Grass Swale (GS)

GW

Practice Description

A grass swale is a natural or constructed channel that is shaped or graded to required dimensions and established with suitable vegetation for the stable conveyance of runoff without causing damage to the channel by erosion. This practice applies to the following sites: 1) where concentrated runoff will cause erosion damage; 2) a vegetative lining provides sufficient stability for the channel as designed; and/or 3) space is available for a relatively large cross section. Typical situations where concentrated-flow areas are addressed with a grass swale include roadside ditches, channels at property boundaries, outlets for diversions and other concentrated-flow areas subject to channel erosion. Grassed swales are generally considered permanent structures but may be used as a temporary measure. Grassed swales as permanent structures are discussed further in Chapter 4 of Volume 2 - *Stormwater Management Manual*.

Planning Considerations

Grass swales should be carefully built to the design cross section, shape, and dimensions specified. Swales are hydraulic structures and as such depend upon the hydraulic parameters to function satisfactorily. Vegetated swales should be well established before large flows are permitted in the channel.

The design of a channel cross section and lining is based primarily upon the volume and velocity of flow expected in the channel. This practice covers grassed swales with low-velocity flows (generally less than 5 ft/sec). Where high velocities are anticipated, lined swales should be used (see *Lined Swale Practice* or *Riprap-lined Swale Practice*). Lined swales should also be used where there is continuous flow in the swale, which would prevent establishment of vegetation within the flow area.

Besides the primary design considerations of capacity and velocity, a number of other important factors should be taken into account when selecting a cross section (Figure GS-1). These factors include land availability, compatibility with land use and surrounding environment, safety, maintenance requirements outlet conditions, etc.

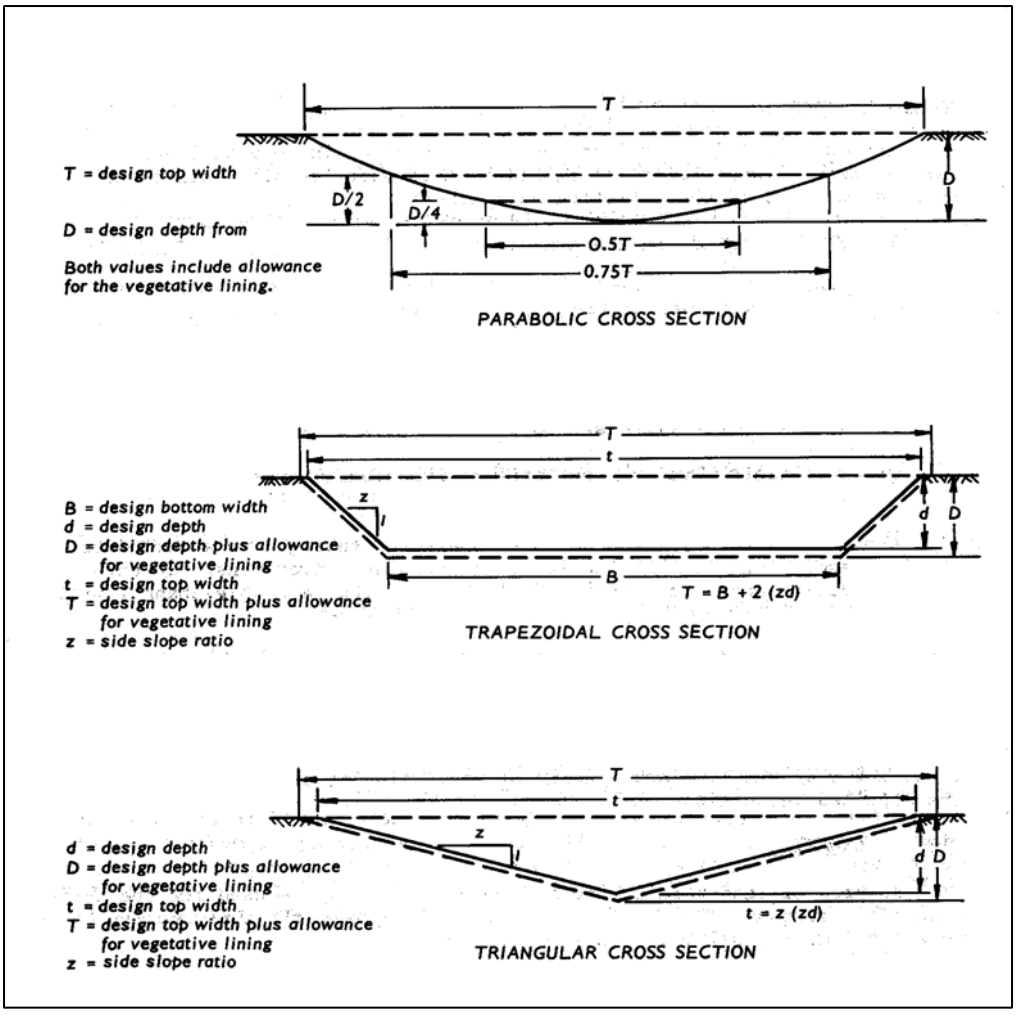


Figure GS-1 Typical Grass Swale Cross Section

Triangular Shaped Ditches

Triangular-shaped ditches are generally used where the quantity of water to be handled is relatively small, such as along roadsides. A triangular grass swale will suffice where velocities in the ditch are low.

Parabolic Channels

Parabolic channels are often used where the quantity of water to be handled is larger and where space is available for a wide, shallow channel with low-velocity flow.

Trapezoidal Channels

Trapezoidal channels are often used where the quantity of water to be carried is large and conditions require that it be carried at a relatively high velocity. Trapezoidal ditches are

generally lined with concrete or riprap, but in some cases can be grassed swales, if lined with erosion control blankets (see *Erosion Control Blanket Practice*).

Other Considerations

Outlet conditions for all channels should be considered. Appropriate measures must be taken to dissipate the energy of the flow to prevent scour at the outlet of the swale.

Grass swales should be protected from erosion by concentrated flows. The methods of protecting grass swales would include, but not be limited to, the following:

- Vegetation.
- A combination of biodegradable linings and vegetation.

The type and intensity of the protective linings will determine the design of the grass swale.

If velocities exceed stable velocities, for vegetated swales or vegetation with biodegradable linings, then other linings should be used (see *Lined Swale* or *Riprap-lined Swale Practice*).

The time of the year should be considered when planning grass swales. Grass swales that are seeded to establish vegetation should not be planned for construction during late fall, winter or early spring. Grass swales constructed during mid-summer to early fall may need temporary seeding followed by permanent seeding at the recommended times. The vegetation species should be recommended for the area of the state that it is planned.

Design Criteria

Capacity

Grass swales shall be designed to convey the peak rate of runoff as shown in Table GS-1. Adjustments should be made for release rates from structures and other drainage facilities. Grass swales shall also be designed to comply with local stormwater ordinances. Grass swales should be designed for greater capacity whenever there is danger of flooding or out-of-bank flow cannot be tolerated.

Table GS-1 Design Frequency for Grassed Swale

Grass Swale Type	Typical Area of Protection	24-Hour Design Storm Frequency
Temporary	Construction Areas	2-year
	Building Sites	5-year
Permanent	Agricultural Land	10-year
	Mined Reclamation Area	10-year
	Recreation Areas	10-year
	Isolated Buildings	10-year
	Urban areas, Residential, School, Industrial Areas, etc.	10-year

Peak rates of runoff values used to determine the capacity requirements should be calculated using accepted engineering methods. Some accepted methods are:

- Natural Resources Conservation Service, National Engineering Handbook Series, Part 650, Engineering Field Handbook, Chapter 2, Estimating Runoff.

- Natural Resources Conservation Service (formerly Soil Conservation Service), Technical Release 55, Urban Hydrology for Small Watersheds.

- Other comparable methods – See Appendix A: Erosion and Stormwater Runoff Calculations found in the Appendices Volume.

Grade of Grass Swale

After selecting a location for the grassed swale that will minimize the impacts to the site and maximize the intended use, the grade in the grass swales should be determined. The grade in feet per 100 feet of length can be determined from a topographic map of the site or from a detailed survey of the planned grassed swale location.

Retardance

The type grass used to vegetate the grassed swale and the degree of maintenance planned for the vegetation determine the retardance of the swale (see Table GS-2).

Generally, the retardance used for the design of grassed swales should be “D” and “C” to produce a stable velocity and adequate capacity to carry the design storm.

Table GS-2 Retardance for Grassed Swales

Retardance	Species	Cover Condition
A	Reed Canarygrass	Excellent stand, tall (average 36″)
	Yellow Bluestem Ischaemum	Excellent stand, tall (average 36″)
B	Smooth Bromegrass	Good stand, mowed (average 12 to 15″)
	Bermuda Grass	Good stand, tall (average 12″)
	Native Grass Mixture (Little Bluestem, Blue Grama, and other long and short Midwest Grasses)	Good stand, unmowed
	Tall Fescue	Good stand, unmowed (average 18″)
	Lespedeza sericea	Good stand, not woody, tall (average 19″)
	Grass-Legume mixture-Timothy, Smooth Bromegrass, or Orchardgrass	Good stand, uncut (average 20″)
	Reed Canarygrass	Good stand, mowed (average 12 to 15″)
	Tall Fescue, with Bird's Foot Trefoil or Ladino Clover	Good stand, uncut (average 18″)
	Blue Grama	Good stand, uncut (average 13″)
C	Bahiagrass	Good stand, uncut (average 6 to 8″)
	Bermuda Grass	Good stand, mowed (average 6″)
	Redtop	Good stand, headed (15 to 20″)
	Grass-Legume Mixture-Summer (Orchardgrass, Redtop, Italian Ryegrass, and Common Lespedeza)	Good stand, uncut (6 to 8″)
	Centipede grass	Very dense cover (average 6″)
	Kentucky Bluegrass	Good stand, headed (6 to 12″)
D	Bermuda Grass	Good stand, cut to 2.5″ height
	Red Fescue	Good stand, headed (12 to 18″)
	Buffalo Grass	Good stand, uncut (3 to 6″)
	Grass-Legume Mixture-fall, spring (Orchard Grass, Redtop, Italian Ryegrass, and Common Lespedeza)	Good stand, uncut (4 to 5″)
	Lespedeza sericea	After cutting to 2″ height. Very good stand before cutting
E	Bermuda Grass	Good stand, cut to 1.5″ height.
	Bermuda Grass	Burned stubble

Velocities

Classify the soil where the swale is to be constructed into erosion-resistant cohesive (clayey) fine and coarse-grained soils or easily eroded noncohesive silt, clays and sands.

Determine the type of vegetative cover to be established in the swale.

Use the swale grade, cover, and soil erodibility to determine permissible velocity using Table GS-3.

Swale Dimensions

The swale may be triangular shaped, parabolic or trapezoidal, as discussed in the planning considerations of this practice and shown in Figure GS-1.

Using the peak discharge, swale grade, permissible velocity and retardance, the parabolic dimensions can be determined using Table GS-4 (Sheets 1 through 14).

Table GS-3 Permissible Velocities in Grassed Swales

Cover	Slope Range[2]	**Permissible Velocity[1]** Erosion-Resistant Soils[3] (clayey)	Easily Eroded Soils[4] (sandy)
	percent	ft/sec	ft/sec
Bermuda Grass	<5	8	6
	5-10	7	4
	over 10	6	3
Bahiagrass	<5	7	5
Tall Fescue	5-10	6	4
	over 10	5	3
Sericea lespedeza **Weeping Lovegrass**	<5[5]	3.5	2.5

[1] Use velocities exceeding (5ft/sec) only where good covers and proper maintenance can be obtained.
[2] Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
[3] Cohesive (clayey) fine-grain soils and coarse-grain soils with cohesive fines with a plasticity index of 10 to 40 (CL, CH, SC, and CG).
[4] Soils that do not meet requirements for erosion-resistant soils.
[5] Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

Design dimensions for triangular-shaped and trapezoidal-shaped swales can be determined using Manning's equation or other accepted engineering designs. (See Appendix A: *Channel Geometry*.)

The design water surface elevation of a channel receiving water from other tributary sources shall be equal to or less than the design water surface elevation of the contributing source. The design water surface elevation of contributing and receiving waters should be the same, whenever practical.

A minimum depth may be necessary to provide adequate outlets for subsurface drains and tributary channels.

Drainage

Polyethylene drainage tubing, tile, or other suitable subsurface drainage measures shall be provided for sites having high water tables or seepage problems.

Freeboard

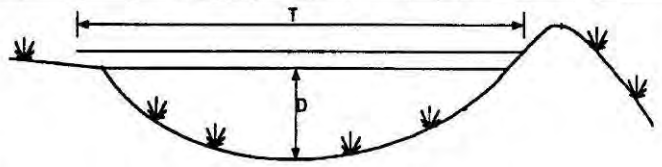
The minimum freeboard is 0.25 foot in depth. Freeboard is not required on grass swales with less than 1% slope and where out-of-bank flow will not be damaging and can be tolerated in the normal operation at the site.

Table GS-4 Parabolic Grass Swale Design Sheet 1 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 0.25 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																											
10																											
15																											
20																											
25	9.3	2.3	1.7																								
30	11.7	2.2	1.8																								
35	14.1	2.1	1.7																								
40	16.3	2.1	1.8																								
45	18.5	2.1	1.8	10.4	2.8	2.3																					
50	20.7	2.1	1.8	12.3	2.6	2.3																					
55	22.9	2.1	1.8	13.8	2.6	2.3																					
60	25.0	2.0	1.8	15.3	2.5	2.3																					
65	27.2	2.0	1.8	16.8	2.5	2.3	10.4	3.4	2.8																		
70	29.3	2.0	1.8	18.2	2.5	2.3	12.1	3.1	2.8																		
75	31.9	2.0	1.7	19.7	2.4	2.3	13.5	3.0	2.8																		
80	34.0	2.0	1.7	21.1	2.4	2.3	14.7	2.9	2.8																		
85	36.1	2.0	1.7	22.5	2.4	2.3	15.8	2.9	2.8																		
90	38.2	2.0	1.7	23.9	2.4	2.3	16.9	2.8	2.8																		
95	40.3	2.0	1.7	25.3	2.4	2.3	18.0	2.8	2.8																		
100	42.4	2.0	1.7	26.7	2.4	2.3	19.1	2.8	2.8																		
105	44.6	2.0	1.7	28.1	2.4	2.3	20.2	2.8	2.8																		
110	46.7	2.0	1.7	29.5	2.4	2.3	21.3	2.8	2.8	12.9	3.8	3.4															
115	48.8	2.0	1.7	30.8	2.4	2.3	22.3	2.8	2.8	14.0	3.7	3.4															
120	50.9	2.0	1.7	32.2	2.4	2.3	23.4	2.8	2.8	15.3	3.5	3.4															
125	53.0	2.0	1.8	33.6	2.4	2.3	24.4	2.8	2.8	16.1	3.5	3.4															
130	55.1	2.0	1.8	35.0	2.4	2.3	25.5	2.8	2.8	16.9	3.4	3.4															
135	57.3	2.0	1.8	36.4	2.4	2.3	26.5	2.7	2.8	17.7	3.4	3.4															
140	59.4	2.0	1.8	38.3	2.4	2.3	27.6	2.7	2.8	18.5	3.4	3.4															
145	61.5	2.0	1.8	39.7	2.4	2.3	28.6	2.7	2.8	19.3	3.3	3.4															
150	63.6	2.0	1.8	41.1	2.4	2.3	29.6	2.7	2.8	20.1	3.3	3.4															



T = Top width, tall vegetation
D = Depth, tall vegetation
V2 = Design velocity, tall vegetation
V1 = Permissible velocity, short vegetation

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 2 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 0.50 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																											
10																											
15	8.4	1.6	1.7																								
20	11.7	1.5	1.7	7.1	2.0	2.2																					
25	14.9	1.5	1.7	9.7	1.8	2.2																					
30	18.0	1.5	1.7	12.0	1.7	2.2																					
35	21.0	1.5	1.7	14.2	1.7	2.2	9.3	2.1	2.7																		
40	24.4	1.5	1.7	16.3	1.7	2.2	10.9	2.0	2.7																		
45	27.4	1.5	1.7	18.5	1.7	2.2	12.5	2.0	2.7																		
50	30.5	1.5	1.7	20.6	1.7	2.2	14.1	1.9	2.7	8.7	2.6	3.3															
55	33.5	1.5	1.7	22.7	1.7	2.2	15.7	1.9	2.7	10.4	2.4	3.3															
60	36.6	1.5	1.7	24.8	1.7	2.2	17.2	1.9	2.7	11.7	2.3	3.3															
65	39.6	1.5	1.7	27.3	1.7	2.2	18.8	1.9	2.7	12.9	2.3	3.3															
70	42.6	1.5	1.7	29.4	1.7	2.2	20.3	1.9	2.7	14.0	2.2	3.3	9.8	2.8	3.8												
75	45.7	1.5	1.7	31.4	1.7	2.2	21.8	1.9	2.7	15.2	2.2	3.3	11.3	2.7	3.8												
80	48.7	1.5	1.7	33.5	1.7	2.2	23.3	1.9	2.7	16.3	2.2	3.3	12.2	2.6	3.8												
85	51.7	1.5	1.7	35.6	1.6	2.2	24.8	1.9	2.7	17.4	2.2	3.3	13.2	2.5	3.8												
90	54.8	1.5	1.7	37.7	1.6	2.2	26.3	1.9	2.7	18.5	2.2	3.3	14.2	2.5	3.8												
95	57.8	1.5	1.7	39.8	1.6	2.2	27.8	1.9	2.7	19.6	2.2	3.3	15.1	2.5	3.8												
100	60.9	1.5	1.7	41.9	1.6	2.2	29.7	1.9	2.7	20.7	2.2	3.3	16.0	2.5	3.8	11.0	3.2	4.3									
105	63.9	1.5	1.7	44.0	1.6	2.2	31.2	1.9	2.7	21.8	2.2	3.3	16.9	2.5	3.8	12.3	3.0	4.3									
110	66.9	1.5	1.7	46.1	1.6	2.2	32.6	1.9	2.7	22.9	2.2	3.3	17.8	2.4	3.8	13.1	2.9	4.3									
115	70.0	1.5	1.7	48.1	1.6	2.2	34.1	1.9	2.7	24.0	2.1	3.3	18.7	2.4	3.8	13.9	2.9	4.3									
120	73.0	1.5	1.7	50.2	1.6	2.2	35.6	1.9	2.7	25.1	2.1	3.3	19.6	2.4	3.8	14.6	2.9	4.3									
125	76.1	1.5	1.7	52.3	1.6	2.2	37.1	1.9	2.7	26.2	2.1	3.3	20.5	2.4	3.8	15.4	2.8	4.3									
130	79.1	1.5	1.7	54.4	1.6	2.2	38.5	1.9	2.7	27.3	2.1	3.3	21.3	2.4	3.8	16.1	2.8	4.3									
135	82.1	1.5	1.7	56.5	1.6	2.2	40.0	1.9	2.7	28.4	2.1	3.3	22.2	2.4	3.8	16.9	2.8	4.3									
140	85.2	1.5	1.7	58.6	1.6	2.2	41.5	1.9	2.7	29.4	2.1	3.3	23.1	2.4	3.8	17.6	2.8	4.3									
145	88.2	1.5	1.7	60.7	1.6	2.2	43.0	1.9	2.7	30.5	2.1	3.3	24.0	2.4	3.8	18.3	2.8	4.3	12.3	3.7	4.9						
150	91.3	1.5	1.7	62.8	1.6	2.2	44.5	1.9	2.7	31.6	2.1	3.3	24.8	2.4	3.8	19.0	2.7	4.3	13.1	3.5	4.9						

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 3 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 0.75 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																											
10	7.0	1.3	1.6																								
15	11.0	1.3	1.6	7.1	1.5	2.1																					
20	14.9	1.3	1.6	9.9	1.4	2.1	6.1	1.9	2.6																		
25	18.9	1.2	1.6	12.7	1.4	2.1	8.6	1.6	2.7																		
30	22.7	1.2	1.6	15.3	1.4	2.1	10.6	1.6	2.6	6.7	2.1	3.2															
35	26.5	1.2	1.6	18.0	1.4	2.1	12.6	1.6	2.7	8.7	1.9	3.2															
40	30.2	1.2	1.6	20.6	1.4	2.1	14.5	1.6	2.7	10.3	1.8	3.2															
45	34.0	1.2	1.6	23.5	1.4	2.1	16.4	1.5	2.7	11.8	1.8	3.2	7.8	2.3	3.8												
50	37.8	1.2	1.6	26.1	1.4	2.1	18.3	1.5	2.7	13.2	1.8	3.2	9.5	2.1	3.8												
55	41.5	1.2	1.6	28.7	1.4	2.1	20.2	1.5	2.7	14.7	1.7	3.2	10.7	2.0	3.8												
60	45.3	1.2	1.6	31.3	1.4	2.1	22.1	1.5	2.7	16.1	1.7	3.2	11.8	2.0	3.8												
65	49.1	1.2	1.6	33.9	1.4	2.1	24.3	1.5	2.6	17.6	1.7	3.2	13.0	2.0	3.8	8.5	2.6	4.4									
70	52.9	1.2	1.6	36.5	1.4	2.1	26.2	1.5	2.6	19.0	1.7	3.2	14.1	2.0	3.8	10.0	2.4	4.3									
75	56.6	1.2	1.6	39.1	1.4	2.1	28.0	1.5	2.6	20.4	1.7	3.2	15.2	2.0	3.8	11.0	2.4	4.4									
80	60.4	1.2	1.6	41.7	1.4	2.1	29.9	1.5	2.6	21.8	1.7	3.2	16.3	1.9	3.8	11.9	2.3	4.4									
85	64.2	1.2	1.6	44.3	1.4	2.1	31.8	1.5	2.6	23.2	1.7	3.2	17.4	1.9	3.8	12.8	2.3	4.4	9.1	2.9	4.8						
90	67.9	1.2	1.6	46.9	1.4	2.1	33.6	1.5	2.6	24.6	1.7	3.2	18.5	1.9	3.8	13.7	2.3	4.4	10.3	2.7	4.8						
95	71.7	1.2	1.6	49.5	1.4	2.1	35.5	1.5	2.6	26.0	1.7	3.2	19.6	1.9	3.8	14.6	2.2	4.4	11.4	2.6	4.8						
100	75.5	1.2	1.6	52.1	1.4	2.1	37.3	1.5	2.6	27.8	1.7	3.2	20.7	1.9	3.8	15.4	2.2	4.4	12.2	2.6	4.8						
105	79.3	1.2	1.6	54.7	1.4	2.1	39.2	1.5	2.6	29.1	1.7	3.2	21.8	1.9	3.8	16.3	2.2	4.4	12.9	2.5	4.8						
110	83.0	1.2	1.6	57.3	1.4	2.1	41.1	1.5	2.6	30.5	1.7	3.2	22.8	1.9	3.8	17.2	2.2	4.4	13.7	2.5	4.8						
115	86.8	1.2	1.6	59.9	1.4	2.1	42.9	1.5	2.6	31.9	1.7	3.2	23.9	1.9	3.8	18.0	2.2	4.4	14.4	2.5	4.8	10.5	3.1	5.3			
120	90.6	1.2	1.6	62.5	1.4	2.1	44.8	1.5	2.7	33.3	1.7	3.2	25.0	1.9	3.8	18.9	2.2	4.4	15.2	2.5	4.8	11.4	3.0	5.3			
125	94.3	1.2	1.6	65.1	1.4	2.1	46.7	1.5	2.7	34.7	1.7	3.2	26.0	1.9	3.8	19.7	2.2	4.4	15.9	2.4	4.8	12.4	2.9	5.3			
130	98.1	1.2	1.6	67.7	1.4	2.1	48.5	1.5	2.7	36.0	1.7	3.2	27.1	1.9	3.8	20.5	2.2	4.4	16.6	2.4	4.8	13.0	2.8	5.3			
135	101.9	1.2	1.6	70.3	1.4	2.1	50.4	1.5	2.7	37.4	1.7	3.2	28.2	1.9	3.8	21.4	2.2	4.4	17.3	2.4	4.8	13.7	2.8	5.3			
140	105.7	1.2	1.6	72.9	1.4	2.1	52.2	1.5	2.7	38.8	1.7	3.2	29.3	1.9	3.8	22.2	2.2	4.4	18.0	2.4	4.9	14.3	2.8	5.3			
145	109.4	1.2	1.6	75.5	1.4	2.1	54.1	1.5	2.7	40.2	1.7	3.2	30.8	1.9	3.7	23.1	2.2	4.4	18.7	2.4	4.9	14.9	2.7	5.3			
150	113.2	1.2	1.6	78.1	1.4	2.1	56.0	1.5	2.7	41.6	1.7	3.2	31.9	1.9	3.7	23.9	2.1	4.4	19.4	2.4	4.9	15.5	2.7	5.3			

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 4 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 1.00 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																											
10	8.2	1.2	1.6	5.2	1.4	2.0																					
15	12.6	1.1	1.6	8.7	1.3	2.1	5.5	1.6	2.6																		
20	17.1	1.1	1.6	11.8	1.2	2.1	8.2	1.4	2.6																		
25	21.4	1.1	1.6	14.9	1.2	2.1	10.5	1.4	2.6	7.3	1.6	3.1															
30	25.7	1.1	1.6	18.0	1.2	2.1	12.8	1.4	2.6	9.1	1.6	3.2															
35	29.9	1.1	1.6	21.2	1.2	2.1	15.0	1.3	2.6	10.9	1.5	3.1	7.8	1.8	3.7												
40	34.2	1.1	1.6	24.3	1.2	2.1	17.3	1.3	2.6	12.6	1.5	3.1	9.2	1.7	3.7												
45	38.5	1.1	1.6	27.3	1.2	2.1	19.5	1.3	2.6	14.3	1.5	3.1	10.6	1.7	3.7	7.2	2.2	4.3									
50	42.7	1.1	1.6	30.3	1.2	2.1	21.9	1.3	2.6	16.0	1.5	3.2	11.9	1.7	3.7	8.8	2.0	4.3									
55	47.0	1.1	1.6	33.3	1.2	2.1	24.1	1.3	2.6	17.7	1.5	3.2	13.3	1.7	3.7	9.9	1.9	4.3									
60	51.3	1.1	1.6	36.3	1.2	2.1	26.3	1.3	2.6	19.3	1.5	3.2	14.6	1.7	3.7	11.0	1.9	4.3									
65	55.5	1.1	1.6	39.4	1.2	2.1	28.5	1.3	2.6	21.0	1.5	3.2	15.9	1.6	3.7	12.1	1.9	4.3	8.0	2.5	4.9						
70	59.8	1.1	1.6	42.4	1.2	2.1	30.7	1.3	2.6	22.7	1.5	3.2	17.1	1.6	3.7	13.2	1.9	4.3	9.5	2.3	4.8						
75	64.1	1.1	1.6	45.4	1.2	2.1	32.9	1.3	2.6	24.6	1.5	3.1	18.5	1.6	3.7	14.2	1.8	4.3	10.4	2.2	4.9						
80	68.3	1.1	1.6	48.4	1.2	2.1	35.0	1.3	2.6	26.2	1.5	3.1	19.8	1.6	3.7	15.2	1.8	4.3	11.3	2.2	4.9						
85	72.6	1.1	1.6	51.5	1.2	2.1	37.2	1.3	2.6	27.9	1.5	3.1	21.0	1.6	3.7	16.3	1.8	4.3	12.1	2.2	4.9	8.8	2.7	5.4			
90	76.9	1.1	1.6	54.5	1.2	2.1	39.4	1.3	2.6	29.5	1.5	3.1	22.3	1.6	3.7	17.3	1.8	4.3	13.0	2.1	4.9	9.8	2.6	5.4			
95	81.1	1.1	1.6	57.5	1.2	2.1	41.6	1.3	2.6	31.1	1.5	3.1	23.6	1.6	3.7	18.3	1.8	4.3	13.8	2.1	4.9	10.9	2.5	5.3			
100	85.4	1.1	1.6	60.5	1.2	2.1	43.8	1.3	2.6	32.7	1.5	3.1	24.9	1.6	3.7	19.3	1.8	4.3	14.6	2.1	4.9	11.6	2.4	5.4			
105	89.7	1.1	1.6	63.6	1.2	2.1	46.0	1.3	2.6	34.4	1.5	3.1	26.5	1.6	3.7	20.3	1.8	4.3	15.4	2.1	4.9	12.4	2.4	5.4	9.7	2.8	5.8
110	94.0	1.1	1.6	66.6	1.2	2.1	48.2	1.3	2.6	36.0	1.5	3.1	27.7	1.6	3.7	21.3	1.8	4.3	16.2	2.1	4.9	13.1	2.4	5.4	10.8	2.6	5.8
115	98.2	1.1	1.6	69.6	1.2	2.1	50.4	1.3	2.6	37.6	1.5	3.1	29.0	1.6	3.7	22.3	1.8	4.3	17.0	2.1	4.9	13.8	2.3	5.4	11.5	2.6	5.8
120	102.5	1.1	1.6	72.6	1.2	2.1	52.5	1.3	2.6	39.3	1.5	3.1	30.2	1.6	3.7	23.3	1.8	4.3	17.9	2.1	4.9	14.5	2.3	5.4	12.2	2.6	5.8
125	106.8	1.1	1.6	75.7	1.2	2.1	54.7	1.3	2.6	40.9	1.5	3.1	31.5	1.6	3.7	24.3	1.8	4.3	18.7	2.1	4.9	15.2	2.3	5.4	12.8	2.5	5.8
130	111.0	1.1	1.6	78.7	1.2	2.1	56.9	1.3	2.6	42.5	1.5	3.1	32.7	1.6	3.7	25.3	1.8	4.3	19.4	2.1	4.9	15.9	2.3	5.4	13.4	2.5	5.8
135	115.3	1.1	1.6	81.7	1.2	2.1	59.1	1.3	2.6	44.2	1.5	3.1	34.0	1.6	3.7	26.3	1.8	4.3	20.2	2.0	4.9	16.6	2.3	5.4	14.1	2.5	5.8
140	119.6	1.1	1.6	84.7	1.2	2.1	61.3	1.3	2.6	45.8	1.5	3.1	35.2	1.6	3.7	27.3	1.8	4.3	21.0	2.0	4.9	17.2	2.3	5.4	14.7	2.5	5.8
145	123.8	1.1	1.6	87.8	1.2	2.1	63.5	1.3	2.6	47.5	1.5	3.1	36.5	1.6	3.7	28.7	1.8	4.3	21.8	2.0	4.9	17.9	2.3	5.4	15.3	2.5	5.8
150	128.1	1.1	1.6	90.8	1.2	2.1	65.7	1.3	2.6	49.1	1.5	3.1	37.8	1.6	3.7	29.7	1.8	4.3	22.6	2.0	4.9	18.6	2.3	5.4	15.9	2.4	5.8

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 5 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 1.25 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	4.1	1.2	1.5																								
10	9.4	1.0	1.5	6.3	1.2	2.0																					
15	14.3	1.0	1.6	9.9	1.1	2.0	6.8	1.3	2.6																		
20	19.4	1.0	1.5	13.4	1.1	2.0	9.5	1.2	2.6	6.7	1.4	3.1															
25	24.2	1.0	1.5	17.0	1.1	2.0	12.1	1.2	2.6	8.8	1.4	3.1	5.9	1.7	3.6												
30	29.0	1.0	1.6	20.4	1.1	2.0	14.6	1.2	2.6	10.7	1.4	3.1	7.8	1.6	3.7												
35	33.8	1.0	1.6	23.8	1.1	2.0	17.1	1.2	2.6	12.7	1.3	3.1	9.4	1.5	3.7	6.5	1.9	4.2									
40	38.6	1.0	1.6	27.1	1.1	2.0	19.8	1.2	2.5	14.6	1.3	3.1	10.9	1.5	3.7	8.1	1.7	4.2									
45	43.5	1.0	1.6	30.5	1.1	2.0	22.3	1.2	2.5	16.5	1.3	3.1	12.5	1.5	3.7	9.4	1.7	4.2									
50	48.3	1.0	1.6	33.9	1.1	2.0	24.8	1.2	2.5	18.3	1.3	3.1	13.9	1.5	3.7	10.6	1.7	4.2	7.7	2.0	4.8						
55	53.1	1.0	1.6	37.3	1.1	2.0	27.2	1.2	2.6	20.5	1.3	3.1	15.4	1.5	3.7	11.8	1.6	4.3	9.0	1.9	4.8						
60	57.9	1.0	1.6	40.7	1.1	2.0	29.7	1.2	2.6	22.3	1.3	3.1	16.9	1.5	3.7	13.0	1.6	4.3	10.1	1.9	4.8						
65	62.8	1.0	1.6	44.1	1.1	2.0	32.2	1.2	2.6	24.2	1.3	3.1	18.3	1.5	3.7	14.2	1.6	4.3	11.1	1.8	4.8	8.0	2.3	5.3			
70	67.6	1.0	1.6	47.5	1.1	2.0	34.6	1.2	2.6	26.0	1.3	3.1	19.8	1.4	3.7	15.4	1.6	4.3	12.0	1.8	4.8	9.3	2.1	5.3			
75	72.4	1.0	1.6	50.8	1.1	2.0	37.1	1.2	2.6	27.9	1.3	3.1	21.2	1.4	3.7	16.5	1.6	4.3	13.0	1.8	4.8	10.1	2.1	5.3			
80	77.2	1.0	1.6	54.2	1.1	2.0	39.6	1.2	2.6	29.7	1.3	3.1	23.0	1.4	3.6	17.7	1.6	4.3	14.0	1.8	4.8	11.0	2.0	5.3			
85	82.1	1.0	1.6	57.6	1.1	2.0	42.0	1.2	2.6	31.6	1.3	3.1	24.4	1.4	3.6	18.8	1.6	4.3	14.9	1.8	4.8	11.8	2.0	5.3			
90	86.9	1.0	1.6	61.0	1.1	2.0	44.5	1.2	2.6	33.5	1.3	3.1	25.8	1.4	3.6	20.0	1.6	4.3	15.9	1.8	4.8	12.6	2.0	5.3	9.1	2.5	5.9
95	91.7	1.0	1.6	64.4	1.1	2.0	47.0	1.2	2.6	35.3	1.3	3.1	27.3	1.4	3.6	21.1	1.6	4.3	16.8	1.8	4.8	13.4	2.0	5.4	10.2	2.4	5.9
100	96.6	1.0	1.6	67.8	1.1	2.0	49.4	1.2	2.6	37.2	1.3	3.1	28.7	1.4	3.6	22.3	1.6	4.3	17.7	1.8	4.8	14.2	2.0	5.4	10.9	2.3	5.9
105	101.4	1.0	1.6	71.2	1.1	2.0	51.9	1.2	2.6	39.0	1.3	3.1	30.1	1.4	3.6	23.4	1.6	4.3	18.7	1.8	4.8	15.0	2.0	5.4	11.6	2.3	5.9
110	106.2	1.0	1.6	74.6	1.1	2.0	54.4	1.2	2.6	40.9	1.3	3.1	31.6	1.4	3.6	24.6	1.6	4.3	19.6	1.7	4.8	15.8	2.0	5.4	12.3	2.3	5.9
115	111.0	1.0	1.6	78.0	1.1	2.0	56.8	1.2	2.6	42.7	1.3	3.1	33.0	1.4	3.6	26.1	1.6	4.2	20.5	1.7	4.8	16.6	1.9	5.4	13.0	2.2	5.9
120	115.9	1.0	1.6	81.3	1.1	2.0	59.3	1.2	2.6	44.6	1.3	3.1	34.4	1.4	3.6	27.2	1.6	4.2	21.5	1.7	4.8	17.3	1.9	5.4	13.6	2.2	5.9
125	120.7	1.0	1.6	84.7	1.1	2.0	61.8	1.2	2.6	46.4	1.3	3.1	35.9	1.4	3.6	28.3	1.6	4.2	22.4	1.7	4.8	18.1	1.9	5.4	14.3	2.2	5.9
130	125.5	1.0	1.6	88.1	1.1	2.0	64.3	1.2	2.6	48.3	1.3	3.1	37.3	1.4	3.7	29.5	1.6	4.2	23.3	1.7	4.8	18.9	1.9	5.4	14.9	2.2	5.9
135	130.3	1.0	1.6	91.5	1.1	2.0	66.7	1.2	2.6	50.2	1.3	3.1	38.7	1.4	3.7	30.6	1.6	4.2	24.2	1.7	4.8	19.6	1.9	5.4	15.6	2.2	5.9
140	135.2	1.0	1.6	94.9	1.1	2.0	69.2	1.2	2.6	52.0	1.3	3.1	40.2	1.4	3.7	31.7	1.6	4.2	25.1	1.7	4.8	20.4	1.9	5.4	16.2	2.2	5.9
145	140.0	1.0	1.6	98.3	1.1	2.0	71.7	1.2	2.6	53.9	1.3	3.1	41.6	1.4	3.7	32.9	1.6	4.2	26.1	1.7	4.8	21.2	1.9	5.4	16.9	2.2	5.9
150	144.8	1.0	1.6	101.7	1.1	2.0	74.1	1.2	2.6	55.7	1.3	3.1	43.0	1.4	3.7	34.0	1.6	4.2	27.0	1.7	4.8	21.9	1.9	5.4	17.5	2.2	5.9

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 6 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 1.50 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	4.9	1.0	1.5																								
10	10.5	0.9	1.5	7.1	1.1	2.0	4.6	1.3	2.5																		
15	16.0	0.9	1.5	10.9	1.0	2.0	7.8	1.1	2.5	5.3	1.4	3.1															
20	21.3	0.9	1.5	14.7	1.0	2.0	10.6	1.1	2.5	7.7	1.3	3.1	5.1	1.6	3.6												
25	26.6	0.9	1.5	18.6	1.0	2.0	13.4	1.1	2.5	9.9	1.2	3.1	7.3	1.4	3.6												
30	31.9	0.9	1.5	22.3	1.0	2.0	16.2	1.1	2.5	12.0	1.2	3.1	9.0	1.4	3.6	6.6	1.6	4.2									
35	37.3	0.9	1.5	26.0	1.0	2.0	19.1	1.1	2.5	14.1	1.2	3.1	10.7	1.4	3.6	8.1	1.5	4.2									
40	42.6	0.9	1.5	29.7	1.0	2.0	21.8	1.1	2.5	16.2	1.2	3.1	12.4	1.3	3.6	9.5	1.5	4.2	6.9	1.8	4.7						
45	47.9	0.9	1.5	33.4	1.0	2.0	24.5	1.1	2.5	18.3	1.2	3.1	14.0	1.3	3.6	10.8	1.5	4.2	8.3	1.7	4.7						
50	53.2	0.9	1.5	37.1	1.0	2.0	27.3	1.1	2.5	20.6	1.2	3.0	15.7	1.3	3.6	12.1	1.5	4.2	9.4	1.7	4.8						
55	58.5	0.9	1.5	40.8	1.0	2.0	30.0	1.1	2.5	22.7	1.2	3.0	17.3	1.3	3.6	13.4	1.5	4.2	10.5	1.6	4.8	8.1	1.9	5.3			
60	63.8	0.9	1.5	44.5	1.0	2.0	32.7	1.1	2.5	24.7	1.2	3.0	18.9	1.3	3.6	14.7	1.4	4.2	11.6	1.6	4.8	9.1	1.9	5.3			
65	69.2	0.9	1.5	48.2	1.0	2.0	35.4	1.1	2.5	26.8	1.2	3.1	20.8	1.3	3.6	16.0	1.4	4.2	12.7	1.6	4.8	10.0	1.8	5.3			
70	74.5	0.9	1.5	51.9	1.0	2.0	38.2	1.1	2.5	28.8	1.2	3.1	22.4	1.3	3.6	17.3	1.4	4.2	13.7	1.6	4.8	10.9	1.8	5.3	8.2	2.2	5.8
75	79.8	0.9	1.5	55.6	1.0	2.0	40.9	1.1	2.5	30.9	1.2	3.1	23.9	1.3	3.6	18.6	1.4	4.2	14.8	1.6	4.8	11.8	1.8	5.3	9.3	2.1	5.8
80	85.1	0.9	1.5	59.4	1.0	2.0	43.6	1.1	2.5	32.9	1.2	3.1	25.5	1.3	3.6	19.9	1.4	4.2	15.8	1.6	4.8	12.7	1.8	5.3	10.1	2.0	5.9
85	90.4	0.9	1.5	63.1	1.0	2.0	46.3	1.1	2.5	35.0	1.2	3.1	27.1	1.3	3.6	21.2	1.4	4.2	16.9	1.6	4.8	13.6	1.8	5.3	10.9	2.0	5.9
90	95.8	0.9	1.5	66.8	1.0	2.0	49.0	1.1	2.5	37.1	1.2	3.1	28.7	1.3	3.6	22.8	1.4	4.1	17.9	1.6	4.8	14.5	1.8	5.3	11.6	2.0	5.9
95	101.1	0.9	1.5	70.5	1.0	2.0	51.8	1.1	2.5	39.1	1.2	3.1	30.3	1.3	3.6	24.0	1.4	4.2	18.9	1.6	4.8	15.3	1.7	5.3	12.4	2.0	5.9
100	106.4	0.9	1.5	74.2	1.0	2.0	54.5	1.1	2.5	41.2	1.2	3.1	31.9	1.3	3.6	25.3	1.4	4.2	20.0	1.6	4.8	16.2	1.7	5.3	13.1	1.9	5.9
105	111.7	0.9	1.5	77.9	1.0	2.0	57.2	1.1	2.5	43.2	1.2	3.1	33.5	1.3	3.6	26.5	1.4	4.2	21.0	1.6	4.8	17.0	1.7	5.3	13.9	1.9	5.9
110	117.0	0.9	1.5	81.6	1.0	2.0	59.9	1.1	2.5	45.3	1.2	3.1	35.1	1.3	3.6	27.8	1.4	4.2	22.0	1.6	4.8	17.9	1.7	5.3	14.6	1.9	5.9
115	122.4	0.9	1.5	85.3	1.0	2.0	62.6	1.1	2.5	47.3	1.2	3.1	36.7	1.3	3.6	29.1	1.4	4.2	23.1	1.6	4.8	18.8	1.7	5.3	15.3	1.9	5.9
120	127.7	0.9	1.5	89.0	1.0	2.0	65.4	1.1	2.5	49.4	1.2	3.1	38.3	1.3	3.6	30.3	1.4	4.2	24.1	1.6	4.8	19.6	1.7	5.3	16.1	1.9	5.9
125	133.0	0.9	1.5	92.7	1.0	2.0	68.1	1.1	2.5	51.4	1.2	3.1	39.9	1.3	3.6	31.6	1.4	4.2	25.4	1.6	4.8	20.5	1.7	5.3	16.8	1.9	5.9
130	138.3	0.9	1.5	96.4	1.0	2.0	70.8	1.1	2.5	53.5	1.2	3.1	41.4	1.3	3.6	32.8	1.4	4.2	26.4	1.6	4.8	21.3	1.7	5.3	17.5	1.9	5.9
135	143.6	0.9	1.5	100.1	1.0	2.0	73.5	1.1	2.5	55.6	1.2	3.1	43.0	1.3	3.6	34.1	1.4	4.2	27.4	1.6	4.8	22.2	1.7	5.3	18.2	1.9	5.9
140	149.0	0.9	1.5	103.9	1.0	2.0	76.3	1.1	2.5	57.6	1.2	3.1	44.6	1.3	3.6	35.3	1.4	4.2	28.5	1.6	4.8	23.0	1.7	5.3	18.9	1.9	5.9
145	154.3	0.9	1.5	107.6	1.0	2.0	79.0	1.1	2.5	59.7	1.2	3.1	46.2	1.3	3.6	36.6	1.4	4.2	29.5	1.6	4.8	23.8	1.7	5.3	19.7	1.9	5.9
150	159.6	0.9	1.5	111.3	1.0	2.0	81.7	1.1	2.5	61.7	1.2	3.1	47.8	1.3	3.6	37.9	1.4	4.2	30.5	1.6	4.8	24.7	1.7	5.3	20.4	1.9	5.9

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

GaSWCC /Amd

Table GS-4 Parabolic Grass Swale Design Sheet 7 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 1.75 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	5.4	0.9	1.5																								
10	11.4	0.9	1.5	7.7	1.0	2.0	5.4	1.1	2.5																		
15	17.3	0.9	1.5	11.8	1.0	2.0	8.6	1.1	2.5	6.2	1.2	3.0															
20	23.1	0.9	1.5	16.0	0.9	2.0	11.6	1.0	2.5	8.6	1.2	3.0	6.3	1.3	3.6												
25	28.8	0.9	1.5	20.0	0.9	2.0	14.6	1.0	2.5	10.9	1.1	3.0	8.2	1.3	3.6	5.9	1.5	4.1									
30	34.6	0.9	1.5	24.0	0.9	2.0	17.8	1.0	2.5	13.2	1.1	3.0	10.1	1.2	3.6	7.6	1.4	4.2									
35	40.3	0.9	1.5	28.0	0.9	2.0	20.7	1.0	2.5	15.5	1.1	3.0	11.9	1.2	3.6	9.1	1.4	4.2	6.9	1.6	4.7						
40	46.1	0.9	1.5	32.0	0.9	2.0	23.7	1.0	2.5	18.0	1.1	3.0	13.7	1.2	3.6	10.6	1.4	4.2	8.2	1.6	4.7						
45	51.9	0.9	1.5	36.0	0.9	2.0	26.6	1.0	2.5	20.2	1.1	3.0	15.4	1.2	3.6	12.0	1.3	4.2	9.4	1.5	4.7	7.0	1.8	5.3			
50	57.6	0.9	1.5	40.0	0.9	2.0	29.6	1.0	2.5	22.4	1.1	3.0	17.2	1.2	3.6	13.5	1.3	4.1	10.6	1.5	4.7	8.3	1.7	5.3			
55	63.4	0.9	1.5	44.0	0.9	2.0	32.5	1.0	2.5	24.7	1.1	3.0	19.2	1.2	3.6	14.9	1.3	4.1	11.8	1.5	4.7	9.3	1.7	5.3	6.7	2.1	5.8
60	69.1	0.9	1.5	48.0	0.9	2.0	35.5	1.0	2.5	26.9	1.1	3.0	20.9	1.2	3.6	16.3	1.3	4.1	12.9	1.5	4.7	10.3	1.6	5.3	8.1	1.9	5.8
65	74.9	0.9	1.5	52.0	0.9	2.0	38.4	1.0	2.5	29.2	1.1	3.0	22.7	1.2	3.6	17.7	1.3	4.1	14.1	1.5	4.7	11.3	1.6	5.3	9.0	1.9	5.8
70	80.7	0.9	1.5	56.0	0.9	2.0	41.4	1.0	2.5	31.4	1.1	3.0	24.4	1.2	3.6	19.1	1.3	4.1	15.2	1.5	4.7	12.3	1.6	5.3	9.8	1.8	5.8
75	86.4	0.9	1.5	60.0	0.9	2.0	44.3	1.0	2.5	33.6	1.1	3.0	26.1	1.2	3.6	20.5	1.3	4.1	16.4	1.4	4.7	13.2	1.6	5.3	10.7	1.8	5.8
80	92.2	0.9	1.5	63.9	0.9	2.0	47.3	1.0	2.5	35.9	1.1	3.0	27.9	1.2	3.6	22.2	1.3	4.1	17.5	1.4	4.7	14.2	1.6	5.3	11.5	1.8	5.8
85	97.9	0.9	1.5	67.9	0.9	2.0	50.2	1.0	2.5	38.1	1.1	3.0	29.6	1.2	3.6	23.5	1.3	4.1	18.6	1.4	4.7	15.1	1.6	5.3	12.3	1.8	5.8
90	103.7	0.9	1.5	71.9	0.9	2.0	53.2	1.0	2.5	40.3	1.1	3.0	31.4	1.2	3.6	24.9	1.3	4.1	19.8	1.4	4.7	16.1	1.6	5.3	13.1	1.8	5.8
95	109.5	0.9	1.5	75.9	0.9	2.0	56.1	1.0	2.5	42.6	1.1	3.0	33.1	1.2	3.6	26.3	1.3	4.1	20.9	1.4	4.7	17.0	1.6	5.3	13.9	1.7	5.8
100	115.2	0.9	1.5	79.9	0.9	2.0	59.1	1.0	2.5	44.8	1.1	3.0	34.8	1.2	3.6	27.7	1.3	4.1	22.0	1.4	4.7	17.9	1.6	5.3	14.7	1.7	5.8
105	121.0	0.9	1.5	83.9	0.9	2.0	62.0	1.0	2.5	47.1	1.1	3.0	36.6	1.2	3.6	29.0	1.3	4.1	23.4	1.4	4.7	18.9	1.6	5.3	15.5	1.7	5.8
110	126.8	0.9	1.5	87.9	0.9	2.0	65.0	1.0	2.5	49.3	1.1	3.0	38.3	1.2	3.6	30.4	1.3	4.1	24.5	1.4	4.7	19.8	1.6	5.3	16.3	1.7	5.8
115	132.5	0.9	1.5	91.9	0.9	2.0	67.9	1.0	2.5	51.5	1.1	3.0	40.1	1.2	3.6	31.8	1.3	4.1	25.6	1.4	4.7	20.7	1.6	5.3	17.1	1.7	5.9
120	138.3	0.9	1.5	95.9	0.9	2.0	70.9	1.0	2.5	53.8	1.1	3.0	41.8	1.2	3.6	33.2	1.3	4.1	26.8	1.4	4.7	21.7	1.6	5.3	17.9	1.7	5.9
125	144.0	0.9	1.5	99.9	0.9	2.0	73.8	1.0	2.5	56.0	1.1	3.0	43.5	1.2	3.6	34.6	1.3	4.1	27.9	1.4	4.7	22.6	1.6	5.3	18.7	1.7	5.9
130	149.8	0.9	1.5	103.9	0.9	2.0	76.8	1.0	2.5	58.3	1.1	3.0	45.3	1.2	3.6	35.9	1.3	4.1	29.0	1.4	4.7	23.5	1.6	5.3	19.4	1.7	5.9
135	155.6	0.9	1.5	107.9	0.9	2.0	79.7	1.0	2.5	60.5	1.1	3.0	47.0	1.2	3.6	37.3	1.3	4.1	30.1	1.4	4.7	24.5	1.6	5.3	20.2	1.7	5.9
140	161.3	0.9	1.5	111.9	0.9	2.0	82.7	1.0	2.5	62.7	1.1	3.0	48.8	1.2	3.6	38.7	1.3	4.1	31.2	1.4	4.7	25.7	1.6	5.3	21.0	1.7	5.9
145	167.1	0.9	1.5	115.9	0.9	2.0	85.6	1.0	2.5	65.0	1.1	3.0	50.5	1.2	3.6	40.1	1.3	4.1	32.3	1.4	4.7	26.6	1.6	5.3	21.8	1.7	5.9
150	172.8	0.9	1.5	119.9	0.9	2.0	88.6	1.0	2.5	67.2	1.1	3.0	52.2	1.2	3.6	41.5	1.3	4.1	33.4	1.4	4.7	27.5	1.6	5.3	22.6	1.7	5.9

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second:
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 8 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 2.00 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	5.9	0.9	1.5																								
10	12.4	0.8	1.5	8.1	0.9	2.0	5.9	1.0	2.5																		
15	18.5	0.8	1.5	12.3	0.9	2.0	9.3	1.0	2.5	6.8	1.1	3.0	4.7	1.4	3.5												
20	24.7	0.8	1.5	16.7	0.9	2.0	12.5	1.0	2.5	9.4	1.1	3.0	7.0	1.2	3.6	4.7	1.5	4.1									
25	30.8	0.8	1.5	20.8	0.9	2.0	15.9	1.0	2.4	11.8	1.1	3.0	9.0	1.2	3.5	6.8	1.3	4.1									
30	37.0	0.8	1.5	25.0	0.9	2.0	19.0	1.0	2.5	14.3	1.1	3.0	11.0	1.2	3.5	8.5	1.3	4.1	6.4	1.5	4.7						
35	43.2	0.8	1.5	29.1	0.9	2.0	22.2	1.0	2.5	16.9	1.0	3.0	12.9	1.1	3.5	10.1	1.3	4.1	7.8	1.4	4.7						
40	49.3	0.8	1.5	33.3	0.9	2.0	25.3	1.0	2.5	19.3	1.0	3.0	14.8	1.1	3.5	11.6	1.3	4.1	9.1	1.4	4.7	7.1	1.6	5.2			
45	55.5	0.8	1.5	37.4	0.9	2.0	28.5	1.0	2.5	21.7	1.0	3.0	16.7	1.1	3.5	13.1	1.3	4.1	10.4	1.4	4.7	8.2	1.6	5.2			
50	61.7	0.8	1.5	41.6	0.9	2.0	31.7	1.0	2.5	24.1	1.0	3.0	18.8	1.1	3.5	14.7	1.2	4.1	11.7	1.4	4.7	9.3	1.5	5.3	7.1	1.8	5.8
55	67.8	0.8	1.5	45.7	0.9	2.0	34.8	1.0	2.5	26.5	1.0	3.0	20.7	1.1	3.5	16.2	1.2	4.1	12.9	1.4	4.7	10.4	1.5	5.3	8.2	1.7	5.8
60	74.0	0.8	1.5	49.9	0.9	2.0	38.0	1.0	2.5	28.9	1.0	3.0	22.6	1.1	3.5	17.7	1.2	4.1	14.1	1.4	4.7	11.4	1.5	5.3	9.2	1.7	5.8
65	80.2	0.8	1.5	54.0	0.9	2.0	41.1	1.0	2.5	31.4	1.0	3.0	24.5	1.1	3.5	19.5	1.2	4.1	15.4	1.3	4.7	12.4	1.5	5.3	10.1	1.7	5.8
70	86.3	0.8	1.5	58.2	0.9	2.0	44.3	1.0	2.5	33.8	1.0	3.0	26.3	1.1	3.5	21.0	1.2	4.1	16.6	1.3	4.7	13.5	1.5	5.3	11.0	1.6	5.8
75	92.5	0.8	1.5	62.3	0.9	2.0	47.5	1.0	2.5	36.2	1.0	3.0	28.2	1.1	3.5	22.4	1.2	4.1	17.8	1.3	4.7	14.5	1.5	5.3	11.8	1.6	5.8
80	98.7	0.8	1.5	66.5	0.9	2.0	50.6	1.0	2.5	38.6	1.0	3.0	30.1	1.1	3.5	23.9	1.2	4.1	19.0	1.3	4.7	15.5	1.5	5.3	12.7	1.6	5.8
85	104.8	0.8	1.5	70.6	0.9	2.0	53.8	1.0	2.5	41.0	1.0	3.0	32.0	1.1	3.5	25.4	1.2	4.1	20.3	1.3	4.7	16.5	1.5	5.3	13.6	1.6	5.8
90	111.0	0.8	1.5	74.8	0.9	2.0	57.0	1.0	2.5	43.4	1.0	3.0	33.8	1.1	3.5	26.9	1.2	4.1	21.8	1.3	4.6	17.5	1.5	5.3	14.4	1.6	5.8
95	117.2	0.8	1.5	78.9	0.9	2.0	60.1	1.0	2.5	45.8	1.0	3.0	35.7	1.1	3.5	28.4	1.2	4.1	23.0	1.3	4.6	18.6	1.5	5.3	15.3	1.6	5.8
100	123.3	0.8	1.5	83.1	0.9	2.0	63.3	1.0	2.5	48.2	1.0	3.0	37.6	1.1	3.5	29.9	1.2	4.1	24.2	1.3	4.6	19.6	1.5	5.3	16.2	1.6	5.8
105	129.5	0.8	1.5	87.3	0.9	2.0	66.4	1.0	2.5	50.6	1.0	3.0	39.5	1.1	3.5	31.4	1.2	4.1	25.4	1.3	4.6	20.6	1.5	5.3	17.0	1.6	5.8
110	135.7	0.8	1.5	91.4	0.9	2.0	69.6	1.0	2.5	53.0	1.0	3.0	41.3	1.1	3.5	32.9	1.2	4.1	26.6	1.3	4.7	21.6	1.4	5.3	17.9	1.6	5.8
115	141.8	0.8	1.5	95.6	0.9	2.0	72.8	1.0	2.5	55.4	1.0	3.0	43.2	1.1	3.5	34.4	1.2	4.1	27.9	1.3	4.7	22.6	1.4	5.3	18.7	1.6	5.8
120	148.0	0.8	1.5	99.7	0.9	2.0	75.9	1.0	2.5	57.9	1.0	3.0	45.1	1.1	3.5	35.9	1.2	4.1	29.1	1.3	4.7	23.9	1.4	5.2	19.5	1.6	5.8
125	154.1	0.8	1.5	103.9	0.9	2.0	79.1	1.0	2.5	60.3	1.0	3.0	47.0	1.1	3.5	37.4	1.2	4.1	30.3	1.3	4.7	24.8	1.4	5.2	20.4	1.6	5.8
130	160.3	0.8	1.5	108.0	0.9	2.0	82.3	1.0	2.5	62.7	1.0	3.0	48.8	1.1	3.5	38.9	1.2	4.1	31.5	1.3	4.7	25.8	1.4	5.3	21.2	1.6	5.8
135	166.5	0.8	1.5	112.2	0.9	2.0	85.4	1.0	2.5	65.1	1.0	3.0	50.7	1.1	3.5	40.3	1.2	4.1	32.7	1.3	4.7	26.8	1.4	5.3	22.1	1.6	5.8
140	172.6	0.8	1.5	116.3	0.9	2.0	88.6	1.0	2.5	67.5	1.0	3.0	52.6	1.1	3.5	41.8	1.2	4.1	33.9	1.3	4.7	27.8	1.4	5.3	22.9	1.6	5.8
145	178.8	0.8	1.5	120.5	0.9	2.0	91.8	1.0	2.5	69.9	1.0	3.0	54.5	1.1	3.5	43.3	1.2	4.1	35.1	1.3	4.7	28.8	1.4	5.3	23.7	1.6	5.8
150	185.0	0.8	1.5	124.6	0.9	2.0	94.9	1.0	2.5	72.3	1.0	3.0	56.4	1.1	3.5	44.8	1.2	4.1	36.3	1.3	4.7	29.8	1.4	5.3	24.6	1.6	5.8

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 9 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 3.00 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	7.4	0.7	1.4	4.9	0.8	1.9	3.2	1.0	2.3																		
10	15.1	0.7	1.4	10.2	0.8	1.9	7.6	0.8	2.4	5.7	0.9	2.9	4.0	1.1	3.4												
15	22.6	0.7	1.4	15.6	0.8	1.9	11.5	0.8	2.4	8.8	0.9	2.9	6.7	1.0	3.4	5.1	1.1	4.0									
20	30.1	0.7	1.4	20.7	0.8	1.9	15.5	0.8	2.4	11.8	0.9	2.9	9.2	0.9	3.4	7.2	1.0	4.0	5.5	1.2	4.6						
25	37.6	0.7	1.4	25.9	0.8	1.9	19.4	0.8	2.4	15.0	0.9	2.9	11.6	0.9	3.4	9.2	1.0	4.0	7.2	1.1	4.6	5.6	1.3	5.1			
30	45.1	0.7	1.4	31.1	0.8	1.9	23.3	0.8	2.4	18.0	0.9	2.9	14.0	0.9	3.4	11.1	1.0	4.0	8.9	1.1	4.6	7.1	1.2	5.2	5.3	1.5	5.7
35	52.7	0.7	1.4	36.2	0.8	1.9	27.1	0.8	2.4	21.0	0.9	2.9	16.5	0.9	3.4	13.0	1.0	4.0	10.5	1.1	4.6	8.4	1.2	5.2	6.7	1.4	5.7
40	60.2	0.7	1.4	41.4	0.8	1.9	31.0	0.8	2.4	24.0	0.9	2.9	18.9	0.9	3.4	14.9	1.0	4.0	12.0	1.1	4.6	9.8	1.2	5.2	7.9	1.3	5.7
45	67.7	0.7	1.4	46.6	0.8	1.9	34.9	0.8	2.4	27.0	0.9	2.9	21.2	0.9	3.4	17.0	1.0	4.0	13.6	1.1	4.6	11.1	1.2	5.2	9.1	1.3	5.7
50	75.2	0.7	1.4	51.8	0.8	1.9	38.8	0.8	2.4	29.9	0.9	2.9	23.6	0.9	3.4	18.9	1.0	4.0	15.2	1.1	4.6	12.4	1.2	5.2	10.2	1.3	5.7
55	82.8	0.7	1.4	56.9	0.8	1.9	42.6	0.8	2.4	32.9	0.9	2.9	25.9	0.9	3.4	20.8	1.0	4.0	16.7	1.1	4.6	13.7	1.2	5.2	11.3	1.3	5.7
60	90.3	0.7	1.4	62.1	0.8	1.9	46.5	0.8	2.4	35.9	0.9	2.9	28.3	0.9	3.4	22.7	1.0	4.0	18.5	1.1	4.5	14.9	1.2	5.2	12.4	1.3	5.7
65	97.8	0.7	1.4	67.3	0.8	1.9	50.4	0.8	2.4	38.9	0.9	2.9	30.6	0.9	3.4	24.6	1.0	4.0	20.0	1.1	4.5	16.2	1.2	5.2	13.5	1.3	5.7
70	105.3	0.7	1.4	72.4	0.8	1.9	54.3	0.8	2.4	41.9	0.9	2.9	33.0	0.9	3.4	26.4	1.0	4.0	21.5	1.1	4.5	17.5	1.2	5.2	14.5	1.3	5.7
75	112.8	0.7	1.4	77.6	0.8	1.9	58.1	0.8	2.4	44.9	0.9	2.9	35.3	0.9	3.4	28.3	1.0	4.0	23.1	1.1	4.5	19.1	1.2	5.1	15.6	1.3	5.7
80	120.4	0.7	1.4	82.8	0.8	1.9	62.0	0.8	2.4	47.9	0.9	2.9	37.7	0.9	3.4	30.2	1.0	4.0	24.6	1.1	4.5	20.3	1.2	5.1	16.7	1.3	5.7
85	127.9	0.7	1.4	88.0	0.8	1.9	65.9	0.8	2.4	50.9	0.9	2.9	40.1	0.9	3.4	32.1	1.0	4.0	26.1	1.1	4.5	21.6	1.2	5.1	17.8	1.2	5.7
90	135.4	0.7	1.4	93.1	0.8	1.9	69.8	0.8	2.4	53.9	0.9	2.9	42.4	0.9	3.4	34.0	1.0	4.0	27.7	1.1	4.5	22.9	1.2	5.1	18.9	1.2	5.7
95	142.9	0.7	1.4	98.3	0.8	1.9	73.6	0.8	2.4	56.9	0.9	2.9	44.8	0.9	3.4	35.9	1.0	4.0	29.2	1.1	4.5	24.1	1.2	5.1	20.2	1.2	5.7
100	150.5	0.7	1.4	103.5	0.8	1.9	77.5	0.8	2.4	59.9	0.9	2.9	47.1	0.9	3.4	37.8	1.0	4.0	30.7	1.1	4.5	25.4	1.2	5.1	21.2	1.2	5.7
105	158.0	0.7	1.4	108.7	0.8	1.9	81.4	0.8	2.4	62.8	0.9	2.9	49.5	0.9	3.4	39.6	1.0	4.0	32.3	1.1	4.5	26.7	1.2	5.1	22.3	1.2	5.7
110	165.5	0.7	1.4	113.8	0.8	1.9	85.3	0.8	2.4	65.8	0.9	2.9	51.8	0.9	3.4	41.5	1.0	4.0	33.8	1.1	4.6	27.9	1.2	5.1	23.3	1.2	5.7
115	173.0	0.7	1.4	119.0	0.8	1.9	89.1	0.8	2.4	68.8	0.9	2.9	54.2	0.9	3.4	43.4	1.0	4.0	35.4	1.1	4.6	29.2	1.2	5.1	24.4	1.2	5.7
120	180.5	0.7	1.4	124.2	0.8	1.9	93.0	0.8	2.4	71.8	0.9	2.9	56.5	0.9	3.4	45.3	1.0	4.0	36.9	1.1	4.6	30.5	1.2	5.1	25.5	1.2	5.7
125	188.1	0.7	1.4	129.4	0.8	1.9	96.9	0.8	2.4	74.8	0.9	2.9	58.9	0.9	3.4	47.2	1.0	4.0	38.4	1.1	4.6	31.7	1.2	5.1	26.5	1.2	5.7
130	195.6	0.7	1.4	134.5	0.8	1.9	100.8	0.8	2.4	77.8	0.9	2.9	61.2	0.9	3.4	49.1	1.0	4.0	40.0	1.1	4.6	33.0	1.2	5.1	27.6	1.2	5.7
135	203.1	0.7	1.4	139.7	0.8	1.9	104.6	0.8	2.4	80.8	0.9	2.9	63.6	0.9	3.4	51.0	1.0	4.0	41.5	1.1	4.6	34.3	1.2	5.1	28.6	1.2	5.7
140	210.6	0.7	1.4	144.9	0.8	1.9	108.5	0.8	2.4	83.8	0.9	2.9	66.0	0.9	3.4	52.8	1.0	4.0	43.0	1.1	4.6	35.6	1.2	5.1	29.7	1.2	5.7
145	218.2	0.7	1.4	150.1	0.8	1.9	112.4	0.8	2.4	86.8	0.9	2.9	68.3	0.9	3.4	54.7	1.0	4.0	44.6	1.1	4.6	36.8	1.2	5.1	30.7	1.2	5.7
150	225.7	0.7	1.4	155.2	0.8	1.9	116.3	0.8	2.4	89.8	0.9	2.9	70.7	0.9	3.4	56.6	1.0	4.0	46.1	1.1	4.6	38.1	1.2	5.1	31.8	1.2	5.7

RETARDANCE "D" AND "C"

NOTE: Width and Depth dir sions are in feet; Velocity measurements are in feet per second;
includ llowance for freeboarc settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 10 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 4.00 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	8.5	0.6	1.4	5.9	0.7	1.8	4.1	0.8	2.3																		
10	17.2	0.6	1.4	12.1	0.7	1.8	8.8	0.7	2.3	6.7	0.8	2.8	5.2	0.9	3.3	3.8	1.0	3.9									
15	25.8	0.6	1.4	18.1	0.7	1.8	13.4	0.7	2.3	10.3	0.8	2.8	8.1	0.8	3.4	6.4	0.9	3.9	4.9	1.0	4.5						
20	34.4	0.6	1.4	24.2	0.7	1.8	17.8	0.7	2.3	13.9	0.8	2.8	10.9	0.8	3.4	8.7	0.9	3.9	6.9	1.0	4.5	5.5	1.1	5.0			
25	43.0	0.6	1.4	30.2	0.7	1.9	22.3	0.7	2.3	17.4	0.8	2.8	13.8	0.8	3.3	10.9	0.9	3.9	8.8	1.0	4.5	7.1	1.0	5.1	5.7	1.2	5.6
30	51.6	0.6	1.4	36.3	0.7	1.9	26.7	0.7	2.3	20.8	0.8	2.8	16.5	0.8	3.3	13.2	0.9	3.9	10.7	0.9	4.5	8.7	1.0	5.1	7.1	1.1	5.6
35	60.2	0.6	1.4	42.3	0.7	1.9	31.1	0.7	2.3	24.3	0.8	2.8	19.3	0.8	3.4	15.6	0.9	3.9	12.5	0.9	4.5	10.3	1.0	5.0	8.4	1.1	5.6
40	68.8	0.6	1.4	48.3	0.7	1.9	35.6	0.7	2.3	27.8	0.8	2.8	22.0	0.8	3.4	17.8	0.9	3.9	14.4	0.9	4.5	11.8	1.0	5.0	9.8	1.1	5.7
45	77.4	0.6	1.4	54.4	0.7	1.9	40.0	0.7	2.4	31.2	0.8	2.8	24.8	0.8	3.4	20.0	0.9	3.9	16.4	0.9	4.4	13.3	1.0	5.0	11.1	1.1	5.7
50	86.0	0.6	1.4	60.4	0.7	1.9	44.5	0.7	2.4	34.7	0.8	2.8	27.5	0.8	3.4	22.2	0.9	3.9	18.2	0.9	4.4	14.9	1.0	5.0	12.3	1.1	5.7
55	94.6	0.6	1.4	66.5	0.7	1.9	48.9	0.7	2.4	38.2	0.8	2.8	30.3	0.8	3.4	24.4	0.9	3.9	20.0	0.9	4.4	16.6	1.0	5.0	13.6	1.1	5.7
60	103.2	0.6	1.4	72.5	0.7	1.9	53.4	0.7	2.4	41.7	0.8	2.8	33.0	0.8	3.4	26.6	0.9	3.9	21.8	0.9	4.5	18.1	1.0	5.0	14.9	1.1	5.7
65	111.8	0.6	1.4	78.5	0.7	1.9	57.8	0.7	2.4	45.1	0.8	2.8	35.8	0.8	3.4	28.9	0.9	3.9	23.6	0.9	4.5	19.6	1.0	5.0	16.2	1.1	5.7
70	120.4	0.6	1.4	84.6	0.7	1.9	62.3	0.7	2.4	48.6	0.8	2.8	38.6	0.8	3.4	31.1	0.9	3.9	25.4	0.9	4.5	21.1	1.0	5.0	17.7	1.1	5.6
75	129.0	0.6	1.4	90.6	0.7	1.9	66.7	0.7	2.4	52.1	0.8	2.8	41.3	0.8	3.4	33.3	0.9	3.9	27.2	0.9	4.5	22.6	1.0	5.0	19.0	1.1	5.6
80	137.6	0.6	1.4	96.7	0.7	1.9	71.2	0.7	2.4	55.5	0.8	2.8	44.1	0.8	3.4	35.5	0.9	3.9	29.1	0.9	4.5	24.1	1.0	5.0	20.2	1.1	5.6
85	146.2	0.6	1.4	102.7	0.7	1.9	75.6	0.7	2.4	59.0	0.8	2.8	46.8	0.8	3.4	37.7	0.9	3.9	30.9	0.9	4.5	25.6	1.0	5.0	21.5	1.1	5.6
90	154.8	0.6	1.4	108.7	0.7	1.9	80.0	0.7	2.4	62.5	0.8	2.8	49.6	0.8	3.4	39.9	0.9	3.9	32.7	0.9	4.5	27.1	1.0	5.0	22.8	1.1	5.6
95	163.4	0.6	1.4	114.8	0.7	1.9	84.5	0.7	2.4	65.9	0.8	2.8	52.3	0.8	3.4	42.2	0.9	3.9	34.5	0.9	4.5	28.6	1.0	5.0	24.0	1.1	5.6
100	172.0	0.6	1.4	120.8	0.7	1.9	88.9	0.7	2.4	69.4	0.8	2.8	55.1	0.8	3.4	44.4	0.9	3.9	36.3	0.9	4.5	30.1	1.0	5.0	25.3	1.1	5.6
105	180.6	0.6	1.4	126.9	0.7	1.9	93.4	0.7	2.4	72.9	0.8	2.8	57.8	0.8	3.4	46.6	0.9	3.9	38.1	0.9	4.5	31.6	1.0	5.0	26.5	1.1	5.6
110	189.2	0.6	1.4	132.9	0.7	1.9	97.8	0.7	2.4	76.3	0.8	2.8	60.6	0.8	3.4	48.8	0.9	3.9	39.9	0.9	4.5	33.1	1.0	5.0	27.8	1.1	5.6
115	197.8	0.6	1.4	138.9	0.7	1.9	102.3	0.7	2.4	79.8	0.8	2.8	63.3	0.8	3.4	51.0	0.9	3.9	41.7	0.9	4.5	34.6	1.0	5.0	29.0	1.1	5.6
120	206.4	0.6	1.4	145.0	0.7	1.9	106.7	0.7	2.4	83.3	0.8	2.8	66.1	0.8	3.4	53.3	0.9	3.9	43.6	0.9	4.5	36.1	1.0	5.0	30.2	1.1	5.7
125	215.0	0.6	1.4	151.0	0.7	1.9	111.2	0.7	2.4	86.8	0.8	2.8	68.8	0.8	3.4	55.5	0.9	3.9	45.4	0.9	4.5	37.6	1.0	5.0	31.5	1.1	5.7
130	223.7	0.6	1.4	157.1	0.7	1.9	115.6	0.7	2.4	90.2	0.8	2.8	71.6	0.8	3.4	57.7	0.9	3.9	47.2	0.9	4.5	39.1	1.0	5.0	32.7	1.1	5.7
135	232.3	0.6	1.4	163.1	0.7	1.9	120.1	0.7	2.4	93.7	0.8	2.8	74.3	0.8	3.4	59.9	0.9	3.9	49.0	0.9	4.5	40.6	1.0	5.0	34.0	1.1	5.7
140	240.9	0.6	1.4	169.1	0.7	1.9	124.5	0.7	2.4	97.2	0.8	2.8	77.1	0.8	3.4	62.1	0.9	3.9	50.8	0.9	4.5	42.1	1.0	5.0	35.2	1.1	5.7
145	249.5	0.6	1.4	175.2	0.7	1.9	129.0	0.7	2.4	100.6	0.8	2.8	79.8	0.8	3.4	64.3	0.9	3.9	52.6	0.9	4.5	43.6	1.0	5.0	36.5	1.1	5.7
150	258.1	0.6	1.4	181.2	0.7	1.9	133.4	0.7	2.4	104.1	0.8	2.8	82.6	0.8	3.4	66.6	0.9	3.9	54.4	0.9	4.5	45.1	1.0	5.0	37.8	1.1	5.7

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second; Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 11 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 5.00 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	9.5	0.6	1.4	6.7	0.6	1.8	4.7	0.7	2.3	3.5	0.8	2.8															
10	19.0	0.6	1.4	13.7	0.6	1.8	9.7	0.7	2.3	7.6	0.7	2.8	6.0	0.8	3.3	4.7	0.8	3.8	3.4	1.0	4.4						
15	28.5	0.6	1.4	20.5	0.6	1.8	14.8	0.7	2.3	11.7	0.7	2.8	9.2	0.7	3.3	7.3	0.8	3.8	5.9	0.9	4.4	4.7	1.0	5.0			
20	38.0	0.6	1.4	27.3	0.6	1.8	19.7	0.7	2.3	15.5	0.7	2.8	12.4	0.7	3.3	9.9	0.8	3.8	8.0	0.9	4.4	6.5	0.9	4.9	5.3	1.0	5.5
25	47.5	0.6	1.4	34.1	0.6	1.8	24.6	0.7	2.3	19.4	0.7	2.8	15.5	0.7	3.3	12.6	0.8	3.8	10.1	0.8	4.4	8.3	0.9	5.0	6.8	1.0	5.6
30	57.0	0.6	1.4	40.9	0.6	1.8	29.5	0.7	2.3	23.3	0.7	2.8	18.6	0.7	3.3	15.1	0.8	3.8	12.2	0.8	4.4	10.1	0.9	5.0	8.3	1.0	5.6
35	66.5	0.6	1.4	47.7	0.6	1.8	34.4	0.7	2.3	27.2	0.7	2.8	21.7	0.7	3.3	17.6	0.8	3.8	14.5	0.8	4.4	11.8	0.9	5.0	9.8	1.0	5.6
40	76.0	0.6	1.4	54.6	0.6	1.8	39.4	0.7	2.3	31.0	0.7	2.8	24.8	0.7	3.3	20.1	0.8	3.8	16.5	0.8	4.4	13.6	0.9	5.0	11.3	1.0	5.5
45	85.5	0.6	1.4	61.4	0.6	1.8	44.3	0.7	2.3	34.9	0.7	2.8	27.9	0.7	3.3	22.6	0.8	3.8	18.6	0.8	4.4	15.5	0.9	4.9	12.8	1.0	5.5
50	95.0	0.6	1.4	68.2	0.6	1.8	49.2	0.7	2.3	38.8	0.7	2.8	31.0	0.7	3.3	25.1	0.8	3.8	20.6	0.8	4.4	17.2	0.9	4.9	14.3	1.0	5.5
55	104.6	0.6	1.4	75.0	0.6	1.8	54.1	0.7	2.3	42.7	0.7	2.8	34.1	0.7	3.3	27.6	0.8	3.8	22.7	0.8	4.4	18.9	0.9	4.9	15.9	0.9	5.5
60	114.1	0.6	1.4	81.8	0.6	1.8	59.0	0.7	2.3	46.6	0.7	2.8	37.2	0.7	3.3	30.1	0.8	3.8	24.7	0.8	4.4	20.6	0.9	4.9	17.3	0.9	5.5
65	123.6	0.6	1.4	88.6	0.6	1.8	63.9	0.7	2.3	50.4	0.7	2.8	40.3	0.7	3.3	32.6	0.8	3.8	26.8	0.8	4.4	22.3	0.9	4.9	18.8	0.9	5.5
70	133.1	0.6	1.4	95.5	0.6	1.8	68.9	0.7	2.3	54.3	0.7	2.8	43.4	0.7	3.3	35.1	0.8	3.8	28.9	0.8	4.4	24.0	0.9	4.9	20.2	0.9	5.5
75	142.6	0.6	1.4	102.3	0.6	1.8	73.8	0.7	2.3	58.2	0.7	2.8	46.5	0.7	3.3	37.7	0.8	3.8	30.9	0.8	4.4	25.7	0.9	4.9	21.6	0.9	5.5
80	152.1	0.6	1.4	109.1	0.6	1.8	78.7	0.7	2.3	62.1	0.7	2.8	49.6	0.7	3.3	40.2	0.8	3.8	33.0	0.8	4.4	27.4	0.9	4.9	23.1	0.9	5.5
85	161.6	0.6	1.4	115.9	0.6	1.8	83.6	0.7	2.3	65.9	0.7	2.8	52.7	0.7	3.3	42.7	0.8	3.8	35.0	0.8	4.4	29.1	0.9	5.0	24.5	0.9	5.5
90	171.1	0.6	1.4	122.7	0.6	1.8	88.5	0.7	2.3	69.8	0.7	2.8	55.8	0.7	3.3	45.2	0.8	3.8	37.1	0.8	4.4	30.9	0.9	5.0	26.0	0.9	5.5
95	180.6	0.6	1.4	129.6	0.6	1.8	93.4	0.7	2.3	73.7	0.7	2.8	58.9	0.7	3.3	47.7	0.8	3.8	39.2	0.8	4.4	32.6	0.9	5.0	27.4	0.9	5.5
100	190.1	0.6	1.4	136.4	0.6	1.8	98.4	0.7	2.3	77.6	0.7	2.8	62.0	0.7	3.3	50.2	0.8	3.8	41.2	0.8	4.4	34.3	0.9	5.0	28.8	0.9	5.5
105	199.6	0.6	1.4	143.2	0.6	1.8	103.3	0.7	2.3	81.5	0.7	2.8	65.1	0.7	3.3	52.7	0.8	3.8	43.3	0.8	4.4	36.0	0.9	5.0	30.3	0.9	5.5
110	209.1	0.6	1.4	150.0	0.6	1.8	108.2	0.7	2.3	85.3	0.7	2.8	68.2	0.7	3.3	55.2	0.8	3.8	45.3	0.8	4.4	37.7	0.9	5.0	31.7	0.9	5.5
115	218.6	0.6	1.4	156.8	0.6	1.8	113.1	0.7	2.3	89.2	0.7	2.8	71.3	0.7	3.3	57.7	0.8	3.8	47.4	0.8	4.4	39.4	0.9	5.0	33.2	0.9	5.5
120	228.1	0.6	1.4	163.6	0.6	1.8	118.0	0.7	2.3	93.1	0.7	2.8	74.3	0.7	3.3	60.2	0.8	3.8	49.5	0.8	4.4	41.1	0.9	5.0	34.6	0.9	5.5
125	237.6	0.6	1.4	170.5	0.6	1.8	123.0	0.7	2.3	97.0	0.7	2.8	77.4	0.7	3.3	62.7	0.8	3.8	51.5	0.8	4.4	42.8	0.9	5.0	36.0	0.9	5.5
130	247.1	0.6	1.4	177.3	0.6	1.8	127.9	0.7	2.3	100.8	0.7	2.8	80.5	0.7	3.3	65.2	0.8	3.8	53.6	0.8	4.4	44.6	0.9	5.0	37.5	0.9	5.5
135	256.6	0.6	1.4	184.1	0.6	1.8	132.8	0.7	2.3	104.7	0.7	2.8	83.6	0.7	3.3	67.8	0.8	3.8	55.6	0.8	4.4	46.3	0.9	5.0	38.9	0.9	5.5
140	266.1	0.6	1.4	190.9	0.6	1.8	137.7	0.7	2.3	108.6	0.7	2.8	86.7	0.7	3.3	70.3	0.8	3.8	57.7	0.8	4.4	48.0	0.9	5.0	40.4	0.9	5.5
145	275.6	0.6	1.4	197.7	0.6	1.8	142.6	0.7	2.3	112.5	0.7	2.8	89.8	0.7	3.3	72.8	0.8	3.8	59.8	0.8	4.4	49.7	0.9	5.0	41.8	0.9	5.5
150	285.1	0.6	1.4	204.6	0.6	1.8	147.5	0.7	2.3	116.4	0.7	2.8	92.9	0.7	3.3	75.3	0.8	3.8	61.8	0.8	4.4	51.4	0.9	5.0	43.2	0.9	5.5

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second:
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 12 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 6.00 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	10.6	0.5	1.3	7.3	0.6	1.8	5.3	0.6	2.3	4.0	0.7	2.8	2.9	0.8	3.2													
10	21.1	0.5	1.3	14.7	0.6	1.8	10.9	0.6	2.3	8.4	0.7	2.8	6.6	0.7	3.2	5.3	0.8	3.8	4.2	0.8	4.3						
15	31.6	0.5	1.3	22.1	0.6	1.8	16.3	0.6	2.3	12.7	0.6	2.7	10.1	0.7	3.3	8.2	0.7	3.8	6.6	0.8	4.3	5.4	0.9	4.9	4.3	1.0	5.5
20	42.1	0.5	1.3	29.5	0.6	1.8	21.7	0.6	2.3	17.0	0.6	2.7	13.6	0.7	3.2	11.1	0.7	3.7	9.0	0.8	4.3	7.4	0.8	4.9	6.1	0.9	5.5
25	52.7	0.5	1.3	36.8	0.6	1.8	27.1	0.6	2.3	21.2	0.6	2.8	17.0	0.7	3.2	13.9	0.7	3.8	11.3	0.8	4.3	9.3	0.8	4.9	7.8	0.9	5.5
30	63.2	0.5	1.3	44.2	0.6	1.8	32.5	0.6	2.3	25.4	0.6	2.8	20.4	0.7	3.2	16.6	0.7	3.8	13.7	0.8	4.3	11.3	0.8	4.9	9.4	0.9	5.5
35	73.7	0.5	1.3	51.6	0.6	1.8	38.0	0.6	2.3	29.7	0.6	2.8	23.8	0.7	3.2	19.4	0.7	3.8	16.0	0.8	4.3	13.4	0.8	4.9	11.1	0.9	5.5
40	84.2	0.5	1.3	58.9	0.6	1.8	43.4	0.6	2.3	33.9	0.6	2.8	27.2	0.7	3.3	22.2	0.7	3.8	18.3	0.8	4.3	15.3	0.8	4.9	12.7	0.9	5.5
45	94.8	0.5	1.3	66.3	0.6	1.8	48.8	0.6	2.3	38.2	0.6	2.8	30.7	0.7	3.3	24.9	0.7	3.8	20.6	0.8	4.3	17.2	0.8	4.9	14.5	0.9	5.4
50	105.3	0.5	1.3	73.6	0.6	1.8	54.2	0.6	2.3	42.4	0.6	2.8	34.1	0.7	3.3	27.7	0.7	3.8	22.8	0.8	4.3	19.1	0.8	4.9	16.1	0.9	5.4
55	115.8	0.5	1.3	81.0	0.6	1.8	59.7	0.6	2.3	46.6	0.6	2.8	37.5	0.7	3.3	30.5	0.7	3.8	25.1	0.8	4.3	21.0	0.8	4.9	17.7	0.9	5.4
60	126.4	0.5	1.3	88.4	0.6	1.8	65.1	0.6	2.3	50.9	0.6	2.8	40.9	0.7	3.3	33.3	0.7	3.8	27.4	0.8	4.3	22.9	0.8	4.9	19.3	0.9	5.4
65	136.9	0.5	1.3	95.7	0.6	1.8	70.5	0.6	2.3	55.1	0.6	2.8	44.3	0.7	3.3	36.0	0.7	3.8	29.7	0.8	4.3	24.8	0.8	4.9	20.9	0.9	5.4
70	147.4	0.5	1.3	103.1	0.6	1.8	75.9	0.6	2.3	59.3	0.6	2.8	47.7	0.7	3.3	38.8	0.7	3.8	32.0	0.8	4.3	26.7	0.8	4.9	22.5	0.9	5.4
75	158.0	0.5	1.3	110.5	0.6	1.8	81.3	0.6	2.3	63.6	0.6	2.8	51.1	0.7	3.3	41.6	0.7	3.8	34.3	0.8	4.3	28.6	0.8	4.9	24.1	0.9	5.4
80	168.5	0.5	1.3	117.8	0.6	1.8	86.8	0.6	2.3	67.8	0.6	2.8	54.5	0.7	3.3	44.3	0.7	3.8	36.5	0.8	4.3	30.5	0.8	4.9	25.7	0.9	5.5
85	179.0	0.5	1.3	125.2	0.6	1.8	92.2	0.6	2.3	72.0	0.6	2.8	57.9	0.7	3.3	47.1	0.7	3.8	38.8	0.8	4.3	32.4	0.8	4.9	27.3	0.9	5.5
90	189.6	0.5	1.3	132.6	0.6	1.8	97.6	0.6	2.3	76.3	0.6	2.8	61.3	0.7	3.3	49.9	0.7	3.8	41.1	0.8	4.3	34.3	0.8	4.9	28.9	0.9	5.5
95	200.1	0.5	1.3	139.9	0.6	1.8	103.0	0.6	2.3	80.5	0.6	2.8	64.7	0.7	3.3	52.6	0.7	3.8	43.4	0.8	4.3	36.2	0.8	4.9	30.5	0.9	5.5
100	210.6	0.5	1.3	147.3	0.6	1.8	108.5	0.6	2.3	84.8	0.6	2.8	68.1	0.7	3.3	55.4	0.7	3.8	45.7	0.8	4.3	38.1	0.8	4.9	32.1	0.9	5.5
105	221.1	0.5	1.3	154.6	0.6	1.8	113.9	0.6	2.3	89.0	0.6	2.8	71.5	0.7	3.3	58.2	0.7	3.8	47.9	0.8	4.3	40.0	0.8	4.9	33.7	0.9	5.5
110	231.7	0.5	1.3	162.0	0.6	1.8	119.3	0.6	2.3	93.2	0.6	2.8	74.9	0.7	3.3	60.9	0.7	3.8	50.2	0.8	4.3	41.9	0.8	4.9	35.3	0.9	5.5
115	242.2	0.5	1.3	169.4	0.6	1.8	124.7	0.6	2.3	97.5	0.6	2.8	78.3	0.7	3.3	63.7	0.7	3.8	52.5	0.8	4.3	43.8	0.8	4.9	36.9	0.9	5.5
120	252.7	0.5	1.3	176.7	0.6	1.8	130.2	0.6	2.3	101.7	0.6	2.8	81.7	0.7	3.3	66.5	0.7	3.8	54.8	0.8	4.3	45.7	0.8	4.9	38.5	0.9	5.5
125	263.3	0.5	1.3	184.1	0.6	1.8	135.6	0.6	2.3	106.0	0.6	2.8	85.1	0.7	3.3	69.3	0.7	3.8	57.1	0.8	4.3	47.6	0.8	4.9	40.1	0.9	5.5
130	273.8	0.5	1.3	191.5	0.6	1.8	141.0	0.6	2.3	110.2	0.6	2.8	88.5	0.7	3.3	72.0	0.7	3.8	59.4	0.8	4.3	49.5	0.8	4.9	41.7	0.9	5.5
135	284.3	0.5	1.3	198.8	0.6	1.8	146.4	0.6	2.3	114.4	0.6	2.8	91.9	0.7	3.3	74.8	0.7	3.8	61.6	0.8	4.3	51.4	0.8	4.9	43.3	0.9	5.5
140	294.9	0.5	1.3	206.2	0.6	1.8	151.8	0.6	2.3	118.7	0.6	2.8	95.3	0.7	3.3	77.6	0.7	3.8	63.9	0.8	4.3	53.3	0.8	4.9	44.9	0.9	5.5
145	305.4	0.5	1.3	213.6	0.6	1.8	157.3	0.6	2.3	122.9	0.6	2.8	98.7	0.7	3.3	80.3	0.7	3.8	66.2	0.8	4.3	55.2	0.8	4.9	46.5	0.9	5.5
150	315.9	0.5	1.3	220.9	0.6	1.8	162.7	0.6	2.3	127.1	0.6	2.8	102.1	0.7	3.3	83.1	0.7	3.8	68.5	0.8	4.3	57.1	0.8	4.9	48.1	0.9	5.5

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second:
Depth "D" does not include allowance for freeboard or settlement.

Table GS-4 Parabolic Grass Swale Design Sheet 13 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D), AND V2 FOR RETARDANCE "C"

Grade 8.00 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	12.0	0.5	1.3	8.5	0.5	1.7	6.2	0.5	2.2	4.6	0.6	2.7	3.7	0.6	3.2	2.9	0.7	3.6									
10	24.1	0.5	1.3	16.9	0.5	1.7	12.6	0.5	2.2	9.6	0.6	2.7	7.8	0.6	3.2	6.3	0.6	3.7	5.1	0.7	4.2	4.2	0.8	4.8	3.2	0.9	5.3
15	36.1	0.5	1.3	25.3	0.5	1.7	18.9	0.5	2.2	14.4	0.6	2.7	11.8	0.6	3.2	9.7	0.6	3.7	7.9	0.7	4.2	6.5	0.7	4.8	5.4	0.8	5.3
20	48.1	0.5	1.3	33.8	0.5	1.7	25.2	0.5	2.2	19.2	0.6	2.7	15.8	0.6	3.2	12.9	0.6	3.7	10.7	0.7	4.2	8.8	0.7	4.8	7.4	0.8	5.3
25	60.1	0.5	1.3	42.2	0.5	1.7	31.5	0.5	2.2	24.0	0.6	2.7	19.7	0.6	3.2	16.2	0.6	3.7	13.4	0.7	4.2	11.2	0.7	4.7	9.3	0.8	5.3
30	72.1	0.5	1.3	50.6	0.5	1.7	37.8	0.5	2.2	28.8	0.6	2.7	23.6	0.6	3.2	19.4	0.6	3.7	16.1	0.7	4.2	13.5	0.7	4.8	11.3	0.7	5.3
35	84.1	0.5	1.3	59.1	0.5	1.7	44.1	0.5	2.2	33.6	0.6	2.7	27.6	0.6	3.2	22.6	0.6	3.7	18.7	0.7	4.2	15.7	0.7	4.8	13.3	0.7	5.3
40	96.2	0.5	1.3	67.5	0.5	1.7	50.4	0.5	2.2	38.4	0.6	2.7	31.5	0.6	3.2	25.8	0.6	3.7	21.4	0.7	4.2	17.9	0.7	4.8	15.2	0.7	5.3
45	108.2	0.5	1.3	76.0	0.5	1.7	56.7	0.5	2.2	43.2	0.6	2.7	35.4	0.6	3.2	29.0	0.6	3.7	24.1	0.7	4.2	20.2	0.7	4.8	17.1	0.7	5.3
50	120.2	0.5	1.3	84.4	0.5	1.7	63.0	0.5	2.2	48.0	0.6	2.7	39.4	0.6	3.2	32.3	0.6	3.7	26.8	0.7	4.2	22.4	0.7	4.8	19.0	0.7	5.3
55	132.2	0.5	1.3	92.8	0.5	1.7	69.3	0.5	2.2	52.8	0.6	2.7	43.3	0.6	3.2	35.5	0.6	3.7	29.4	0.7	4.2	24.7	0.7	4.8	20.9	0.7	5.3
60	144.2	0.5	1.3	101.3	0.5	1.7	75.6	0.5	2.2	57.6	0.6	2.7	47.2	0.6	3.2	38.7	0.6	3.7	32.1	0.7	4.2	26.9	0.7	4.8	22.8	0.7	5.3
65	156.3	0.5	1.3	109.7	0.5	1.7	81.8	0.5	2.2	62.4	0.6	2.7	51.2	0.6	3.2	41.9	0.6	3.7	34.8	0.7	4.2	29.1	0.7	4.8	24.7	0.7	5.3
70	168.3	0.5	1.3	118.2	0.5	1.7	88.1	0.5	2.2	67.2	0.6	2.7	55.1	0.6	3.2	45.2	0.6	3.7	37.5	0.7	4.2	31.4	0.7	4.8	26.6	0.7	5.3
75	180.3	0.5	1.3	126.6	0.5	1.7	94.4	0.5	2.2	72.0	0.6	2.7	59.0	0.6	3.2	48.4	0.6	3.7	40.1	0.7	4.2	33.6	0.7	4.8	28.5	0.7	5.3
80	192.3	0.5	1.3	135.0	0.5	1.7	100.7	0.5	2.2	76.8	0.6	2.7	63.0	0.6	3.2	51.6	0.6	3.7	42.8	0.7	4.2	35.9	0.7	4.8	30.3	0.7	5.3
85	204.3	0.5	1.3	143.5	0.5	1.7	107.0	0.5	2.2	81.6	0.6	2.7	66.9	0.6	3.2	54.9	0.6	3.7	45.5	0.7	4.2	38.1	0.7	4.8	32.2	0.7	5.3
90	216.4	0.5	1.3	151.9	0.5	1.7	113.3	0.5	2.2	86.4	0.6	2.7	70.8	0.6	3.2	58.1	0.6	3.7	48.1	0.7	4.2	40.3	0.7	4.8	34.1	0.7	5.3
95	228.4	0.5	1.3	160.3	0.5	1.7	119.6	0.5	2.2	91.2	0.6	2.7	74.8	0.6	3.2	61.3	0.6	3.7	50.8	0.7	4.2	42.6	0.7	4.8	36.0	0.7	5.3
100	240.4	0.5	1.3	168.8	0.5	1.7	125.9	0.5	2.2	96.0	0.6	2.7	78.7	0.6	3.2	64.5	0.6	3.7	53.5	0.7	4.2	44.8	0.7	4.8	37.9	0.7	5.3
105	252.4	0.5	1.3	177.2	0.5	1.7	132.2	0.5	2.2	100.8	0.6	2.7	82.6	0.6	3.2	67.8	0.6	3.7	56.2	0.7	4.2	47.1	0.7	4.8	39.8	0.7	5.3
110	264.4	0.5	1.3	185.7	0.5	1.7	138.5	0.5	2.2	105.6	0.6	2.7	86.6	0.6	3.2	71.0	0.6	3.7	58.8	0.7	4.2	49.3	0.7	4.8	41.7	0.7	5.3
115	276.5	0.5	1.3	194.1	0.5	1.7	144.8	0.5	2.2	110.4	0.6	2.7	90.5	0.6	3.2	74.2	0.6	3.7	61.5	0.7	4.2	51.5	0.7	4.8	43.6	0.7	5.3
120	288.5	0.5	1.3	202.5	0.5	1.7	151.1	0.5	2.2	115.2	0.6	2.7	94.4	0.6	3.2	77.4	0.6	3.7	64.2	0.7	4.2	53.8	0.7	4.8	45.5	0.7	5.3
125	300.5	0.5	1.3	211.0	0.5	1.7	157.4	0.5	2.2	120.0	0.6	2.7	98.4	0.6	3.2	80.7	0.6	3.7	66.9	0.7	4.2	56.0	0.7	4.8	47.4	0.7	5.3
130	312.5	0.5	1.3	219.4	0.5	1.7	163.7	0.5	2.2	124.8	0.6	2.7	102.3	0.6	3.2	83.9	0.6	3.7	69.5	0.7	4.2	58.3	0.7	4.8	49.3	0.7	5.3
135	324.5	0.5	1.3	227.9	0.5	1.7	170.0	0.5	2.2	129.6	0.6	2.7	106.2	0.6	3.2	87.1	0.6	3.7	72.2	0.7	4.2	60.5	0.7	4.8	51.2	0.7	5.3
140	336.6	0.5	1.3	236.3	0.5	1.7	176.3	0.5	2.2	134.4	0.6	2.7	110.2	0.6	3.2	90.3	0.6	3.7	74.9	0.7	4.2	62.7	0.7	4.8	53.1	0.7	5.3
145	348.6	0.5	1.3	244.7	0.5	1.7	182.6	0.5	2.2	139.2	0.6	2.7	114.1	0.6	3.2	93.6	0.6	3.7	77.6	0.7	4.2	65.0	0.7	4.8	55.0	0.7	5.3
150	360.6	0.5	1.3	253.2	0.5	1.7	188.9	0.5	2.2	144.0	0.6	2.7	118.0	0.6	3.2	96.8	0.6	3.7	80.2	0.7	4.2	67.2	0.7	4.8	56.9	0.7	5.3

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second
Depth "D" does not include allowance for freeboard or settlement

Table GS-4 Parabolic Grass Swale Design Sheet 14 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "C"

Grade 10.00 Percent

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	13.3	0.4	1.3	9.4	0.5	1.7	6.8	0.5	2.2	5.3	0.5	2.6	4.1	0.6	3.2	3.4	0.6	3.6	2.6	0.7	4.1						
10	26.6	0.4	1.3	18.7	0.5	1.7	13.8	0.5	2.2	10.9	0.5	2.6	8.5	0.6	3.2	7.1	0.6	3.6	5.9	0.6	4.1	4.9	0.7	4.7	4.0	0.7	5.3
15	39.9	0.4	1.3	28.0	0.5	1.7	20.7	0.5	2.2	16.3	0.5	2.6	12.8	0.6	3.2	10.9	0.6	3.6	9.0	0.6	4.1	7.5	0.6	4.7	6.3	0.7	5.2
20	53.2	0.4	1.3	37.4	0.5	1.7	27.6	0.5	2.2	21.7	0.5	2.7	17.0	0.6	3.2	14.5	0.6	3.6	12.1	0.6	4.1	10.2	0.6	4.6	8.5	0.7	5.2
25	66.5	0.4	1.3	46.7	0.5	1.7	34.5	0.5	2.2	27.1	0.5	2.7	21.3	0.6	3.2	18.1	0.6	3.6	15.1	0.6	4.1	12.7	0.6	4.7	10.8	0.7	5.2
30	79.8	0.4	1.3	56.1	0.5	1.7	41.4	0.5	2.2	32.5	0.5	2.7	25.5	0.6	3.2	21.7	0.6	3.6	18.1	0.6	4.1	15.2	0.6	4.7	12.9	0.7	5.2
35	93.1	0.4	1.3	65.4	0.5	1.7	48.3	0.5	2.2	37.9	0.5	2.7	29.8	0.6	3.2	25.3	0.6	3.6	21.1	0.6	4.1	17.8	0.6	4.7	15.1	0.7	5.2
40	106.4	0.4	1.3	74.7	0.5	1.7	55.2	0.5	2.2	43.3	0.5	2.7	34.0	0.6	3.2	29.0	0.6	3.6	24.1	0.6	4.1	20.3	0.6	4.7	17.2	0.7	5.2
45	119.7	0.4	1.3	84.1	0.5	1.7	62.1	0.5	2.2	48.8	0.5	2.7	38.3	0.6	3.2	32.6	0.6	3.6	27.2	0.6	4.1	22.8	0.6	4.7	19.4	0.7	5.2
50	133.0	0.4	1.3	93.4	0.5	1.7	69.0	0.5	2.2	54.2	0.5	2.7	42.5	0.6	3.2	36.2	0.6	3.6	30.2	0.6	4.1	25.4	0.6	4.7	21.5	0.7	5.2
55	146.3	0.4	1.3	102.8	0.5	1.7	75.9	0.5	2.2	59.6	0.5	2.7	46.8	0.6	3.2	39.8	0.6	3.6	33.2	0.6	4.1	27.9	0.6	4.7	23.7	0.7	5.2
60	159.6	0.4	1.3	112.1	0.5	1.7	82.8	0.5	2.2	65.0	0.5	2.7	51.0	0.6	3.2	43.4	0.6	3.6	36.2	0.6	4.1	30.5	0.6	4.7	25.9	0.7	5.2
65	172.9	0.4	1.3	121.4	0.5	1.7	89.7	0.5	2.2	70.4	0.5	2.7	55.3	0.6	3.2	47.1	0.6	3.6	39.2	0.6	4.1	33.0	0.6	4.7	28.0	0.7	5.2
70	186.2	0.4	1.3	130.8	0.5	1.7	96.6	0.5	2.2	75.8	0.5	2.7	59.5	0.6	3.2	50.7	0.6	3.6	42.2	0.6	4.1	35.5	0.6	4.7	30.2	0.7	5.2
75	199.5	0.4	1.3	140.1	0.5	1.7	103.5	0.5	2.2	81.2	0.5	2.7	63.8	0.6	3.2	54.3	0.6	3.6	45.2	0.6	4.1	38.1	0.6	4.7	32.3	0.7	5.2
80	212.8	0.4	1.3	149.5	0.5	1.7	110.5	0.5	2.2	86.7	0.5	2.7	68.0	0.6	3.2	57.9	0.6	3.6	48.3	0.6	4.1	40.6	0.6	4.7	34.5	0.7	5.2
85	226.1	0.4	1.3	158.8	0.5	1.7	117.4	0.5	2.2	92.1	0.5	2.7	72.3	0.6	3.2	61.5	0.6	3.6	51.3	0.6	4.1	43.1	0.6	4.7	36.6	0.7	5.2
90	239.4	0.4	1.3	168.1	0.5	1.7	124.3	0.5	2.2	97.5	0.5	2.7	76.5	0.6	3.2	65.2	0.6	3.6	54.3	0.6	4.1	45.7	0.6	4.7	38.8	0.7	5.2
95	252.7	0.4	1.3	177.5	0.5	1.7	131.2	0.5	2.2	102.9	0.5	2.7	80.8	0.6	3.2	68.8	0.6	3.6	57.3	0.6	4.1	48.2	0.6	4.7	40.9	0.7	5.2
100	266.0	0.4	1.3	186.8	0.5	1.7	138.1	0.5	2.2	108.3	0.5	2.7	85.0	0.6	3.2	72.4	0.6	3.6	60.3	0.6	4.1	50.7	0.6	4.7	43.1	0.7	5.2
105	279.3	0.4	1.3	196.2	0.5	1.7	145.0	0.5	2.2	113.7	0.5	2.7	89.3	0.6	3.2	76.0	0.6	3.6	63.3	0.6	4.1	53.3	0.6	4.7	45.2	0.7	5.2
110	292.6	0.4	1.3	205.5	0.5	1.7	151.9	0.5	2.2	119.2	0.5	2.7	93.5	0.6	3.2	79.6	0.6	3.6	66.4	0.6	4.1	55.8	0.6	4.7	47.4	0.7	5.2
115	305.9	0.4	1.3	214.9	0.5	1.7	158.8	0.5	2.2	124.6	0.5	2.7	97.8	0.6	3.2	83.3	0.6	3.6	69.4	0.6	4.1	58.3	0.6	4.7	49.5	0.7	5.3
120	319.2	0.4	1.3	224.2	0.5	1.7	165.7	0.5	2.2	130.0	0.5	2.7	102.0	0.6	3.2	86.9	0.6	3.6	72.4	0.6	4.1	60.9	0.6	4.7	51.7	0.7	5.3
125	332.5	0.4	1.3	233.5	0.5	1.7	172.6	0.5	2.2	135.4	0.5	2.7	106.3	0.6	3.2	90.5	0.6	3.6	75.4	0.6	4.1	63.4	0.6	4.7	53.8	0.7	5.3
130	345.8	0.4	1.3	242.9	0.5	1.7	179.5	0.5	2.2	140.8	0.5	2.7	110.5	0.6	3.2	94.1	0.6	3.6	78.4	0.6	4.1	66.0	0.6	4.7	56.0	0.7	5.3
135	359.1	0.4	1.3	252.2	0.5	1.7	186.4	0.5	2.2	146.2	0.5	2.7	114.8	0.6	3.2	97.7	0.6	3.6	81.4	0.6	4.1	68.5	0.6	4.7	58.1	0.7	5.3
140	372.4	0.4	1.3	261.6	0.5	1.7	193.3	0.5	2.2	151.7	0.5	2.7	119.0	0.6	3.2	101.3	0.6	3.6	84.4	0.6	4.1	71.0	0.6	4.7	60.3	0.7	5.3
145	385.7	0.4	1.3	270.9	0.5	1.7	200.2	0.5	2.2	157.1	0.5	2.7	123.3	0.6	3.2	105.0	0.6	3.6	87.5	0.6	4.1	73.6	0.6	4.7	62.5	0.7	5.3
150	399.0	0.4	1.3	280.2	0.5	1.7	207.1	0.5	2.2	162.5	0.5	2.7	127.5	0.6	3.2	108.6	0.6	3.6	90.5	0.6	4.1	76.1	0.6	4.7	64.6	0.7	5.3

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second; Depth "D" does not include allowance for freeboard or settlement.

Construction

Prior to start of construction, grass swale channels should be designed by a qualified design professional. Plans and specifications should be referred to by field personnel throughout the construction process to ensure that the channel has planned alignment, grade, and cross section.

Scheduling

Schedule construction during a period of relatively low rainfall and runoff events if practical. Consider also the establishment period (planting dates) for the planned species that will be used for long-term vegetative cover.

Site Preparation

Determine exact location of underground utilities. (See Appendix C: MS One-Call and 811 Color Coding.)

Install any structures required to stabilize the swale outlet or to provide drainage along the swale prior to beginning installation of the swale. Refer to design for structures to be installed.

Remove brush, trees, and other debris from the construction area and dispose of properly.

Constructing

Excavate and shape the channel to dimensions shown in the design specifications, removing and properly disposing of excess soil so surface water can enter the channel freely. The typical features of a grass swale are shown in Figure GS-2 and listed below, but may be different in the design for a specific site.

Cross Section: trapezoidal or parabolic.

Side Slopes: 3:1 (Horizontal: Vertical) or flatter for trapezoidal channels.

Outlet: Channel should empty into a stable outlet, sediment traps, or detention/retention basins.

Subsurface Drain: Use in areas with seasonally high water tables or seepage problems.

Topsoil: Provide topsoil as needed to grow grass on areas disturbed by construction.

Protect all concentrated inflow points along the channel with erosion-resistant linings, such as riprap, sod, mulch, erosion control blankets, turf-reinforcement mats or other appropriate practices as specified in the design plan.

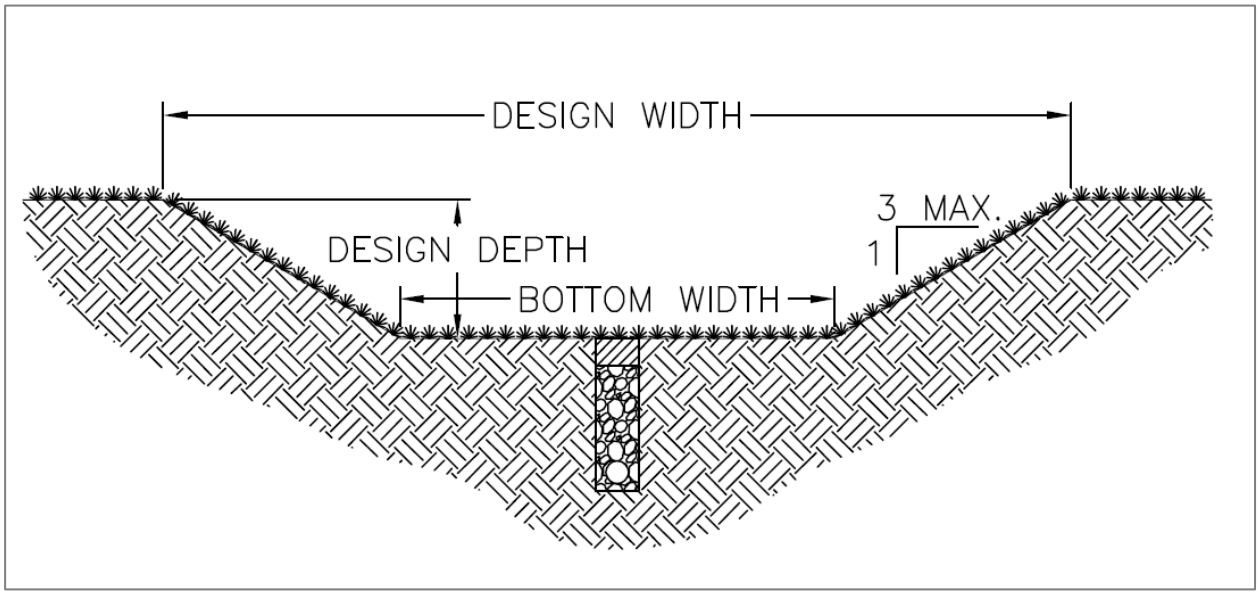


Figure GS-2 Typical Trapezoidal Grass-Lined Channel

Construction Verification

Check finished grade and cross section of channel throughout the length of the watercourse. Verify channel cross sections at several locations to avoid constrictions to flow.

Vegetating

Prepare seedbed; apply lime, fertilizer, and seed or sod in the swale immediately after grading; and protect with erosion control blankets, turf-reinforcement mats, or mulch according to the design plan. If not specified in a plan, select lime, fertilizer, grass variety and mulching components from related practices (*Permanent Seeding* or *Temporary Seeding*, *Erosion Control Blanket* or *Sodding*).

Common Problems

Consult with a qualified design professional if any of the following occur:

Variations in topography on site indicate practice will not function as intended.

Changes in plan may be needed.

Design specifications for seed variety, seeding dates or erosion control materials cannot be met; substitution may be required.

Erosion occurs in channel before vegetation is fully established.

Erosion occurs at channel outlet before vegetation is fully established.

Sediment is deposited at channel outlet before vegetation is fully established.

Maintenance

Inspect the channel following storm events both during and after grass cover is established; make needed repairs immediately.

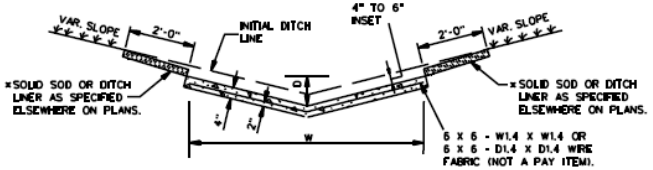
Check the channel outlet and road crossings for blockage, ponding, sediment, and bank instability, breaks and eroded areas; remove any blockage; and make repairs immediately to maintain design cross section and grade.

References

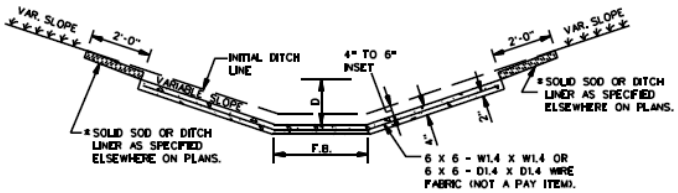
BMPs from Volume 1

Chapter 4

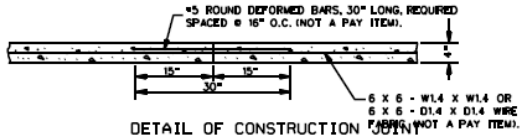
MDOT Drawing DT-1



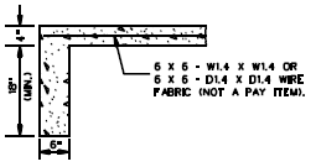
"V" TYPE SECTION



FLAT BOTTOM SECTION



DETAIL OF CONSTRUCTION JOINT



DETAIL OF TOE WALL

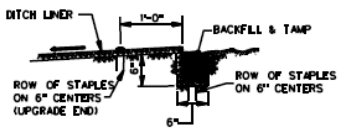
NOTE: TOE WALL REQUIRED UPSTREAM AND DOWNSTREAM.

CONCRETE PAVED DITCH

NOTES:

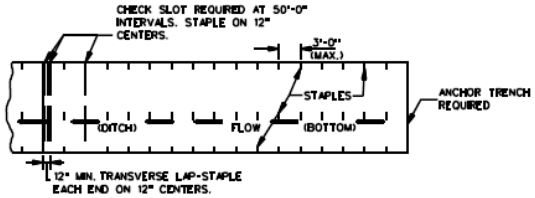
1. CONCRETE PAVED DITCHES SHALL BE GROOVED AT 20'-0" INTERVALS. THE GROOVES SHALL BE CUT TO A DEPTH OF NOT LESS THAN 1".
2. DIMENSIONS D & W ARE AS FOLLOWS:
   D(MINIMUM) = 6"
   D(NOMINAL) = 9"
   W(MINIMUM) = 24"
3. CHAIR SUPPORTS FOR THE WIRE MESH WILL NOT BE REQUIRED. HOWEVER, THE CONTRACTOR SHALL PLACE THE WIRE MESH IN A SATISFACTORY AND WORKMANLIKE MANNER TO ENSURE THAT THE FINAL POSITION IS REASONABLY NEAR THE POSITION INDICATED.

* 4. CENTER ROW OF STAPLES MAY BE OMITTED ON DITCH LINER.

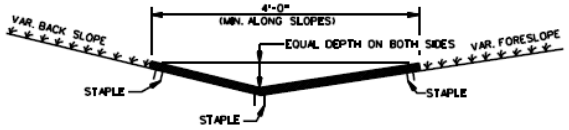


ANCHOR TRENCH DETAIL

NOTE: ANCHOR TRENCH REQUIRED AT THE BEGINNING AND ENDING OF EACH AREA TO BE COVERED, EXCEPT DOWNSTREAM END ADJOINING A STRUCTURE.



PLAN



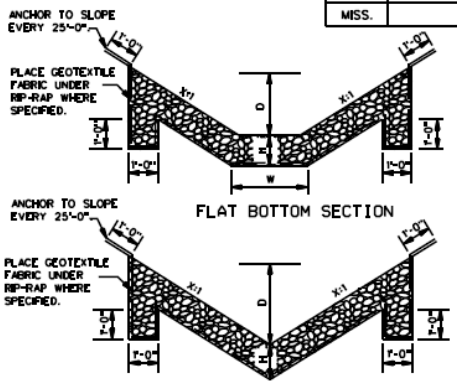
SECTION

DITCH LINER TREATMENT

(EXCELSIOR BLANKET, JUTE MESH OR EROSION CONTROL FABRIC)

NOTE: DITCHES TREATED WITH DITCH LINER WILL BE VEGETATED PRIOR TO TREATMENT, UNLESS OTHERWISE INDICATED.

STATE	PROJECT NO.
MISS.	



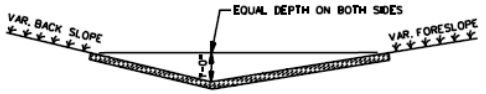
FLAT BOTTOM SECTION

"V" TYPE SECTION
RIP-RAP TREATMENT

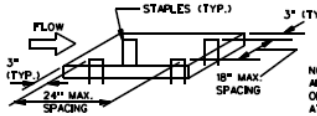
NOTES:

1. DIMENSIONS D, W AND X ARE VARIABLE AND ARE SHOWN ELSEWHERE ON THE PLANS.
2. THE RIP-RAP SIZE AND MINIMUM DEPTH "H" FOR RIP-RAP TREATMENT ARE AS FOLLOWS.

RIP-RAP SIZE & MINIMUM DEPTH "H"	
H (in)	RIP-RAP SIZE (lbs)
12"	100
18"	300



SOLID SOD TREATMENT



NOTE: SOLID SOD (STRIPS OR BLOCKS) ARE TO BE STAPLED, PINNED, PEGGED OR STAKED AT THE FOUR CORNERS OR AT THE MAXIMUM SPECIFIED SPACING.

GENERAL NOTE:

1. FOR LOCATION OF APPROPRIATE DITCH TREATMENTS, SEE PLAN SHEETS AS DENOTED BY THE FOLLOWING LEGEND OR AS DIRECTED BY THE ENGINEER:

DITCH LINER
SOLID SOD
CONCRETE PAVED DITCH
RIP-RAP

MISSISSIPPI DEPARTMENT OF TRANSPORTATION

DETAILS OF TYPICAL DITCH TREATMENTS

BY	REVISION	DATE

WORKING NUMBER: DT-1

SHEET NUMBER

FILENAME: EROSION CONTROL\DT-1.DGN

DESIGN TEAM: CHECKED: DATE: