September 15, 2023

LCRA Highland Lakes Watershed Ordinance Technical Manual – Biofiltration Basin

This bulletin provides technical guidance and criteria for the design, implementation and maintenance of biofiltration systems as an alternative BMP to the BMPs found in LCRA Highland Lakes Watershed Ordinance Technical Manual (5th Edition, 2007). Designers will also need to meet relevant criteria found in Sections 2, 4 and 5 of the Technical Manual. CAD and PDF details are provided on the LCRA HLWO website.

Biofiltration Basin, San Marcos, Texas

Description

A biofiltration basin is a type of best management practice (BMP) that uses the chemical, biological and physical properties of plants, microbes, and soils to remove pollutants from stormwater runoff. **A biofiltration basin can be used as a stand-alone BMP to obtain compliance with the Highland Lakes Watershed Ordinance.**

A biofiltration basin uses more than one treatment mechanism to manage pollutants from stormwater runoff. A forebay provides pretreatment of runoff to protect the biofiltration media from becoming clogged prematurely by sediment loads. Then, flows are directed through a biofiltration media that removes pollutants.

Biofiltration basins use vegetation to enhance the removal of pollutants and sustain the permeability of the biofiltration medium for longer periods of time without maintenance. This biological community differentiates a biofiltration BMP from a typical sand filter, which is similar in design.

Hydraulic components make a biofiltration basin work effectively. The inflow must incorporate a stabilized outfall or other structure designed to spread flows, so runoff does not concentrate and potentially channelize in the sediment forebay or biofiltration area. A sediment forebay captures coarse sediments with a separator element between the forebay and the biofiltration area. The biofiltration area must have an underdrain piping system with native or adapted vegetation rooted in the biofiltration media (soil) selected for tolerance to ponding and dry soil conditions. Finally, the basin underdrain pipe must have a raised outlet at the point of discharge to help sustain vegetation on the surface, promote infiltration and nutrient attenuation.

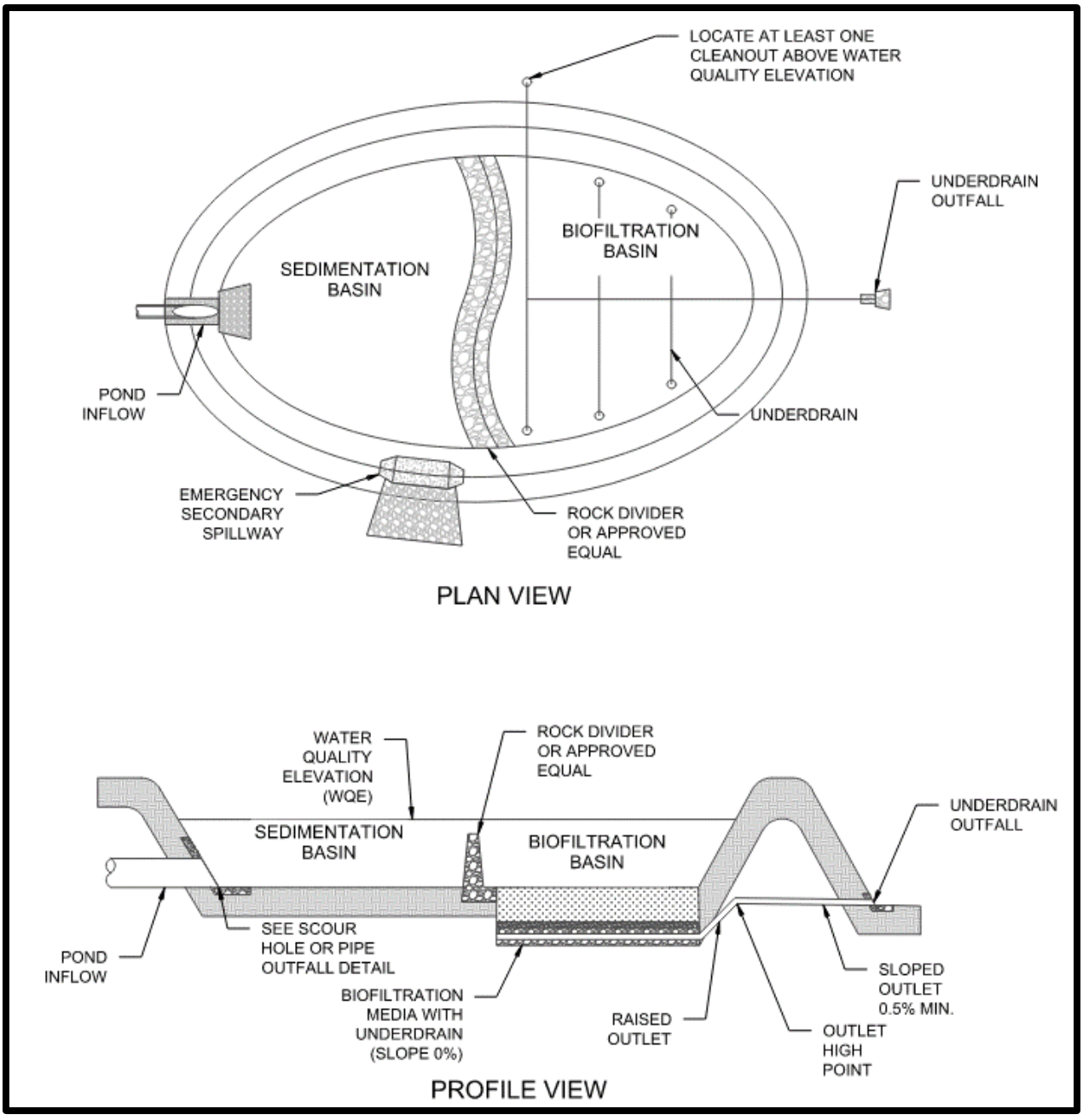
The forebay (sedimentation basin) of the biofiltration basin also can be used as a temporary sediment basin during development construction.

As an alternative to Technical Manual Section 4.2.1 (8) (iii) (flow spreading device), the water quality outlet (6-inch PVC pipe or appropriately sized pipe) may discharge across the buffer zone to the receiving waterway, creek, or channel. Please see the Technical Manual Bulletins - BMP Details for guidance.

Design Steps Summary

1. Determine drainage area, impervious cover, and compute water quality volume per the LCRA design spreadsheet and Step 5 below. If stormwater credits are used such as pervious pavement, landscape conservation, rainwater harvesting, etc., include those measures to reduce the required water quality volume.
2. Compute the required biofiltration media area per Step 10 below.
3. If stormwater detention is also provided, determine the detention volume and required peak flow control.

4. Prepare the basin grading plan to manage the water quality volume and detention (if provided). Provide a minimum pretreatment volume of 50% as noted in Step 3 below.
5. Ensure pond grading, basin configuration, and depth (maximum water quality depth of six feet) are in compliance with Steps 5, 6, and 7.
6. Design pond bottom soils (six to eight inches deep and composed of high-quality topsoil) and vegetation per Step 8.
7. Use the LCRA details found on the website for the biofiltration media per Step 9.
8. Design the underdrain system, 0% grade within the filter media, raised outlet, and discharge pipe (slope between 0.5% and 1.0%) per Step 13 and apply LCRA details.
9. See this technical guidance to design the underdrain outlet location and outfall stabilization ("Flow Spreading Device Alternative".
10. Determine water surface elevations for the water quality design storm and other storm events to establish outlet/weir elevations and freeboard.
11. Provide energy dissipation and stabilization at all inflow and outflow points per Step 2.
12. Consider using the basin as a temporary sediment basin during construction per Step 17.
13. See the Design Example at the end of this document.



Biofiltration Basin Plan and Profile

Application

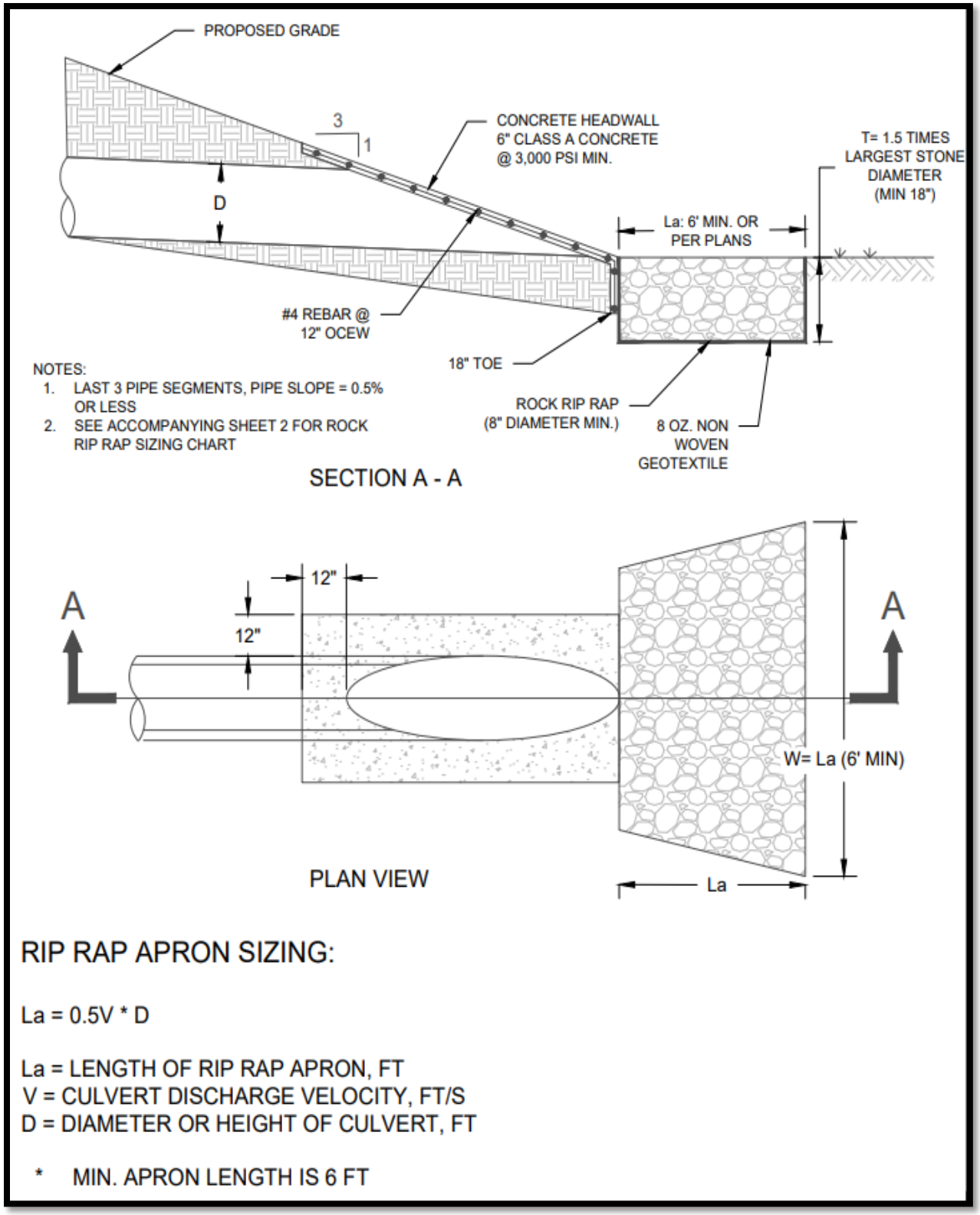
Biofiltration basins are adaptable and can be used on areas with thin soils, high evaporation rates, low-soil infiltration rates, limited-space, and where groundwater is to be protected. A biofiltration basin tends to have good longevity due to the high porosity of the biofiltration medium. However, without proper maintenance, a biofiltration system may clog, which can reduce performance and lead to nuisances associated with standing water.

Design Guidelines

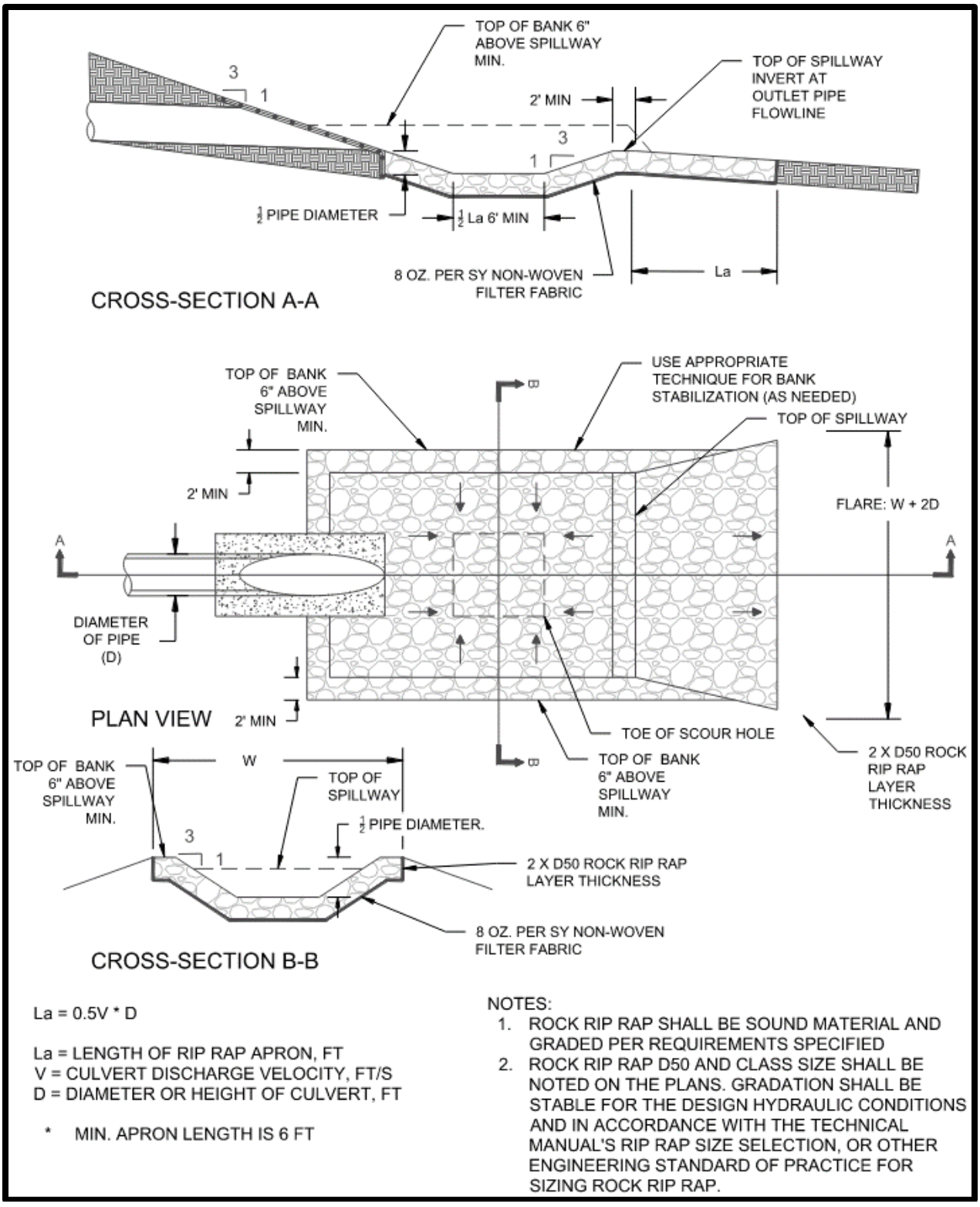
Basin geometry of a biofiltration basin is not critical to performance. This allows for flexible basin designs to accommodate the site constraints and incorporate aesthetic appeal. Some constraints to consider in the design are existing topography, the location of existing and proposed utilities, depth to bedrock, and location and number of existing trees. The sedimentation basin component of a biofiltration basin can be used for low impact recreational activities.

(1) *Contributing drainage area:* Less than 30 acres is recommended.

(2) *Basin inflow stabilization:* A stabilized outfall into the basin manages erosion and reduces flow velocity. See the details below and apply Figure 3-4 in the Technical Manual for rock rip rap size selection.



Pipe Outfall Detail



La = 0.5V * D

La = LENGTH OF RIP RAP APRON, FT
V = CULVERT DISCHARGE VELOCITY, FT/S
D = DIAMETER OR HEIGHT OF CULVERT, FT

* MIN. APRON LENGTH IS 6 FT

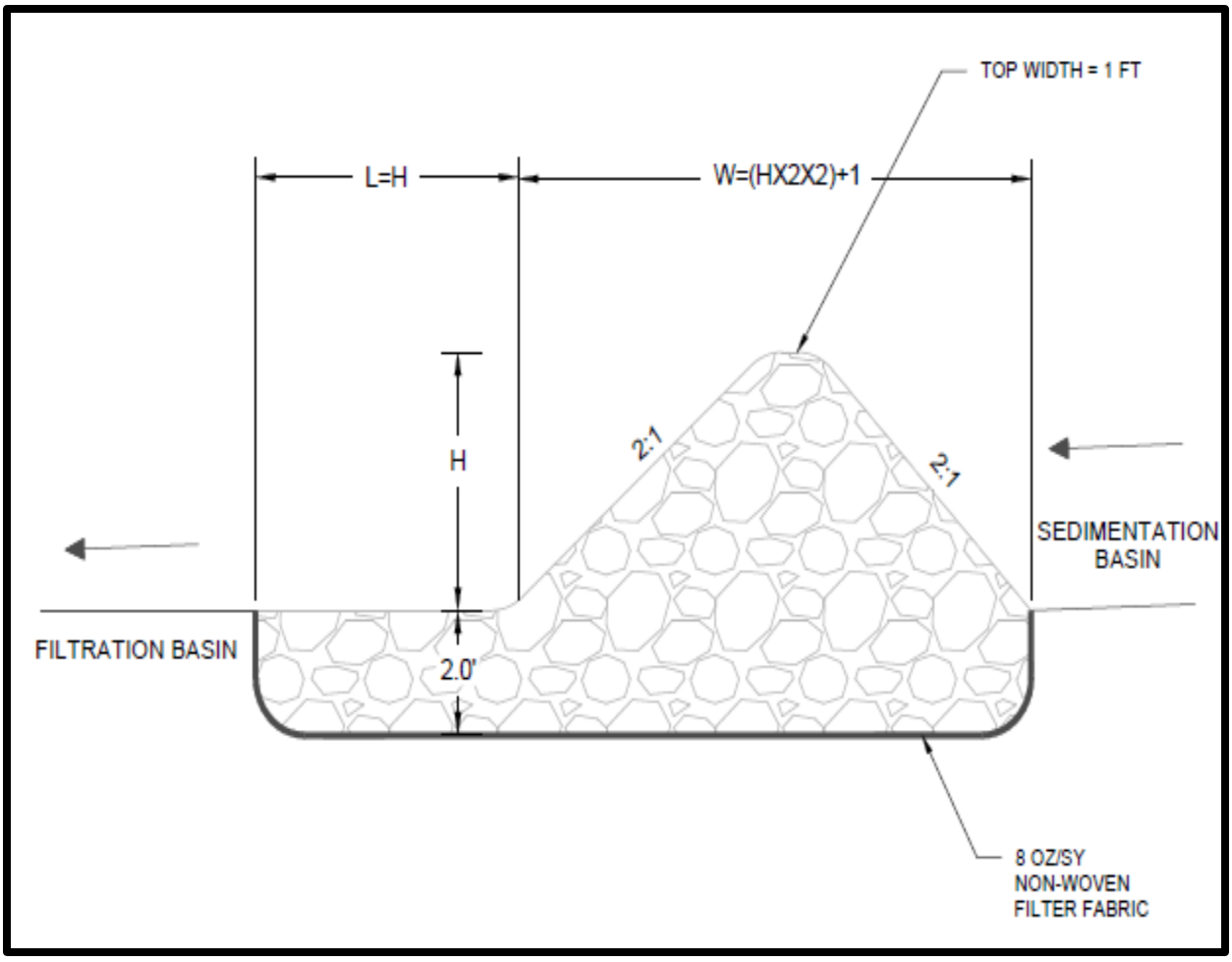
NOTES:

1. ROCK RIP RAP SHALL BE SOUND MATERIAL AND GRADED PER REQUIREMENTS SPECIFIED
2. ROCK RIP RAP D50 AND CLASS SIZE SHALL BE NOTED ON THE PLANS. GRADATION SHALL BE STABLE FOR THE DESIGN HYDRAULIC CONDITIONS AND IN ACCORDANCE WITH THE TECHNICAL MANUAL'S RIP RAP SIZE SELECTION, OR OTHER ENGINEERING STANDARD OF PRACTICE FOR SIZING ROCK RIP RAP.

Scour Hole Outfall Detail

(3) *Pretreatment:* A sediment basin (forebay) is designed to retain the bulk of the sediment entering the basin. This will simplify sediment removal and reduce overall basin maintenance. Refer to the design guidelines for sediment forebays in the Technical Manual, Section 4.2.1(7)(iv.). In the biofiltration BMP, the **forebay volume is equal to 50% of the water quality volume** to retain the first flush runoff volume. To promote advanced treatment of the first flush volume, the forebay design relies on a rock berm and/or gabion (diver structure) within the basin with the top of the divider one foot below the water quality elevation. A rock rip rap splash pad shall be placed on the downstream side of the divider structure to prevent scouring per detail and photograph below. **(**d50= 12”). Big Muhly and Emory Sedge also can be planted downstream of the divider barrier for aesthetics and to provide additional flow spreading. During the project construction phase, a temporary 6-inch PVC pipe with a skimmer constructed upgradient from the separator device and used with an impermeable liner on the separator device will help manage sediment and protect the biofiltration media.

Sediment Forebay



Rock Divider Detail

Rock Divider Structure

(4) *Secondary treatment:* None required.

(5) *Basin sizing*: The required BMP capture volume is calculated by applying a factor of 1.05 to the water quality volume (WQV). See Chapter 2.3 of the Technical Manual. The WQV is increased by a factor of 5% to accommodate the reduction in the available storage volume due to deposition of solids between full-scale maintenance activities.

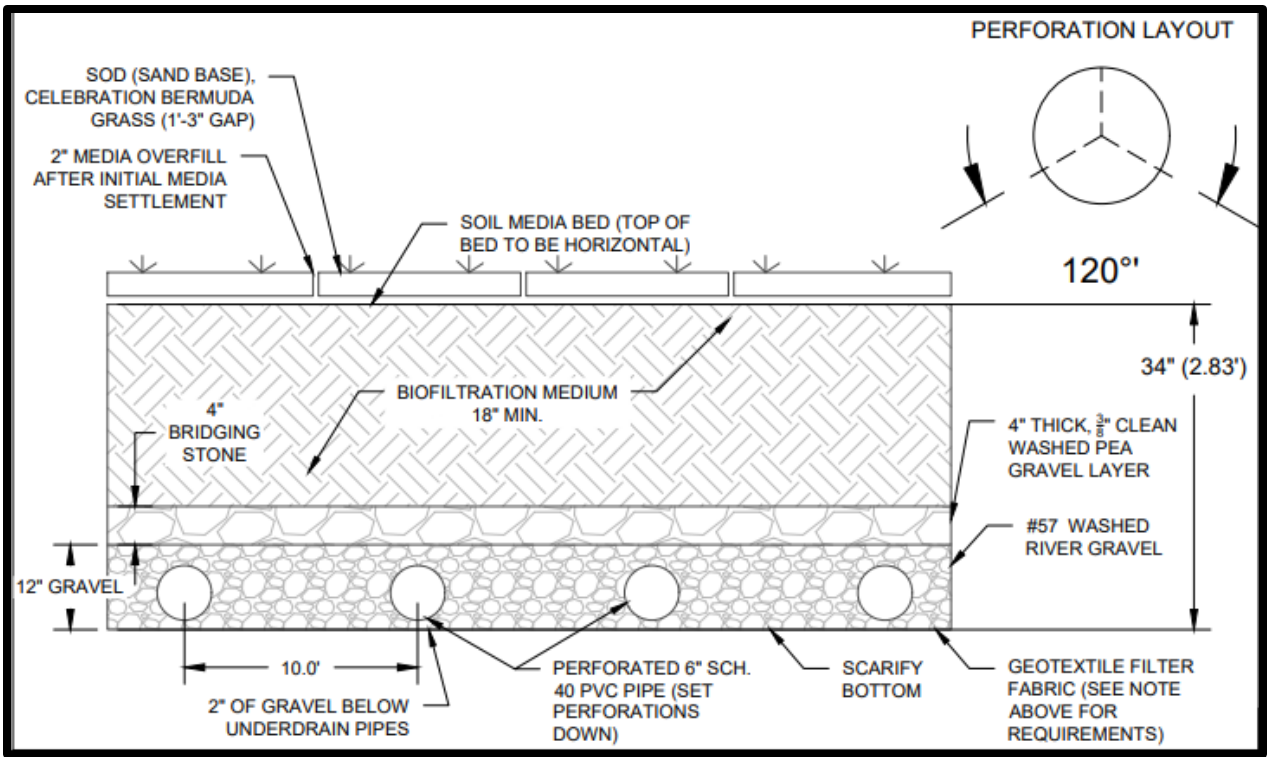
*BMP Volume = WQV * 1.05 (cubic feet)*

(6) *Sediment forebay configuration:* The basin should maintain a longitudinal slope between 0.5 – 2.0% with a lateral slope between 1.0 – 1.5%. Runoff from the basin inflow should be spread across the forebay in a non-erosive manner.

(7) *Depth*: Maximum water depth for the water quality volume should not exceed 6 feet. If the facility is online and the flood volume will be stacked on top of the water quality volume, the maximum depth is 8 feet. Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.

(8) *Sediment forebay soils and vegetation:* To enhance infiltration and water storage in the basin, topsoil must be placed on the sedimentation area floor after the excavated bottom is scarified to a depth of 2 to 3 inches. The topsoil must be 6 to 8 inches deep and composed of a soil mixture of 30-40% sand or granite sand and 60-70% topsoil by volume. The topsoil must have a clay content less than 20% and be free of stones, stumps, roots, or other similar objects larger than 1 inch. Do not use caliche or infertile soils. Topsoil placement may be omitted if existing soils demonstrate an infiltration rate of 0.5 inches per hour after excavation and certified by the design engineer. The bottom of the sediment forebay should be at least 3 inches higher than the top of the biofiltration area to uniformly discharge flow and minimize flow blockage. The topsoil should be sodded with Celebration Bermuda or approved equal to stabilize the area and irrigated, if necessary, to establish vegetation.

(9) *Biofiltration media*: The biofiltration media must be 18 inches thick with a level surface when installed. To provide acceptable drainage and plant growth characteristics, the biofiltration media must meet the following performance criteria per ASTM D-422:



Biofiltration Media Section

Percent Organic Matter (by weight) of 0.5—5.0% per ASTM D2974 Method C

Texture Analysis (particle size distribution by weight):

- Percent Sand 70—90%
- Percent Clay 3—10%
- Percent Silt plus Clay ≤27%

Suppliers of biofiltration media must have laboratory testing conducted at a minimum of six-month intervals to verify percent organic matter and texture analysis. The media must not contain any contaminated soils and be free of any household or hazardous waste. It must be free of stones, trash, and other undesirable material, and should not contain weeds or weed seeds. No infertile alluvial soils (e.g. “red death”) may be used in the mixture.

Compost derived from animal or human sources and unstable forms of organic matter may not be included in the biofiltration media. Recommended sources of organic matter include that found naturally in native topsoil, humus, coir fiber, peat, and mature plant-derived composts with an established fungal component.

The biofiltration media must be certified by the project engineer or their designee (e.g., contractor, soil supplier or appropriate qualified alternative individual) as meeting the above performance criteria (based on submittal of delivery tickets, test results, etc.) before acceptance. The media must not be compacted by construction equipment.

The following mixture (% by volume) should create an appropriate biofiltration media, subject to the specific characteristics of the topsoil, which may exhibit considerable variability.

- 70-80% concrete sand per ASTM C33 and/or screened decomposed granite sand

- 20-30% screened bulk topsoil (chocolate loam is acceptable)

- The ingredients shall be well-mixed to create a homogeneous medium.

The biofiltration media must be stored on-site separate from other materials and covered to prevent erosion of the mixture by rain and runoff. The media must have a prominent tag affixed that reads “BIOFILTRATION MEDIA FOR WATER QUALITY POND”. *Biofiltration media placement:* The bottom of the biofiltration area should be scarified to a depth of 2 to 3 inches to promote infiltration prior to placement of the biofiltration system (gravel, pea gravel, biofiltration media). **The media must not be compacted and a 2” overfill is necessary to allow for natural settlement**. The biofiltration media should be placed in 12” lifts without using heavy operating equipment or compaction. Lifts should be lightly watered to encourage soil settling. The final surface must be raked flat. **Skid steers cannot be used to on top of the biofiltration media surface**. Track loaders can be used to place the media but turns must be minimized to reduce compaction. Alternatively, the media and underdrain gravel can be placed from the sides of the basin using commercially available equipment like that shown below. When the media is placed, the contractor must call for an LCRA inspection to observe the placement technique. The project engineer must be notified 24 hours prior to installation of the biofiltration media and approve and certify the installation.

The media is the last item installed in the basin construction process and siltation from up-gradient processes should be limited due to the use of the forebay as a temporary sediment basin with an outlet outside of the biofiltration basin (see above pre-treatment section). As an alternative, the contractor can cover the biofiltration media with an impermeable geomembrane liner and when the upstream drainage area is stabilized liner can be removed and the sod is placed on the biofiltration media surface.

Media Placement Option (Nashville, TN)

Media Placement Option (San Marcos, TX)

(10) *Biofiltration area:* To achieve a 48-hour drawdown time, the minimum surface area required for the biofiltration area within the SCM is:

$$Af = WQV/(7 + 2.33*H)$$

Af = required surface area of the medium in square feet

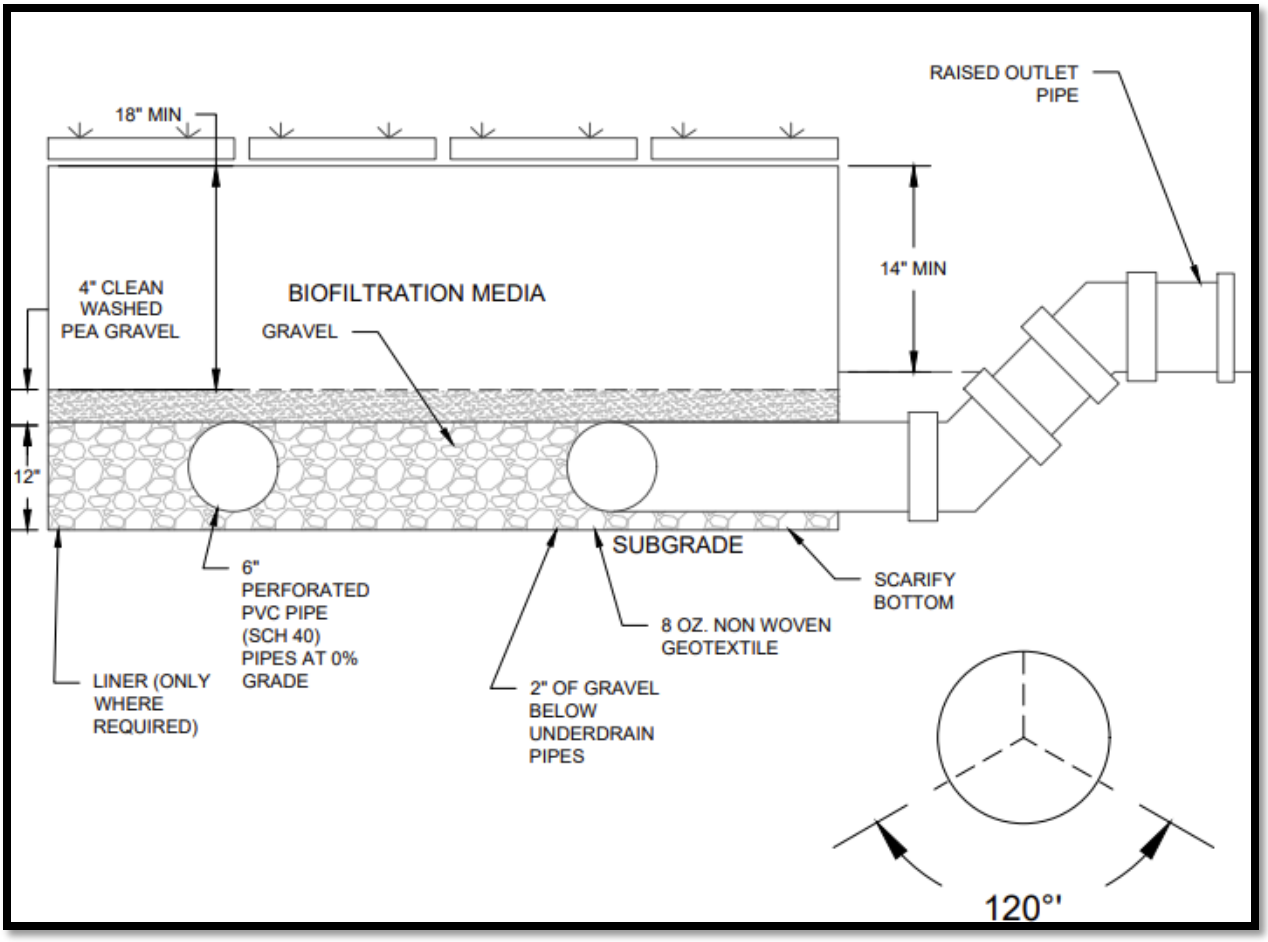
WQV = water quality volume in cubic feet as defined in Section 2.3 of the Technical Manual

H = maximum ponding depth above the filtration medium in feet.

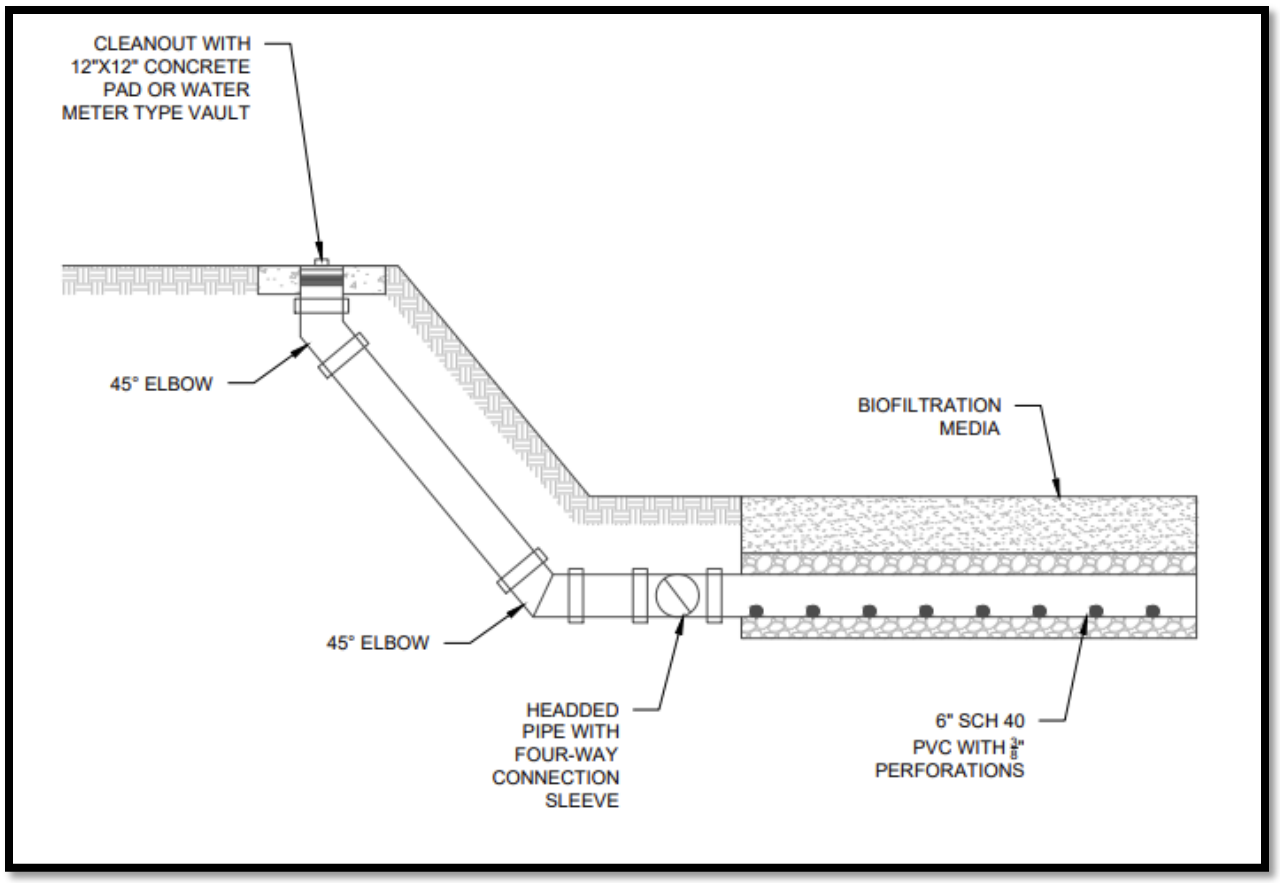
(11) *Vegetation:* Celebration Bermuda sod should be installed on the filtration media with a spacing of one to three inches between the sod sections, then backfill biofiltration media to be level with the sod. **Sod should be in a sand-base with limited clay content**. Irrigate, as needed, to establish vegetation. For more diverse plant options, refer to the City of Austin Environmental Criteria Manual for guidance. Note that many of the plant species included on the Austin-approved list are not as resilient when submerged for long periods of time, so a maximum water depth of 2 feet is recommended when using a variety of species.

(12) *Underdrain gravel*: The underdrain gravel layer must consist of a 4-inch layer of clean washed pea gravel (ASTM C-33, Size 7) overlying a 12-inch layer of 0.5- to 1.5-inch clean aggregate with no fines (ASTM C-33, Size 5, aka river gravel). A non-woven filter fabric (4 oz./SY with a minimum flow rate of 110 gal/min/sq. ft) shall be placed on the scarified ground surface below the clean washed river gravel.

(13) *Underdrain pipe*: The underdrain pipe must be 6-inch perforated Schedule 40 PVC with 3/8-inch perforations installed near the base of the gravel layer (see detail below). Maximum spacing between rows of perforations should not exceed 6 inches. The underdrain piping must not be wrapped in filter fabric and should consist of a main collector pipe and two or more lateral branch pipes spaced at intervals of no more than 10 feet and not more than 5 feet from pond side slopes or walls. At least one of the laterals should include a cleanout access point with a watertight threaded cap above the water quality elevation as illustrated below. Underdrain pipes in the biofiltration area should be laid on a flat grade, and the pipes should come together to flow to the outlet at a 0.5 to 1% slope. The discharge pipe must have a raised outlet so that the invert of the discharge pipe is 1.2 feet below the top of the media. The outlet can be in a manhole, precast box inlet with a grate on top, or at grade depending on the elevation of the local land surface. The contractor must call for an LCRA inspection of the underdrain installation.



Raised Outlet Detail



Underdrain Cleanout Detail

(14) *Overflow weir:* A splitter structure or overflow weir can be used to isolate the water quality volume and/or bypass the remaining flow around the system once the entire water quality volume has been captured. An overflow weir should be located within the sediment forebay to reduce potential damage to the biofiltration media.

(15) *Safety considerations:* See Section 4.2.1 of the Technical Manual.

(16) *Maintenance:* See Chapter 5 of Technical Manual for maintenance plan requirements for all permanent BMPs and the specific maintenance requirements for sand filter basins. When mowing the vegetation, grass clippings should be collected and removed. Replace or amend biofiltration media as needed to ensure that the design drawdown time is not exceeded.

(17) *Temporary sediment basin:* The biofiltration basin may be used as a temporary sediment control basin during construction, provided that the filtration media, underdrain, and subsoil are protected from clogging. This can be accomplished in one of two ways.

Option 1 is to defer placement of the underdrain, gravel and biofiltration media until the last step in construction when the contributing drainage area to the basin has been stabilized. In this option, the bioretention basin is initially excavated to the same level as the sedimentation basin, and over-excavated immediately prior to placement of the underdrain, gravel and biofiltration media.

Option 2 is to install the underdrain, gravel and biofiltration media and protect these components as follows.

1) Install a temporary outlet consisting of 6-inch PVC pipe from the sediment forebay to a discharge point outside of the basin and place rock rip rap around the pipe outfall to manage discharge velocity.

2) Cover the basin divider structure that separates the forebay from the biofiltration area with a temporary impermeable geomembrane liner or approved equal, to minimize flow through the structure.

3) Connect a Faircloth skimmer, or approved equal, to the temporary 6-inch PVC pipe with sufficient length of flexible tubing to be able to float to the top of the basin. This will allow the sedimentation forebay to function as a temporary sediment control basin while the contributing drainage area is developed/stabilized.

4) Once the contributing drainage area is stabilized, remove the skimmer, plug the 6-inch PVC pipe, and remove the impermeable geomembrane liner from the divider structure. It is recommended that the plug on the 6-inch PVC pipe be removable (threaded cap) as a secondary outlet to drain the forebay during future maintenance operations.

Example BMP Design – Single Family Subdivision Project

Project: 50-acre single family subdivision in the Highland Lakes Ordinance jurisdiction

Topography: Slopes vary from 2 to 5% within the 50-acre tract

Soils: Brackett and Tarrant soils as commonly found in the region

This example will look at one 25-acre drainage area within the residential development.

Biofiltration basin example.

Step 1 – Define creek buffer zones beginning at creeks with 5 acres of drainage area.

Step 2 - Determine potential compliance with alternate standards. Total impervious cover is 45% and project greater than 3 acres in area. Project cannot comply with alternate standards.

Step 3 - Design project to comply with Performance Standards found in the Ordinance.

a) *Pre-development Planning Meeting*. Planner prepares conceptual plan for development outside the buffer zone, designing with drainage in mind by utilizing topography and slopes to minimize cut and fill for development construction. In addition, minimal land clearing is proposed, thus, construction sediment can be more effectively managed. A pre-development planning meeting is conducted with LCRA staff to review proposed development project and water quality management approaches. Recommendations are provided and the subdivision plan is slightly modified to promote more sheet flow and natural drainage conveyance.

b) *Construction Phase Erosion and Sediment Control* design will be detailed and minimize the concentration of flow. In areas of concentrated flow, sediment basins or other stabilization methods will be used to prevent scour and sediment discharge. Construction phasing will be defined and coordinated with construction limits. The proper sediment controls such as silt fence and rock berms will be selected based upon upstream contributing drainage area. Once areas are disturbed, revegetation will occur as soon as possible through broadcast seeding, hydromulch, compost/seed distribution, and erosion control blankets/matting when necessary. The goal of the erosion sediment control design is to minimize land clearing to reduce erosion potential, then stabilize with vegetation in a rapid manner.

c) *Water Quality Volume (WQV)/Design* computations for the structural basin to manage pollutants and channel erosion. Design volume computed using Equations 2.9 and 2.10.

Drainage Area = 25 acres

Impervious cover = 45%

Runoff volume = 0.83 inches from Eq. 2-9

WQV = (0.83 inches) * (25 acres) * (43560/12) = 75,322 cubic feet (Eq. 2-10)

Designer selects the use of a biofiltration basin to avoid the use of a secondary BMP. To account for potential sedimentation within the biofiltration basin, the water quality volume must be increased by 5%. Basin located adjacent to buffer zone.

BMP Volume = WQV * 1.05 = 79,089 cubic feet.

Average Basin Depth = 4 feet (6 feet maximum)

Total Basin Area is approximately 0.45 acres (140 feet by 140 feet)

Biofiltration Media Area *Af = WQV/(7 + 2.33*H) = 4615 square feet*

d) *Water Quality Education*. To minimize pollution at the source, LCRA staff will visit the neighborhood association at least once per year to provide programs and materials on proper lawn care and chemical disposal. Also, each new resident will receive a packet of information concerning lawn maintenance, car care, and other housekeeping tips to minimize the introduction of chemicals into the watershed.

e) *Maintenance Permit*. Since this project constructed a biofiltration basin the owner/operator of the facility must enter into an agreement with LCRA to ensure proper and timely facility maintenance. The Maintenance Permit will specify the timing of trash collection, vegetation mowing, vegetation removal, sediment removal, and inspect other hydraulic functions for proper basin operation. LCRA will inspect at least one time each year, if not more frequently, and provide reports to the owner/operator. If the owner does not respond to maintenance requests, LCRA has enforcement authority to ensure BMP system maintenance.