3.3.1 Filter Strip

Limited Application
Structural Stormwater Control

Description: Filter strips are uniformly graded and densely vegetated sections of land, engineered and designed to treat runoff from and remove pollutants through vegetative filtering and infiltration.

REASONS FOR LIMITED USE

- Cannot alone achieve the 80% TSS removal target

KEY CONSIDERATIONS

- Runoff from an adjacent impervious area must be evenly distributed across the filter strip as sheet flow
- Can be used as part of the runoff conveyance system to provide pretreatment
- Can provide groundwater recharge
- Reasonably low construction cost
- Large land requirement
- Requires periodic repair, regrading, and sediment removal to prevent channelization

STORMWATER MANAGEMENT SUITABILITY

- [x] **Water Quality**
- [ ] **Channel/Flood Protection**

SPECIAL APPLICATIONS

- [x] **Pretreatment**
- [ ] **High Density/Ultra-Urban**
- [x] **Other:** Use in buffer system; treating runoff from pervious areas

Residential Subdivision Use: *Yes*

3.3.1.1 General Description

Filter strips are uniformly graded and densely vegetated sections of land, engineered and designed to treat runoff and remove pollutants through vegetative filtering and infiltration. Filter strips are best suited to treating runoff from roads and highways, roof downspouts, very small parking lots, and pervious surfaces. They are also ideal components of the "outer zone" of a stream buffer, or as pretreatment for another structural stormwater control. Filter strips can serve as a buffer between incompatible land uses, be landscaped to be aesthetically pleasing, and provide groundwater recharge in areas with pervious soils. Filter strips are often used as a stormwater site design credit (see Section 1.4 for more information).

Filter strips rely on the use of vegetation to slow runoff velocities and filter out sediment and other pollutants from urban stormwater. There can also be a significant reduction in runoff volume for smaller flows that infiltrate pervious soils while contained within the filter strip. To be effective, however, sheet flow must be maintained across the entire filter strip. Once runoff flow concentrates, it effectively short-circuits the filter strip and reduces any water quality benefits. Therefore, a flow spreader must normally be included in the filter strip design.

There are two different filter strip designs: a simple filter strip and a design that includes a permeable berm at the bottom. The presence of the berm increases the contact time with the runoff, thus reducing the overall width of the filter strip required to treat stormwater runoff. Filter strips are typically an on-line practice, so they must be designed to withstand the full range of storm events without eroding.

3.3.1.2 Pollutant Removal Capabilities

Pollutant removal from filter strips is highly variable and depends primarily on density of vegetation and contact time for filtration and infiltration. These, in turn, depend on soil and vegetation type, slope, and presence of sheet flow.

The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment.

- **Total Suspended Solids – 50%**
- **Total Phosphorus – 20%**
- **Total Nitrogen – 20%**
- **Fecal Coliform – insufficient data**
- **Heavy Metals – 40%**

3.3.1.3 Design Criteria and Specifications

General Criteria

- Filter strips should be used to treat small drainage areas. Flow must enter the filter strip as sheet flow spread out over the width (long dimension normal to flow) of the strip, generally no deeper than 1 to 2 inches. As a rule, flow concentrates within a maximum of 75 feet for impervious surfaces, and 150 feet for pervious surfaces (CWP, 1996). For longer flow paths, special provision must be made to ensure design flows spread evenly across the filter strip.

- Filter strips should be integrated within site designs.

- Filter strips should be constructed outside the natural stream buffer area whenever possible to maintain a more natural buffer along the streambank.

- Filter strips should be designed for slopes between 2% and 6%. Greater slopes than this would encourage the formation of concentrated flow. Flatter slopes would encourage standing water.

- Filter strips should not be used on soils that cannot sustain a dense grass cover with high retardance. Designers should choose a grass that can withstand relatively high velocity flows at the entrances, and both wet and dry periods. See Appendix F for a list of appropriate grasses for use in Georgia.

- The filter strip should be at least 15 feet long to provide filtration and contact time for water quality treatment. 25 feet is preferred (where available), though length will normally be dictated by design method.

- Both the top and toe of the slope should be as flat as possible to encourage sheet flow and prevent erosion.

- An effective flow spreader is to use a pea gravel diaphragm at the top of the slope (ASTM D 448 size no. 6, 1/8” to 3/8”). The pea gravel diaphragm (a small trench running along the top of the filter strip) serves two purposes. First, it acts as a pretreatment device, settling out sediment particles before they reach the practice. Second it acts as a level spreader, maintaining sheet flow as runoff flows over the filter strip. Other types of flow spreaders include a concrete sill, curb stops, or curb and gutter with “sawteeth” cut into it.

- Ensure that flows in excess of design flow move across or around the strip without damaging it. Often a bypass channel or overflow spillway with protected channel section is designed to handle higher flows.

- Pedestrian traffic across the filter strip should be limited through channeling onto sidewalks.

- Maximum discharge loading per foot of filter strip width (perpendicular to flow path) is found using the Manning's equation:

$$q = \frac{0.00236}{n} Y^{\frac{5}{3}} S^{\frac{1}{2}} \tag{3.3.1}$$

Where: q = discharge per foot of width of filter strip (cfs/ft)
Y = allowable depth of flow (inches)
S = slope of filter strip (percent)
n = Manning's "n" roughness coefficient

(use 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass)

- The minimum length of a filter strip is:

$$W_{fMIN} = \frac{Q}{q} \tag{3.3.2}$$

Where: W_{fMIN} = minimum filter strip width perpendicular to flow (feet)

Filter without Berm

- Size filter strip (parallel to flow path) for a contact time of 5 minutes minimum

- Equation for filter length is based on the SCS TR55 travel time equation (SCS, 1986):

$$L_f = \frac{(T_t)^{1.25} (P_{2-24})^{0.625} (S)^{0.5}}{3.34n} \tag{3.3.3}$$

Where: L_f = length of filter strip parallel to flow path (ft)
T_t = travel time through filter strip (minutes)
P_{2-24} = 2-year, 24-hour rainfall depth (inches)
S = slope of filter strip (percent)
n = Manning's "n" roughness coefficient

(use 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass)

Filter Strips with Berm

- Size outlet pipes to ensure that the bermed area drains within 24 hours.

- Specify grasses resistant to frequent inundation within the shallow ponding limit.

- Berm material should be of sand, gravel and sandy loam to encourage grass cover (Sand: ASTM C-33 fine aggregate concrete sand 0.02"-0.04", Gravel: AASHTO M-43 ½" to 1").

- Size filter strip to contain the WQ_v within the wedge of water backed up behind the berm.

- Maximum berm height is 12 inches.

Filter Strips for Pretreatment

- A number of other structural controls, including bioretention areas and infiltration trenches, may utilize a filter strip as a pretreatment measure. The required length of the filter strip depends on the drainage area, imperviousness, and the filter strip slope. Table 3.3.3-1 provides sizing guidance for bioretention filter strips for pretreatment.

Table 3.3.1-1 Bioretention Filter Strip Sizing Guidance
(Source: Claytor and Schueler, 1996)

Parameter	Impervious Areas				Pervious Areas (Lawns, etc)			
Maximum inflow approach length (feet)	35		75		75		100	
Filter strip slope (max = 6%)	< 2%	> 2%	< 2%	> 2%	< 2%	> 2%	< 2%	> 2%
Filter strip minimum length (feet)	10	15	20	25	10	12	15	18

3.3.1.4 Inspection and Maintenance Requirements

Table 3.3.1-2. Typical Maintenance Activities for Filter Strips
(Source: CWP, 1996)

Activity	Schedule
• Mow grass to maintain a 2 to 4 inch height.	Regularly (frequently)
• Inspect pea gravel diaphragm for clogging and remove built-up sediment. • Inspect vegetation for rills and gullies and correct. Seed or sod bare areas. • Inspect to ensure that grass has established. If not, replace with an alternative species.	Annual Inspection (Semi-annual first year)

Additional Maintenance Considerations and Requirements

- Filter strips require similar maintenance to other vegetative practices. Maintenance is very important for filter strips, particularly in terms of ensuring that flow does not short circuit the practice.

3.3.1.5 Example Schematic

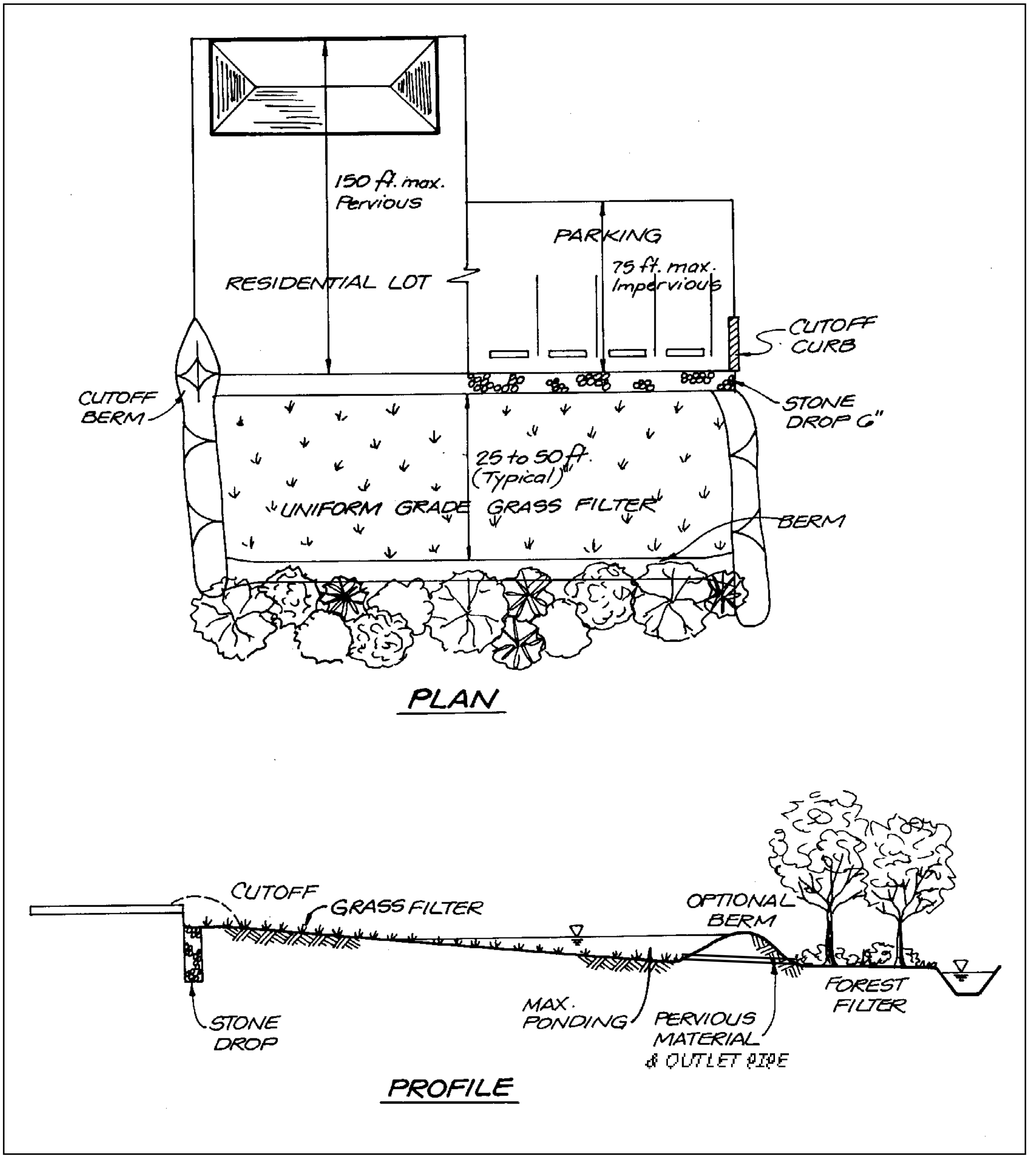

Figure 3.3.1-1 Schematic of Filter Strip (with Berm)

3.3.1.6 Design Example

Basic Data

Small commercial lot 150 feet deep x 100 feet wide located in Smyrna

- Drainage area (A) = 0.34 acres
- Impervious percentage (I) = 70%
- Slope equals 4%, Manning's n = 0.25

Calculate Maximum Discharge Loading Per Foot of Filter Strip Width

Using equation 3.3.1:

$q = 0.00236/0.25 * (1.0)^{5/3} * (4)^{1/2} = 0.019$ cfs/ft

Water Quality Peak Flow

See subsection 2.1.7 for details

Compute the Water Quality Volume in inches:

$WQ_v = 1.2\ (0.05 + 0.009 * 70) = 0.82$ inches

Compute modified CN for 1.2-inch rainfall (P=1.2):

$$CN = 1000/[10+5P+10Q-10(Q^2+1.25*Q*P)^{½}]$$
$$= 1000/[10+5*1.2+10*0.82-10(0.82^2+1.25*0.82*1.2)^{½}]$$
$$= 96.09 \text{ (Use CN = 96)}$$

For CN = 96 and an estimated time of concentration (T_c) of 8 minutes (0.13 hours), compute the Q_{wq} for a 1.2 inch storm.

From Section 2.1, $I_a = 0.083$, therefore $I_a/P = 0.083/1.2 = 0.069$.

For a Type II storm (using the limiting values) q_u = 950 csm/in, and therefore:

Q_{wq} = (950 csm/in) (0.34ac/640ac/mi^2) (0.82") = 0.41 cfs

Minimum Filter Width

Using equation 3.3.2:

$W_{fMIN} = Q/q = 0.41/0.019 = 22$ feet

Since the width of the lot is 100 feet, the actual width of the filter strip will depend on site grading and the ability to deliver the drainage to the filter strip in sheet flow through a pea gravel filled trench.

Filter without Berm

- 2-year, 24-hour storm (see Appendix A) = 0.17 in/hr or 0.17*24= 4.08 inches
- Use 5 minute travel (contact) time

Using equation 3.3.3:

$L_f = (5)^{1.25} * (4.08)^{0.625} * (4)^{0.5} / (3.34 * 0.25) = 43$ feet

Note: Reducing the filter strip slope to 2% and planting a denser grass (raising the Manning n to 0.35) would reduce the filter strip length to 22 feet. Sensitivity to slope and Manning's n changes are illustrated for this example in Figure 3.3.1-2.

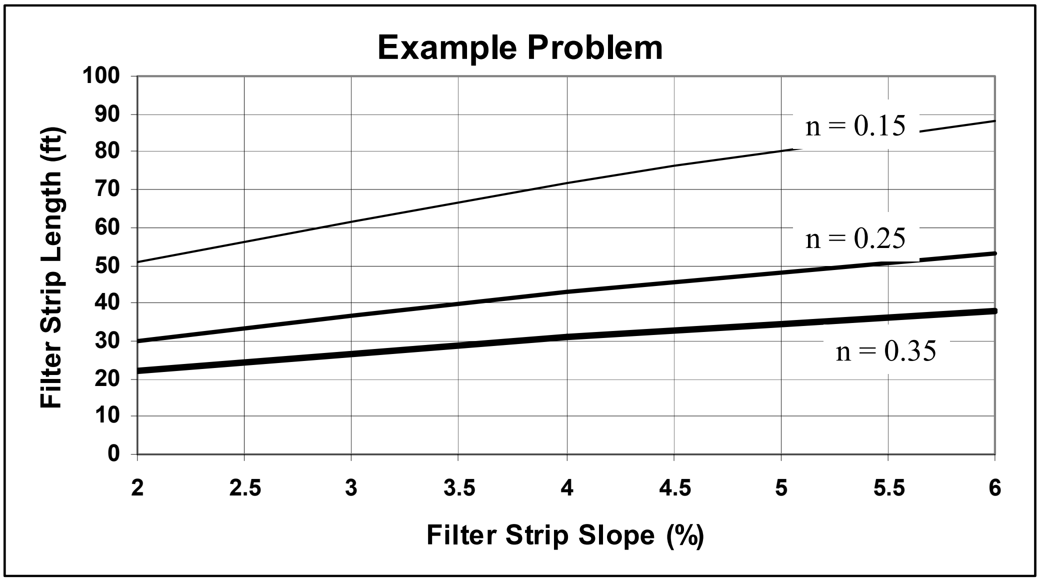

Figure 3.3.1-2 Example Problem Sensitivity of Filter Strip Length to Slope and Manning's n Values

Filter With Berm

- Pervious berm height is 6 inches

Compute the Water Quality Volume in cubic feet:

$WQ_v = R_v * 1.2/12 * A = (0.05 + 0.009 * 70) * 1.2/12 * 0.34 = 0.023$ Ac-ft or 1,007 ft^3

For a berm height of 6 inches the "wedge" of volume captured by the filter strip is:

Volume = $W_f * ½ * L_f * 0.5 = 0.25W_fL_f = 1{,}007\ ft^3$

For a maximum width of the filter of 100 feet, the length of the filter would then be 40 feet.

For a 1-foot berm height, the length of the filter would be 20 feet.

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