particulates from the runoff. The *ponding area* provides for temporary storage of stormwater runoff prior to its evaporation, infiltration, or uptake and provides additional settling capacity. The *organic or mulch layer* provides filtration as well as an environment conducive to the growth of microorganisms that degrade hydrocarbons and organic material. The *planting soil* in the bioretention facility acts as a filtration system, and clay in the soil provides adsorption sites for heavy metals, nutrients and other pollutants. Both *woody and herbaceous plants* in the ponding area provide vegetative uptake of runoff and pollutants and also serve to stabilize the surrounding soils. Finally, an *underdrain system* provides for positive drainage and aerobic conditions in the planting soil.

Section 4.3.5.3 provides median pollutant removal efficiencies that can be used for planning and design purposes.

Channel Protection (CPv)
For smaller sites, a bioretention area may be designed to capture the entire channel protection volume (CPv) in either an off or on-line configuration. Given that a bioretention facility must be designed to completely drain over 48 hours, the requirement of extended detention of the 1-year, 24-hour storm runoff volume will be met. For larger sites or where only the WQv is diverted to the bioretention facility, another structural BMP must be used to provide CPv extended detention.

Overbank Flood Protection (up to Qp_{25}) and Extreme Flood Protection (Qp_{100})
Another structural BMP must be used in conjunction with a bioretention area to reduce the post-development peak flow of the 2, 10, 25, and 100-year storm events to pre-development levels (detention). Bioretention areas must provide flow diversion and/or be designed to safely pass larger storm flows and protect the ponding area, mulch layer and vegetation. *The volume of runoff removed and treated in the bioretention area may be considered in the calculations for overbank and extreme flood protection.*

4.3.5.3 Pollutant Removal Capabilities

Bioretention areas are presumed to be able to remove 85% of the total suspended solids load in typical urban post-development runoff when sized, designed, constructed and maintained in accordance with the recommended specifications. Undersized or poorly designed bioretention areas can reduce TSS removal performance.

Additionally, research has shown that use of bioretention areas will have benefits beyond the removal of TSS, such as the removal of other pollutants (i.e. phosphorous, nitrogen, fecal coliform and heavy metals), as well, which is useful information should the pollutant removal criteria change in the future. The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment. In a situation where a removal rate is not deemed sufficient, additional BMPs may be put in place at the given site in a series or “treatment train” approach.

- Total Suspended Solids – 85%
- Total Phosphorus – 60%
- Total Nitrogen – 50%

- Pathogens – Insufficient data to provide a pollutant removal value
- Heavy Metals – 80%

For additional information and data on pollutant removal capabilities for bioretention areas, see the National Pollutant Removal Performance Database (2nd Edition) available at www.stormwatercenter.net and the International Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

4.3.5.4 Application and Site Feasibility Criteria

Bioretention areas are suitable for many types of development, from single-family residential to high-density commercial projects. Bioretention is also well suited for small lots, including those of 1 acre or less. Because of its ability to be incorporated in landscaped areas, the use of bioretention is extremely flexible. Bioretention areas are an ideal structural stormwater BMP for use as roadway median strips and parking lot islands and are also good candidates for the treatment of runoff from pervious areas, such as a lawn area. Bioretention can also be used to retrofit existing development with stormwater quality treatment capacity.

The following criteria should be evaluated to ensure the suitability of a bioretention area for meeting stormwater management objectives on a site or development.

General Feasibility

- Suitable for Residential Subdivision Usage – YES
- Suitable for Regional Stormwater Control – NO

Physical Feasibility - Physical Constraints at Project Site

- Drainage Area – 5 acres maximum; 0.5 to 2 acres are preferred.
- Space Required – Approximately 5% of the tributary impervious area is required; minimum 200 ft^2 area for small sites (10 feet x 20 feet).
- Site Slope – No more than 6% slope in the contributing drainage area.
- Minimum Head – Elevation difference needed at a site from the inflow to the outflow underdrain or peak gravel under-layer: 5 feet.
- Minimum Depth to Water Table – A separation distance of 2 feet is recommended between the bottom of the bioretention facility and the elevation of the seasonally high water table.
- Soils – No restrictions; engineered media required. Karst areas may require a liner.

Other Constraints / Considerations

- Wellhead Protection – Reduce potential groundwater contamination (in required wellhead protection areas) by preventing infiltration of hotspot runoff. May require liner for type “A” and “B” soils; pretreat hotspots; 2 to 4 foot separation distance from water table. Wellhead protection areas may require guidance from other agencies, such as TDEC.

4.3.5.5 Planning and Design Standards

The following standards are to be considered **minimum** standards for the design of a bioretention facility. Consult with Knox County to determine if there are any variations to these criteria or additional standards that must be followed.

A. LOCATION AND SITING

- Bioretention areas should have a maximum contributing drainage area of 5 acres or less; 0.5 to 2 acres are preferred. Multiple bioretention areas can be used for larger areas.
- Bioretention areas can either be used to capture sheet flow from a drainage area or function as an off-line device. On-line designs should be limited to a maximum drainage area of 0.5 acres.
- When used in an off-line configuration, the WQv is diverted to the bioretention area through the use of a flow splitter or other means. Stormwater flows greater than the WQv are diverted to other controls or downstream (see Chapter 4, Section 4.2 for more discussion of off-line systems and design guidance for diversion structures and flow splitters).
- Bioretention systems are designed for intermittent flow and must be allowed to drain and reaerate between rainfall events. Bioretention systems will not be allowed for sites that have a continuous flow from groundwater, sump pumps, or other sources.
- Aesthetic considerations should be taken into account in the siting and design of bioretention areas. Elevations must be carefully determined to ensure that the desired runoff flow enters the facility with no more than the maximum design depth.
- Ideally, the construction of an bioretention area should take place after the construction site has been stabilized to avoid deposition of sediment in the media. In the event that the bioretention area is not constructed after site stabilization, diversion of site runoff around the bioretention area and installation and maintenance of appropriate erosion prevention and sediment controls prior to site stabilization is required. Erosion prevention and sediment controls shall be maintained around the bioretention area to prevent runoff and sediment from entering the trench during construction.
- Alternatively, the empty pit can be used as a sediment trap while the site is unstabilized. The media, however, cannot be placed into the bioretention area until all sediment has been removed and the site completely stabilized.
- During and after excavation of the bioretention area, all excavated materials shall be placed downstream, away from the bioretention area, to prevent redeposit of the material during runoff events.

B. GENERAL DESIGN

- A bioretention area shall consist of:
  (1) A grass filter strip (or grass channel) between the contributing drainage area and the ponding area,
  (2) A ponding area containing vegetation with a planting soil bed,
  (3) An organic/mulch layer,
  (4) A gravel and perforated pipe underdrain system to collect runoff that has filtered through the soil layers (bioretention areas can optionally be designed to infiltrate into the soil – see description of infiltration trenches for infiltration criteria).
- A bioretention area design may also include some of the following:
  (1) An optional sand filter layer with geotextile fabric to spread flow, filter runoff, and aid in aeration and drainage of the planting soil, located between the underdrain and planting soil.
  (2) A pea gravel diaphragm at the beginning of the grass filter strip to reduce runoff velocities and spread flow into the grass filter.
  (3) Energy dissipation techniques will be required for contributing drainage areas that have a 6% slope or greater.
  (4) Inflow diversion or an overflow structure(s) that is designed based on one of five main methods:

- Use of a flow diversion structure;
- Use of curbed pavements as an inlet deflector (see Figure 4-30);
- Use of a slotted curb along with the design of parking lot grades to divert the WQv into the bioretention facility. Additional runoff will be bypassed to a downstream catch basin inlet. The alternative requires temporary ponding in the parking lot (see Figure 4-29);
- Figure 4-29 illustrates the use of a short deflector weir (maximum height 6 inches) designed to divert the maximum water quality peak flow into the bioretention area;
- Use of an in-system overflow consisting of an overflow catch basin inlet and/or a pea gravel curtain drain overflow.

See Figure 4-27 for an overview of the various components of a bioretention area. Figure 4-28 provides a plan view and profile schematic of an on-line bioretention area. An example of an off-line facility is shown in Figure 4-29.

C. PHYSICAL SPECIFICATIONS / GEOMETRY

- The minimum dimensions of a bioretention area shall be 10 feet wide by 20 feet long, or 200 square feet in area for roughly circular designs. All designs, except small residential applications such as bio-retention areas placed in cul-de-sac islands to treat runoff from the surrounding street, shall maintain a length to width ratio of at least 2:1.
- The planting soil filter bed shall be sized using a Darcy's Law equation with a filter bed drain time of 48 hours and a coefficient of permeability (k) of 0.5 ft/day.
- The maximum ponding depth of a bioretention area is 6 inches.
- The planting soil bed shall be at least 4 feet in depth when trees are planted in the bioretention area but can be a minimum of 2 feet deep in facilities that will utilize plants other than trees. Planting soils shall consist of a sandy loam, loamy sand, or loam texture with a clay content ranging from 10 to 25%. The soil must have an infiltration rate of at least 0.5 inches per hour and a pH between 5.5 and 6.5. In addition, the planting soil must have a 1.5 to 3% organic content and a maximum 500 ppm concentration of soluble salts.
- The mulch layer must consist of 2 to 4 inches of commercially available fine shredded hardwood mulch or shredded hardwood chips.
- Pea gravel for the diaphragm and curtain, when used, should be ASTM D 448 size No. 6 ($^1/_8$" to $^1/_4$").
- The underdrain collection system shall include a 4 to 6 inch pipe wrapped in a 6 to 8 inch gravel layer. The pipe shall have 3/8-inch perforations, spaced at 6-inch centers, with a minimum of 4 holes per row around the circumference of the pipe. The pipe spacing shall be at a maximum of 10 feet on center and a minimum grade of 0.5% must be maintained. A permeable filter fabric shall be required between the gravel layer and the planting soil bed. High density polyethylene (HDPE) pipe is the preferred pipe material, however other suitable pipe materials may be approved.

D. PRETREATMENT / INLETS

- Adequate pretreatment and inlet protection for bioretention systems shall be provided, such as: a grass filter strip below a flow spreader, or a grass channel, or a pea gravel diaphragm.
- For on-line configurations, a grass filter strip with a pea gravel diaphragm or other flow spreader shall be utilized (see Figure 4-28) as the pretreatment measure. The required length of the filter strip depends on the drainage area, imperviousness, and the filter strip slope. Design guidance on filter strips for pretreatment can be found in Volume 2, Chapter 4, Section 4.3.9 of this manual.
- For off-line applications, a grass channel with a pea gravel diaphragm or other flow spreader shall be used for pretreatment. The length of the grass channel depends on the drainage area, land use, and channel slope. The minimum grassed channel length shall be 20 feet. Design guidance on grass channels for pretreatment can be found in Volume 2, Chapter 4, Section 4.3.10 of this manual.

E. OUTLET STRUCTURES

- For bioretention areas placed in soils having a hydrologic soil group designation of C or D, an outlet pipe shall be provided from the underdrain system to the facility discharge. Outlet pipes are optional for group B soils. Discharges shall not exit the outlet pipe in an erosive manner. Due to the slow rate of discharge, outlet erosion protection is generally unnecessary. The outlet barrel shall be of reinforced concrete for bioretention areas that are used for flood protection.

F. EMERGENCY SPILLWAY

- An overflow structure and nonerosive overflow channel must be provided to safely pass flows that exceed the storage capacity of the bioretention area to a stabilized downstream area or watercourse. If the system is located off-line, the overflow shall be set above the shallow ponding limit.
- A high flow overflow system within a bioretention structure may consist of a yard drain catchbasin (Figure 4-27), though any number of conventional systems could be used. The throat of the catch basin inlet located in a bioretention facility must be no more than 6 inches above the mulch layer at the elevation of the shallow ponding area.

G. MAINTENANCE ACCESS

- A minimum 20' wide maintenance right-of-way or easement shall be provided from a driveway, public or private road. The maintenance access easement shall have a maximum slope of no more than 15% and shall have a minimum unobstructed drive path having a width of 12 feet, appropriately stabilized to withstand maintenance equipment and vehicles.
- The maintenance access shall be designed such that all areas of the bioretention area can be easily accessed, and shall be designed to allow vehicles to turn around.

H. SAFETY FEATURES

- Bioretention areas generally do not require any special safety features. Fencing of bioretention facilities is not generally desirable.

I. LANDSCAPING

- Landscaping is critical to the performance and function of bioretention areas.
- A dense and vigorous vegetative cover that is appropriate for use in a bioretention area shall be established over the contributing pervious drainage areas before runoff can be accepted into the facility. While the contributing drainage area is disturbed or unstabilized, sediment laden runoff shall not be allowed to reach an established bioretention area. A sediment trap can be converted to a bioretention area, but only after removal of all accumulated sediment.
- In general, vegetation utilized in the bioretention area should be native to East Tennessee, resistant to drought and inundation, tolerant of pollutants, have low fertilization requirements, and be easily maintained. Grasses, shrubs, and trees are all permissible vegetation types for bioretention areas, as long as the species used meet the general guidance provided herein.
- Bioretention areas that will contain trees shall be vegetated as follows:
    - The bioretention area shall be vegetated to resemble a terrestrial forest ecosystem, with a mature tree canopy, subcanopy of understory trees, shrub layer, and herbaceous ground cover. Three species each of both trees and shrubs are recommended to be planted.
    - The tree-to-shrub ratio should be 2:1 to 3:1. On average, the trees should be spaced 8 feet apart. Plants should be placed at regular intervals to replicate a natural forest. Woody vegetation should not be specified at inflow locations.
    - After the trees and shrubs are established, the ground cover and mulch should be established.

Additional information and guidance on bioretention area design and vegetation can be found on the EPA website at http://cfpub.epa.gov/npdes/stormwater and on the North Carolina State University Biological and Agricultural Engineering website at http://bae.ncsu.edu/stormwater/ .

J. ADDITIONAL SITE-SPECIFIC DESIGN CRITERIA AND ISSUES

Physiographic Factors - Local terrain design constraints

- Low Relief – Use of bioretention areas may be limited by low head.
- High Relief – Ponding area surface must be relatively level.
- Karst – Use poly-liner or impermeable membrane to seal bottom.

Soils

- No restrictions, however, planting soil must meet the required design infiltration rate.

Special Downstream Watershed Considerations

- Wellhead Protection – Reduce potential groundwater contamination (in required wellhead protection areas) by preventing infiltration of hotspot runoff. May require liner for type "A" and "B" soils; pretreat hotspots; 2 to 4 foot separation distance from water table. Wellhead protection areas may require guidance from other agencies, such as TDEC.

4.3.5.6 Design Procedures

Step 1. Compute runoff control volumes

> Calculate WQv, CPv, Qp_2, Qp_{10}, Qp_{25}, and Qp_{100}, in accordance with the guidance presented in Volume 2, Chapter 3.

Step 2. Determine if the development site and conditions are appropriate for the use of a bioretention area

> Consider the Application and Site Feasibility Criteria in subsections 4.3.5.4 and 4.3.5.5-A (Location and Siting).

Step 3. Confirm design criteria and applicability

> Consider any special site-specific design conditions/criteria from subsection 4.3.5.5-J (Additional Site-Specific Design Criteria and Issues).
>
> Check with Knox County and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

Step 4. Compute WQv peak discharge (Q_{wq})

> The peak rate of discharge for water quality design storm is needed for sizing of off-line diversion structures (see Volume 2, Chapter 3 for more detail).
>
> (a) Using WQv (or total volume to be captured), compute CN
> (b) Compute time of concentration using TR-55 method
> (c) Determine appropriate unit peak discharge from time of concentration
> (d) Compute Q_{wq} from unit peak discharge, drainage area, and WQv.

Step 5. Size flow diversion structure, if needed

> A flow regulator (or flow splitter diversion structure) should be supplied to divert the WQv to the bioretention area.
>
> Size low flow orifice, weir, or other device to pass Q_{wq}.

Step 6. Determine size of bioretention ponding/filter area

The required planting soil filter bed area is computed using the following equation (based on Darcy's Law):

$$A_f = \frac{(WQ_v)(d_f)}{[(k)(h_f + d_f)(t_f)]}$$

where:

A_f	=	surface area of ponding area (ft^2)
WQv	=	water quality volume (or total volume to be captured)
d_f	=	filter bed depth (4 feet minimum)
k	=	coefficient of permeability of filter media (ft/day) (use 0.5 ft/day for silt-loam)
h_f	=	average height of water above filter bed (ft) (typically 3 inches, which is half of the 6-inch ponding depth)
t_f	=	design filter bed drain time (days) (2.0 days or 48 hours is recommended maximum)

Step 7. Set design elevations and dimensions of facility

See subsection 4.3.5.5-C (Physical Specifications/Geometry).

Step 8. Design conveyances to facility (off-line systems)

See the example figures to determine the type of conveyances needed for the site.

Step 9. Design pretreatment

Pretreat with a grass filter strip (on-line configuration) or grass channel (off-line), and stone diaphragm.

Step 10. Size underdrain system

See subsection 4.3.5.5-C (Physical Specifications/Geometry)

Step 11. Design emergency overflow

An overflow must be provided to bypass and/or convey larger flows to the downstream drainage system or stabilized watercourse. Nonerosive velocities are required at the outlet point.

Step 12. Design vegetation

A landscaping plan for the bioretention area should be prepared to indicate how it will be established with vegetation.

See subsection 4.3.5.5-I (Landscaping) for more details.

4.3.5.7 Maintenance Requirements and Inspection Checklist

Note: Section 4.3.5.7 must be included in the Operations and Maintenance Plan that is recorded with the deed.

Regular inspection and maintenance is critical to the effective operation of bioretention areas as designed. It is the responsibility of the property owner to maintain all stormwater BMPs in accordance with the minimum design standards and other guidance provided in this manual. The Director has the authority to impose additional maintenance requirements where deemed necessary.

This section provides guidance on maintenance activities that are typically required for bioretention areas, along with a suggested frequency for each activity. Individual bioretention areas may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e.., drought) regional hydrologic conditions, and any changes or redevelopment in the upstream land use. Each property owner shall perform the activities identified below at the frequency needed to maintain the pond in proper operating condition at all times.

Inspection Activities	**Suggested Schedule**
• After several storm events or an extreme storm event, inspect for signs of erosion, signs of mulch movement out of the treatment area, signs of damage to plants or dead or diseased vegetation.	As needed
• Inspect: inflow points for clogging (off-line systems), strip/grass channel for erosion or gullying, • Inspect trees, shrubs and other vegetation to evaluate their health and replace any dead or diseased vegetation. • Inspect surrounding drainage area for erosion or signs of sediment delivery to the bioretention area.	Semi-annually
• Check for signs of vegetation overgrowth. • Inspect treatment area during a rain event and visually verify that stormwater recedes within 24-48 hours from the treatment area.	Annually
Maintenance Activities	**Suggested Schedule**
• Replace mulch and repair areas of erosion, when identified. • Replace dead or diseased plants.	As needed
• Remove clogs from the stormwater system inflow and overflow components. • Remove sediments from pretreatment areas and restabilize with stone or vegetation as appropriate.	Semi-annually
• Harvest overgrown vegetation and remove from the bioretention area.	As needed
• The planting soils should be tested for pH to establish acidic levels. If the pH is below 5.2, limestone should be applied. If the pH is above 7.0 to 8.0, then iron sulfate plus sulfur can be added to reduce the pH. • Check that planting soils still have specified infiltration rate.	Annually
• Replace mulch over the entire area. • Replace pea gravel diaphragm if warranted. • Note that the surface of the ponding area may become clogged with fine sediment over time. Core aeration or cultivating of un-vegetated areas may be required to ensure adequate filtration.	2 to 3 years

Knox County encourages the use of the inspection checklist that is presented on the next page to guide the property owner in the inspection and maintenance of bioretention areas. The Director can require the use of this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the bioretention area. Questions regarding stormwater facility inspection and maintenance should be referred to the Knox County Department of Engineering and Public Works, Stormwater Management Division.

INSPECTION CHECKLIST AND MAINTENANCE GUIDANCE (continued)
BIORETENTION AREA INSPECTION CHECKLIST

Location: ____ Owner Change since last inspection? Y N

Owner Name, Address, Phone:____

Date: ___________ Time: ______________ Site conditions:____

Inspection Items	Satisfactory (S) or Unsatisfactory (U)	Comments/Corrective Action
Inflow and Overflow Points		
Clear of debris and functional?		
Sediment accumulation?		
Vegetation in good condition?		
Signs of erosion?		
Other (describe)?		
Sediment Pretreament		
Evidence of sediment accumulation?		
Treatment Area and Vegetation		
Signs of erosion or movement of mulch?		
Vegetation healthy or damaged?		
Signs of sediment?		
Signs of thinning mulch layer?		
Vegetation overgrown and in need of harvesting?		
Standing water for more than 24-48 hours after rain events?		
Other (describe)?		
Hazards		
Have there been complaints from residents?		
Public hazards noted?		

If any of the above inspection items are **UNSATISFACTORY**, list corrective actions and the corresponding completion dates below:

Corrective Action Needed	Due Date

Inspector Signature:________________________________ Inspector Name (printed)____________________________

4.3.5.8 Example Schematics

Figure 4-27. Schematic of a Typical Bioretention Area
(Source: Claytor and Schueler, 1996)

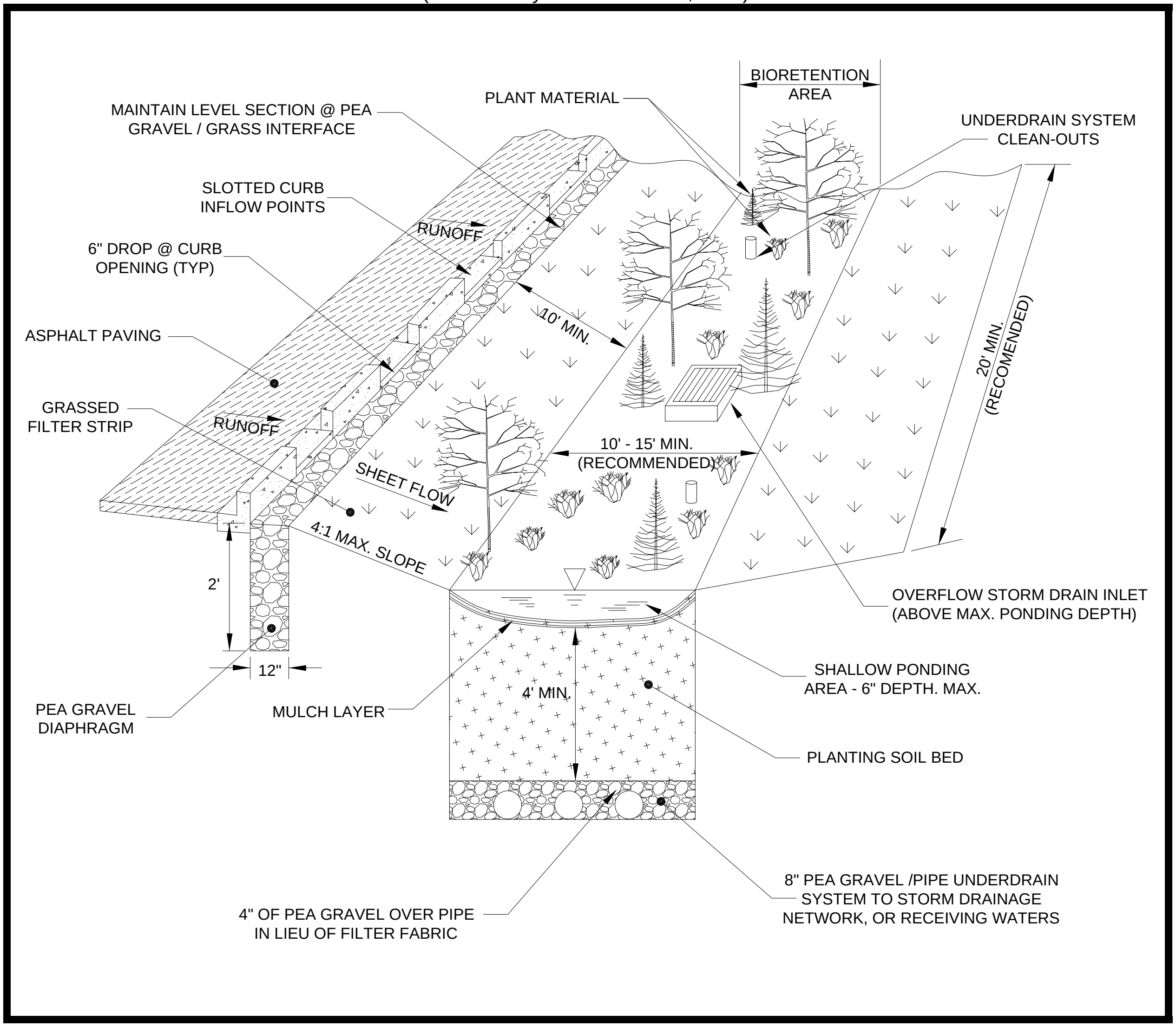


Figure 4-28. Schematic of a Typical On-line Bioretention Area
(Source: Claytor and Schueler, 1996)

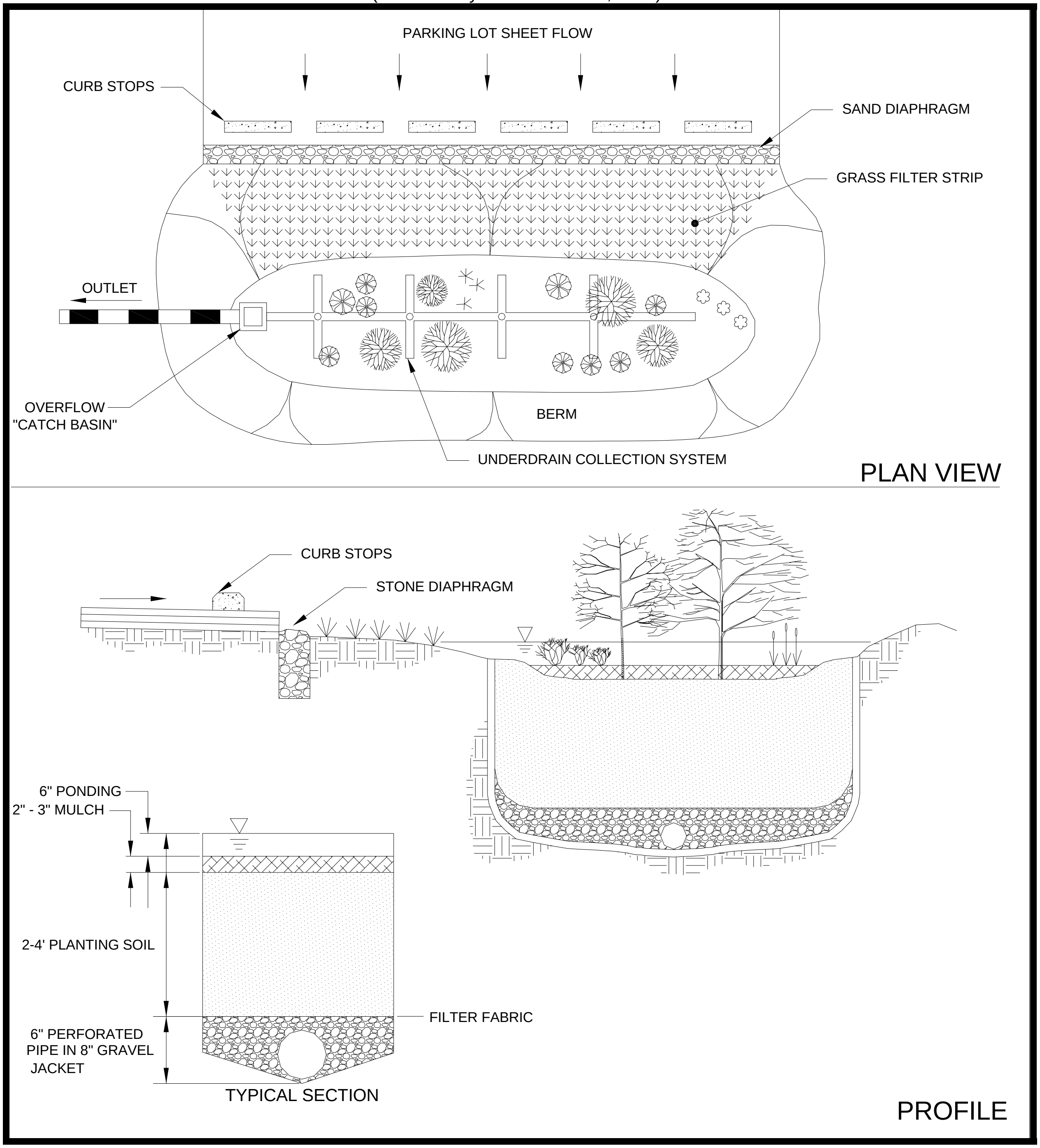


Figure 4-29. Schematic of a Typical Off-line Bioretention Area

(Source: Claytor and Schueler, 1996)

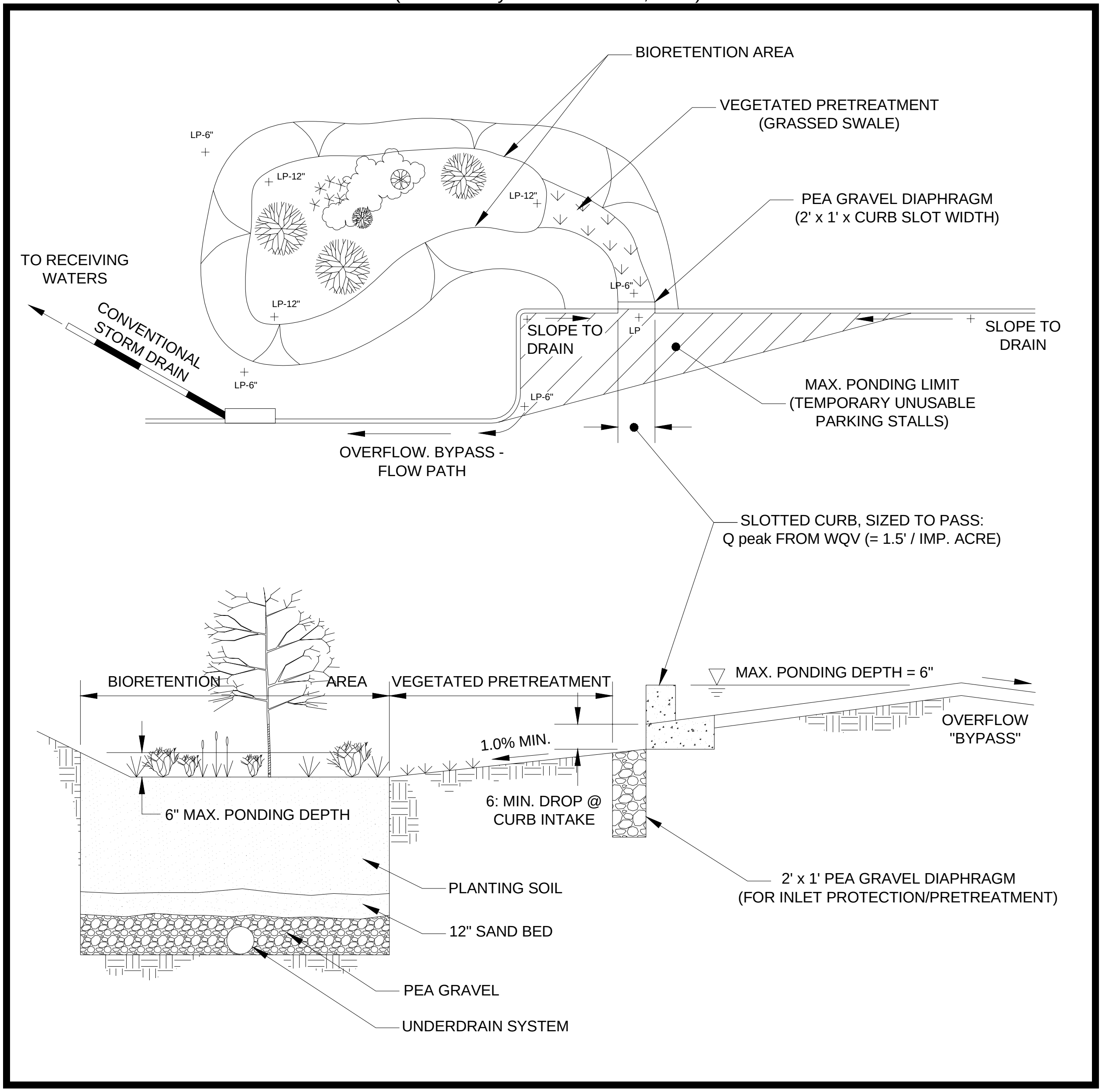
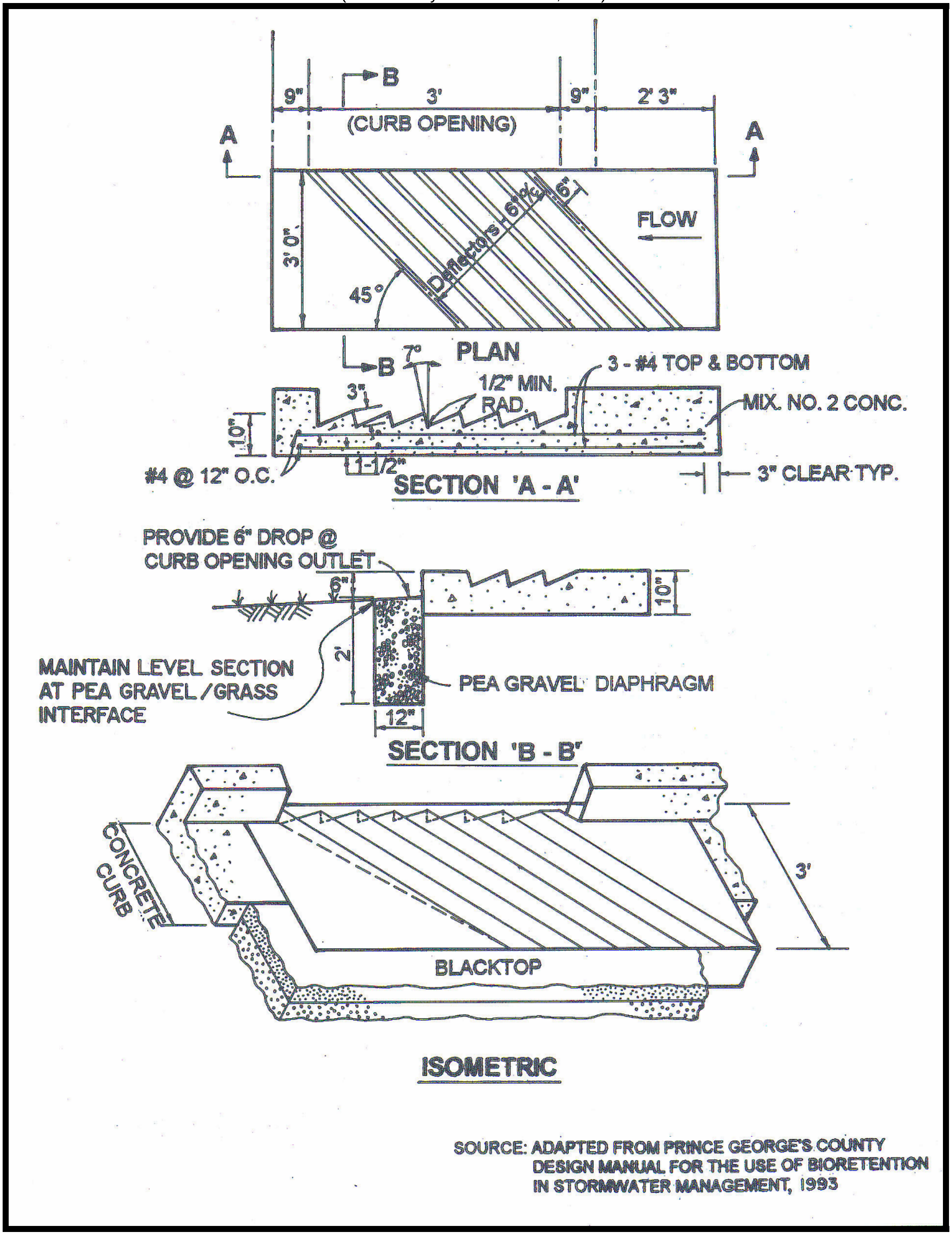


Figure 4-30. Schematic of a Typical Inlet Deflector
(Source: Claytor and Schueler, 1996)



4.3.5.9. Design Form

Knox County recommends the use of the following design procedure forms when designing a bioretention area. Proper use and completion of the form may allow a faster review of the Stormwater Management Plan by Knox County Engineering.

Design Procedure Form: Bioretention Areas

PRELIMINARY HYDROLOGIC CALCULATIONS	
1a. Compute Runoff Coefficient, Rv	Rv = ______
Compute WQv	WQv = ______ acre-ft
1b. Estimate CPv	CPv = ______ acre-ft
1c. Estimate storage volumes	
Estimate storage volume required for 2-year storm	2-year storage = ______ acre-ft
Estimate storage volume required for 10-year storm	10-year storage = ______ acre-ft
Estimate storage volume required for 25-year storm	25-year storage = ______ acre-ft
Estimate storage volume required for 100-year storm	100-year storage = ______ acre-ft
BIORETENTION AREA DESIGN	
2. Is the use of a bioretention area appropriate?	***See subsections 4.3.5.4 and 4.3.5.5 - A***
3. Confirm design criteria and applicability.	***See subsection 4.3.5.5 - J***
4. Determine size of bioretention filter area	A_f= ______ ft^2
5. Set design elevations and dimensions	Length = ______ ft Width = ______ ft ______ elevation top of facility ______ other elev: ______ ______ other elev: ______ ______ other elev: ______
6. Conveyance to bioretention facility	______ Online or ______ Offline ?
7. Pretreatment	Type: ______
8. Size underdrain area Based on guidance: Approx. 10% A_f	Length= ______ ft
9. Overdrain design	Type: ______ Size: ______
10. Emergency storm weir design Overflow weir - Weir equation	Length= ______ ft
11. Choose plants for planting area	Select native plants based on resistance to drought and inundation, cost, aeshetics, maintenance, etc.
12. Verify peak flow control (if applicable), water quality drawdown time and channel protection detention time	

4.3.5.10 References

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4.3.5.11 Suggested Reading

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