2.2.3 Grass Channel

Description: Vegetated open channels designed to filter stormwater runoff and meet veocity targets for the water quality design storm and the "Streambank Protection" storm event.

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Should not be used on slopes greater than 4%; slopes between 1% and 2% recommended
- Ineffective unless carefully designed to achieve low flow rates in the channel (< 1.0 ft/s)

ADVANTAGES / BENEFITS:

- Can be used as part of the runoff conveyance system to provided pretreatment
- Grass channels can act to partially infiltrate runoff from small storm events if underlying soils are pervious
- Less expensive to construct than curb and gutter systems

DISADVANTAGES / LIMITATIONS:

- May require more maintenance than curb and gutter system
- Cannot alone achieve the 80% TSS removal target
- Potential for bottom erosion and re-suspension
- Standing water may not be acceptable in some areas

POLLUTANT REMOVAL

50%	**Total Suspended Solids**
25/20%	**Nutrients** – Total Phosphorous / Total Nitrogen Removal
30%	**Metals** – Cadmium, Copper, Lead, and Zinc Removal
No Data	**Pathogens** – Coliform, Streptococci, E. Coli Removal

STORMWATER MANAGEMENT SUITABILITY

P	Water Quality Protection
S	Streambank Protection
P	On-Site Flood Control
S	Downstream Flood Control

IMPLEMENTATION CONSIDERATIONS

H	Land Requirement
H	Capital Cost
L	Maintenance Burden

Residential Subdivision Use: Yes
Hi Density/Ultra-Urban: No
Drainage Area: 5 Ac. Max.
Soils: No Restrictions
Other Considerations:

- Curb and gutter replacement

L = Low M = Moderate H = High

2.2.3.1 General Description

Grass channels, also termed "biofilters," are typically designed to provide nominal treatment of runoff as well as meet runoff velocity targets for the water quality design storm. Grass channels are well suited to a number of applications and land uses, including treating runoff from roads and highways and pervious surfaces.

Grass channels differ from the enhanced dry swale design in that they do not have an engineered filter media to enhance pollutant removal capabilities and, therefore, have a lower pollutant removal rate than for a dry or wet (enhanced) swale. Grass channels can partially infiltrate runoff from small storm events in areas with pervious soils. When properly incorporated into an overall site design, grass channels can reduce impervious cover, accent the natural landscape, and provide aesthetic benefits.

When designing a grass channel, the two primary considerations are channel capacity and minimization of erosion. Runoff velocity should not exceed 1.0 foot per second during the peak discharge associated with the water quality design rainfall event, water depth should generally be less than 4 inches (height of the grass), and the total length of a grass channel should provide at least 5 minutes of residence time. To enhance water quality treatment, grass channels must have broader bottoms, lower slopes, and denser vegetation than most drainage channels. Additional treatment can be provided by placing check-dams across the channel below pipe inflows, and at various other points along the channel.

2.2.3.2 Pollutant Removal Capabilities

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 – 25%**
- **Total Nitrogen – 20%**
- **Fecal Coliform – insufficient data**
- **Heavy Metals – 30%**

Fecal coliform removal is uncertain. In fact, grass channels are often a source of fecal coliforms from local residents walking their dogs.

2.2.3.3 Design Criteria and Specifications

- Grass channels should generally be used to treat small drainage areas of less than 5 acres. If the practices are used on larger drainage areas, the flows and volumes through the channel become too large to allow for filtering and infiltration of runoff.
- Grass channels should be designed on relatively flat slopes of less than 4%; channel slopes between 1% and 2% are recommended.
- Grass channels can be used on most soils with some restrictions on the most impermeable soils. Grass channels should not be used on soils with infiltration rates less than 0.27 inches per hour if infiltration of small runoff flows is intended.
- A grass channel should accommodate the peak flow for the water quality design storm Q_{wq} (see Section 2.1.10).
- Grass channels should have a trapezoidal or parabolic cross section with relatively flat side slopes (generally 3:1 or flatter).
- The bottom of the channel should be between 2 and 6 feet wide. The minimum width ensures an adequate filtering surface for water quality treatment, and the maximum width prevents braiding, which is the formation of small channels within the swale bottom. The bottom width is a dependent
- variable in the calculation of velocity based on Manning's equation. If a larger channel is needed, the use of a compound cross section is recommended.
- Runoff velocities must be nonerosive. The full-channel design velocity will typically govern.
- A 5-minute residence time is recommended for the water quality peak flow. Residence time may be increased by reducing the slope of the channel, increasing the wetted perimeter, or planting a denser grass (raising the Manning's n).
- The depth from the bottom of the channel to the groundwater should be at least 2 feet to prevent a moist swale bottom, or contamination of the groundwater.
- Incorporation of check dams within the channel will maximize retention time.
- Designers should choose a grass that can withstand relatively high velocity flows at the entrances for both wet and dry periods. See Appendix F for a list of appropriate grasses for use in North Central

Texas.

See Section 4.4 (*Open Channel Design*) for more information and specifications on the design of grass channels.

Grass Channels for Pretreatment

A number of other structural controls, including bioretention areas and infiltration trenches, may utilize a grass channel as a pretreatment measure. The length of the grass channel depends on the drainage area, land use, and channel slope. Table 2.2.3-1 provides sizing guidance for grass channels for a 1acre drainage area. The minimum grassed channel length should be 20 feet.

Table 2.2.3-1 Bioretention Grass Channel Sizing Guidance

Parameter	< = 33% Impervious		Between 34% and 66% Impervious		> = 67% Impervious	
Slope (max = 4%)	< 2%	> 2%	< 2%	> 2%	< 2%	> 2%
Grass channel minimum length* (feet) *assumes 2-foot wide bottom width	25	40	30	45	35	50

(Source: Claytor and Schueler, 1996)

2.2.3.4 Inspection and Maintenance Requirements

Table 2.2.3-2 Typical Maintenance Activities for Grass Channels

Activity	Schedule
• Mow grass to maintain a height of 3 to 4 inches.	As needed (frequently/seasonally)
• Remove sediment build-up within the bottom of the grass channel once it has accumulated to 25% of the original design volume.	As needed (Infrequently)
• Inspect grass along side slopes for erosion and formation of rills or gullies and correct. • Remove trash and debris accumulated in the channel. • Based on inspection, plant an alternative grass species if the original grass cover has not been successfully established.	Annually (Semi-annually the first year)

(Source: Adapted from CWP, 1996)

2.2.3.5 Example Schematics

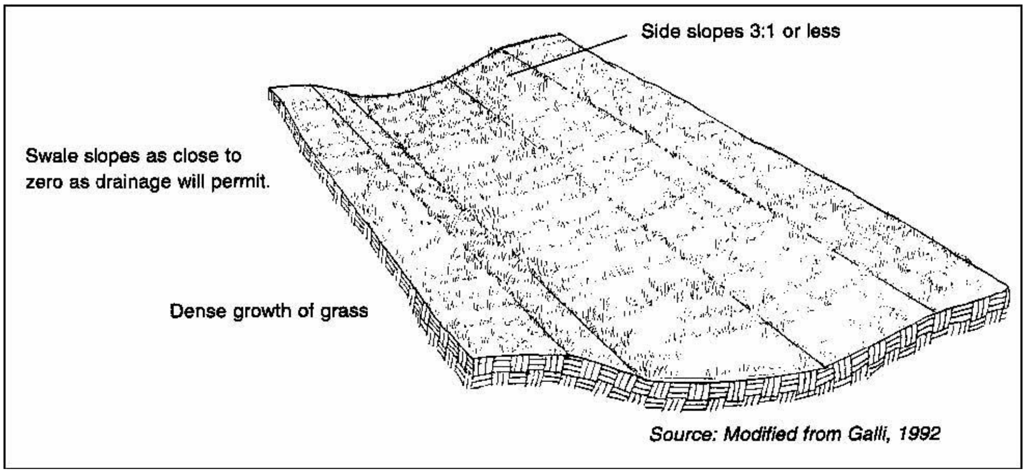


Figure 2.2.3-1 Typical Grass Channel

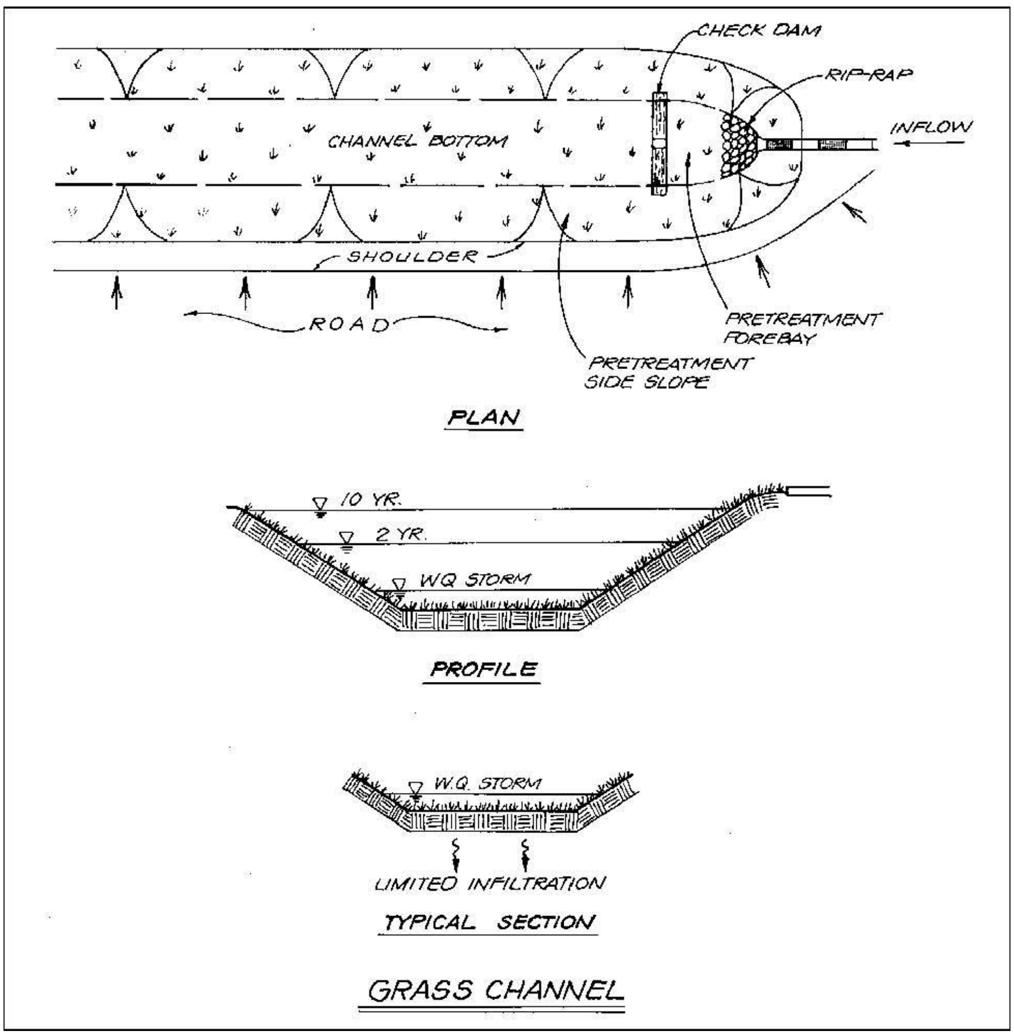


Figure 2.2.3-2 Schematic of Grass Channel

2.2.3.6 Design Example

Basic Data Small commercial lot 300 feet deep x 145 feet wide

- Drainage area (A) = 1.0 acres
- Impervious percentage (I) = 70%

Water Quality Peak Flow

See subsection 1.4.2.1 for details

Compute the Water Quality Protection Volume in inches: WQ_v = 1.5 (0.05 + 0.009 * 70) = 1.02 inches Compute modified CN for 1.5-inch rainfall (P=1.5): $CN = 1000/[10+5P+10Q-10(Q^2+1.25*Q*P)^{½}] = 1000/[10+5*1.5+10*0.82-10(0.82^2+1.25*0.82*1.5)^{½}] = 92.4$ (Use CN = 92)

For CN = 92 and an estimated time of concentration (T_c) of 8 minutes (0.13 hours), compute the Q_{wq} for a 1.5-inch storm. From Table 2.1.5-3, I_a = 0.174, therefore I_a/P = 0.174/1.5 = 0.116. From Figure 2.1.5-6 for a Type II storm (using the limiting values) q_u = 950 csm/in, and therefore: Q_{wq} = (950 csm/in) (1.0ac/640ac/mi^2) (1.02") = 1.51 cfs

Utilize Q_{wq} to Size the Channel

The maximum flow depth for water quality treatment should be approximately the same height of the grass. A maximum flow depth of 4 inches is allowed for water quality design. A maximum flow velocity of 1.0 foot per second for water quality treatment is required. For Manning's n use 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass. Site slope is 2%.

Input variables:

n = 0.15
S = 0.02 ft/ft
D = 4/12 = 0.33 ft

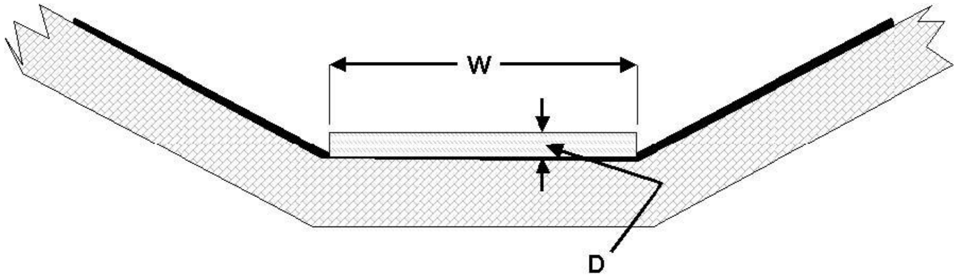
Then:

$$Q_{wq} = Q = VA = 1.49/n\ D^{2/3}\ S^{1/2}\ DW$$

where:

Q = peak flow (cfs)
V = velocity (ft/sec)
A = flow area (ft^2) = WD
W = channel bottom width (ft)
D = flow depth (ft)
S = slope (ft/ft)

(Note: D approximates hydraulic radius for shallow flows)



Then for a known n, Q, D and S minimum width can be calculated.

$(nQ)/(1.49\ D^{5/3}\ S^{1/2}) = W = (0.15*1.51)/(1.49*0.33^{5/3}*0.02^{1/2}) = 6.84$ feet minimum

$V = Q/(WD) = 1.51/(6.84 * 4/12) = 0.66$ fps (okay)

(Note: WD approximates flow area for shallow flows.)

Minimum length for 5-minute residence time, L = V * (5*60) = 198 feet

Depending on the site geometry, the width or slope or density of grass (Manning's n value) might be adjusted to slow the velocity and shorten the channel in the next design iteration. For example, using a 10-foot bottom width* of flow and a Manning's n of 0.20, solve for new depth and length.

$Q = VA = 1.49/n\ D^{5/3}\ S^{1/2}\ W$

$D = [(Q * n)/(1.49 * S^{1/2} * W)]^{3/5}$

$= [(1.51 * 0.20)/(1.49 * 0.02^{1/2} * 10.0)]^{3/5} = 0.31$ ft = 4" (okay)

V = Q/WD = 1.51/(10.0 * 0.31) = 0.49 feet per second

L = V * 5 * 60 = 146 feet

** In this case a dividing berm should be used to control potential braiding.*

Refer to standard engineering criteria for design of open channels to complete the grass channel design for a specified design storm event.

Grass Channel – end