Grassed Waterway Design Charts
for
Drainage Areas from 0 to 30 Acres

A large number of waterways are constructed throughout Iowa which have drainage areas ranging from 0 to 30 acres. The charts with this amendment provide a standard design for these size waterways. The charts are only applicable if a parabolic waterway cross section is selected.

These charts should not be used if any of the following conditions exist:

1. The drainage area and/or slope exceeds the limits of the chart.
2. The chart shows "na" for the specific condition.
3. There are complex geologic, hydrologic, or topographic features at the site.

For these cases, site specific designs should be completed. A more detailed design procedure may be used in any situation when a site specific design is desired.

Following are some assumptions that went into the development of the charts:

1. The hydrology used for design was based on:
    a. A typical watershed shape was used where the watershed length was equal to 1.5 times the width.
    b. A typical watershed slope was selected for each drainage area and waterway slope.
    c. Runoff curve numbers were based on contoured row crops with a RCN = 75 for hydrologic soil group "B" and a RCN = 82 for hydrologic soil group "C".
    d. The state was divided into two regions based on rainfall. Counties with 10yr.-24hr. rainfalls of 4.2 to 4.5 inches were placed in the North Region and counties with rainfalls of 4.6 to 4.9 inches were placed in the South Region.
2. The vegetative factor used was 0.87. This is valid for brome grass and brome grass mixtures.
3. Designs for grassed waterways with drainage areas from 0 to 10 acres were based on B-C retardance values for capacity and stability design respectively. Designs for waterways with drainage areas from 11 to 30 acres were based on B-D retardance values for capacity and stability design respectively.
4. The minimum waterway depth used is 1.0 ft.
5. Minimum top widths varied depending on the side slope (z) ratio. For a "z" value of 6, the minimum top width is 30 ft. For a "z" value of 8, the minimum top width is 32 ft.

Waterway designs using the charts may be completed by utilizing the following procedure:

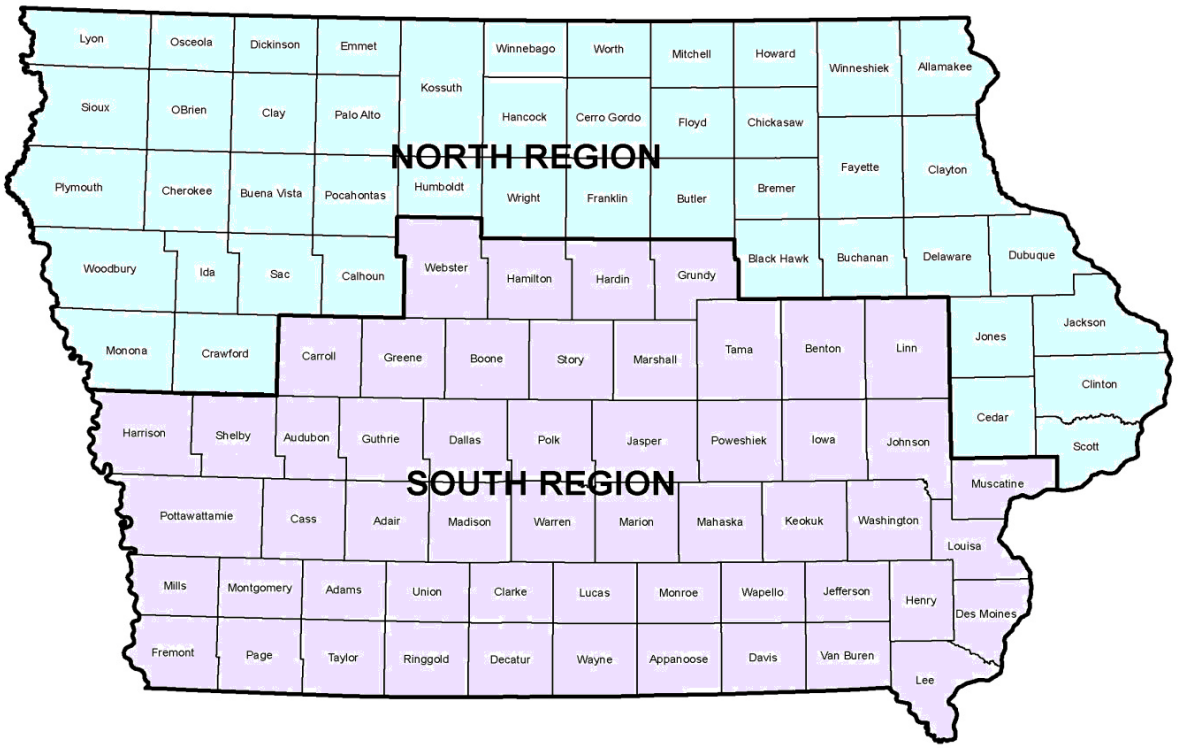
1. Determine if the county where the waterway is located is in the North or South Region of the state from Exhibit IA7-2.
2. Determine if the maximum side slope "z" at the outer edges of the waterway will be 6:1 or 8:1.
3. Determine the drainage area of the waterway.
4. Determine the slope of the waterway.
5. Determine if the average runoff curve number of the drainage area is approximately 75 or 82.
6. Using the type of soil in the planned waterway, determine the soil erodibility category from Exhibit IA7-1.
7. Using the information from steps 1 through 6, enter the appropriate design chart in Exhibit IA7-3 and select the waterway dimensions.

Waterway dimensions taken from the design charts may be used with standard drawings, job sheets, etc. to meet minimum documentation requirements as shown in the Field Office Technical Guide Statement of Work for Grassed Waterways.

Note: The Design Tables for Parabolic Channels presented in Appendix D of this chapter are based on a side slope ratio of 1:1 at the outer edges of the waterway. These tables may be used for design; however, the designer should be aware that the cross section will generally not be crossable with any type of farm equipment.

Grassed Waterway Design

Rainfall Regions Map



GRASSED WATERWAY DESIGN CHARTS									
South Region RCN = 75 z=6									
DA	WW Slope	Allowable Stress							
Acres	Per Cent	Easily Eroded		Erodible		Erosion Resistant		Very Erosion	
		Top Width	Depth	Top Width	Depth	Top Width	Depth	Top Width	Depth
Design Based on B - C Retardance									
0-6	0-1	34	1.4	34	1.4	34	1.4	34	1.4
	2	30	1.2	30	1.2	30	1.2	30	1.2
*	3	30	1.1	30	1.1	30	1.1	30	1.1
*	4	30	1.0	30	1.0	30	1.0	30	1.0
*	6	30	1.0	30	1.0	30	1.0	30	1.0
*	8	30	1.0	30	1.0	30	1.0	30	1.0
*	10	30	1.0	30	1.0	30	1.0	30	1.0
*	12	30	1.0	30	1.0	30	1.0	30	1.0
7-10	0-1	34	1.4	34	1.4	34	1.4	34	1.4
	2	30	1.2	30	1.2	30	1.2	30	1.2
	3	30	1.1	30	1.1	30	1.1	30	1.1
	4	30	1.0	30	1.0	30	1.0	30	1.0
	6	30	1.0	30	1.0	30	1.0	30	1.0
	8	30	1.0	30	1.0	30	1.0	30	1.0
	10	34	1.0	30	1.0	30	1.0	30	1.0
	12	36	1.0	30	1.0	30	1.0	30	1.0
Design Based on B - D Retardance									
11-20	0-1	38	1.5	38	1.5	38	1.5	38	1.5
	2	32	1.3	32	1.3	32	1.3	32	1.3
	3	42	1.2	30	1.2	30	1.2	30	1.2
	4	50	1.0	34	1.1	30	1.2	30	1.2
	6	70	1.0	48	1.0	30	1.0	30	1.1
	8	na	na	58	1.0	36	1.0	30	1.0
	10	na	na	68	1.0	42	1.0	40	1.0
21-30	0-1	40	1.6	40	1.6	40	1.6	40	1.6
	2	36	1.4	34	1.4	34	1.4	34	1.4
	3	48	1.2	32	1.3	32	1.3	32	1.3
	4	70	1.0	46	1.1	30	1.2	30	1.2
	6	na	na	62	1.0	38	1.0	30	1.1
	8	na	na	80	1.0	50	1.0	36	1.0

* The dimensions for waterways in this line may be changed to T=20 ft. and d=0.75 ft. if the criteria for Special Treatment Areas in the 412 Standard is met.

GRASSED WATERWAY DESIGN CHARTS									
South Region RCN = 82 z=6									
DA	WW Slope	Allowable Stress							
Acres	Per Cent	Easily Eroded		Erodible		Erosion Resistant		Very Erosion	
		Top Width	Depth	Top Width	Depth	Top Width	Depth	Top Width	Depth
Design Based on B - C Retardance									
0-6	0-1	34	1.4	34	1.4	34	1.4	34	1.4
	2	30	1.2	30	1.2	30	1.2	30	1.2
*	3	30	1.1	30	1.1	30	1.1	30	1.1
*	4	30	1.0	30	1.0	30	1.0	30	1.0
*	6	30	1.0	30	1.0	30	1.0	30	1.0
*	8	30	1.0	30	1.0	30	1.0	30	1.0
*	10	30	1.0	30	1.0	30	1.0	30	1.0
*	12	30	1.0	30	1.0	30	1.0	30	1.0
7-10	0-1	36	1.5	36	1.5	36	1.5	36	1.5
	2	32	1.3	32	1.3	32	1.3	32	1.3
	3	30	1.2	30	1.2	30	1.2	30	1.2
	4	30	1.1	30	1.1	30	1.1	30	1.1
	6	32	1.0	30	1.0	30	1.0	30	1.0
	8	40	1.0	30	1.0	30	1.0	30	1.0
	10	44	1.0	32	1.0	30	1.0	30	1.0
	12	50	1.0	36	1.0	36	1.0	30	1.0
Design Based on B - D Retardance									
11-20	0-1	40	1.6	40	1.6	40	1.6	40	1.6
	2	38	1.4	34	1.4	34	1.4	34	1.4
	3	54	1.2	36	1.3	32	1.3	32	1.3
	4	70	1.0	46	1.1	30	1.2	30	1.2
	6	na	na	62	1.0	38	1.0	30	1.1
	8	na	na	80	1.0	50	1.0	36	1.0
	10	na	na	na	na	58	1.0	56	1.0
21-30	0-1	42	1.7	42	1.7	42	1.7	42	1.7
	2	52	1.4	38	1.5	38	1.5	38	1.5
	3	72	1.2	48	1.3	34	1.4	34	1.4
	4	na	na	66	1.1	38	1.3	32	1.3
	6	na	na	na	na	54	1.0	38	1.1
	8	na	na	na	na	70	1.0	52	1.0

* The dimensions for waterways in this line may be changed to T=20 ft. and d=0.75 ft. if the criteria for Special Treatment Areas in the 412 Standard is met.

GRASSED WATERWAY DESIGN CHARTS									
North Region RCN = 75 z=6									
DA	WW Slope	Allowable Stress							
Acres	Per Cent	Easily Eroded		Erodible		Erosion Resistant		Very Erosion	
		Top Width	Depth	Top Width	Depth	Top Width	Depth	Top Width	Depth
Design Based on B - C Retardance									
0-6	0-1	34	1.4	34	1.4	34	1.4	34	1.4
	2	30	1.1	30	1.1	30	1.1	30	1.1
*	3	30	1.0	30	1.0	30	1.0	30	1.0
*	4	30	1.0	30	1.0	30	1.0	30	1.0
*	6	30	1.0	30	1.0	30	1.0	30	1.0
*	8	30	1.0	30	1.0	30	1.0	30	1.0
*	10	30	1.0	30	1.0	30	1.0	30	1.0
*	12	30	1.0	30	1.0	30	1.0	30	1.0
7-10	0-1	34	1.4	34	1.4	34	1.4	34	1.4
	2	30	1.2	30	1.2	30	1.2	30	1.2
	3	30	1.1	30	1.1	30	1.1	30	1.1
	4	30	1.0	30	1.0	30	1.0	30	1.0
	6	30	1.0	30	1.0	30	1.0	30	1.0
	8	30	1.0	30	1.0	30	1.0	30	1.0
	10	30	1.0	30	1.0	30	1.0	30	1.0
	12	32	1.0	30	1.0	30	1.0	30	1.0
Design Based on B - D Retardance									
11-20	0-1	36	1.5	36	1.5	36	1.5	36	1.5
	2	32	1.3	32	1.3	32	1.3	32	1.3
	3	36	1.2	30	1.2	30	1.2	30	1.2
	4	44	1.0	30	1.1	30	1.1	30	1.1
	6	62	1.0	42	1.0	30	1.0	30	1.0
	8	74	1.0	50	1.0	30	1.0	30	1.0
	10	na	na	58	1.0	36	1.0	36	1.0
21-30	0-1	40	1.6	40	1.6	40	1.6	40	1.6
	2	36	1.4	34	1.4	34	1.4	34	1.4
	3	48	1.2	32	1.3	32	1.3	32	1.3
	4	62	1.0	42	1.1	30	1.2	30	1.2
	6	na	na	56	1.0	34	1.0	30	1.1
	8	na	na	70	1.0	42	1.0	32	1.0

* The dimensions for waterways in this line may be changed to T=20 ft. and d=0.75 ft. if the criteria for Special Treatment Areas in the 412 Standard is met.

GRASSED WATERWAY DESIGN CHARTS									
North Region RCN = 82 z=6									
DA	WW Slope	Allowable Stress							
Acres	Per Cent	Easily Eroded		Erodible		Erosion Resistant		Very Erosion	
		Top Width	Depth	Top Width	Depth	Top Width	Depth	Top Width	Depth
Design Based on B - C Retardance									
0-6	0-1	34	1.4	34	1.4	34	1.4	34	1.4
	2	30	1.2	30	1.2	30	1.2	30	1.2
*	3	30	1.1	30	1.1	30	1.1	30	1.1
*	4	30	1.0	30	1.0	30	1.0	30	1.0
*	6	30	1.0	30	1.0	30	1.0	30	1.0
*	8	30	1.0	30	1.0	30	1.0	30	1.0
*	10	30	1.0	30	1.0	30	1.0	30	1.0
*	12	30	1.0	30	1.0	30	1.0	30	1.0
7-10	0-1	36	1.5	36	1.5	36	1.5	36	1.5
	2	30	1.3	30	1.3	30	1.3	30	1.3
	3	30	1.1	30	1.1	30	1.1	30	1.1
	4	30	1.1	30	1.1	30	1.1	30	1.1
	6	30	1.0	30	1.0	30	1.0	30	1.0
	8	36	1.0	30	1.0	30	1.0	30	1.0
	10	40	1.0	30	1.0	30	1.0	30	1.0
	12	44	1.0	32	1.0	32	1.0	30	1.0
Design Based on B - D Retardance									
11-20	0-1	38	1.6	38	1.6	38	1.6	38	1.6
	2	34	1.4	34	1.4	34	1.4	34	1.4
	3	48	1.2	32	1.3	32	1.3	32	1.3
	4	62	1.0	42	1.1	30	1.2	30	1.2
	6	na	na	58	1.0	36	1.0	30	1.1
	8	na	na	72	1.0	44	1.0	32	1.0
	10	na	na	na	na	50	1.0	50	1.0
21-30	0-1	42	1.8	42	1.8	42	1.8	42	1.8
	2	46	1.4	36	1.5	36	1.5	36	1.5
	3	66	1.2	44	1.3	34	1.4	34	1.4
	4	na	na	58	1.1	34	1.3	32	1.3
	6	na	na	78	1.0	48	1.0	34	1.2
	8	na	na	na	na	62	1.0	46	1.0

* The dimensions for waterways in this line may be changed to T=20 ft. and d=0.75 ft. if the criteria for Special Treatment Areas in the 412 Standard is met.

GRASSED WATERWAY DESIGN CHARTS									
South Region RCN = 75 z=8									
DA	WW Slope	Allowable Stress							
Acres	Per Cent	Easily Eroded		Erodible		Erosion Resistant		Very Erosion	
		Top Width	Depth	Top Width	Depth	Top Width	Depth	Top Width	Depth
Design Based on B - C Retardance									
0-6	0-1	44	1.4	44	1.4	44	1.4	44	1.4
	2	36	1.1	36	1.1	36	1.1	36	1.1
*	3	34	1.0	34	1.0	34	1.0	34	1.0
*	4	32	1.0	32	1.0	32	1.0	32	1.0
*	6	32	1.0	32	1.0	32	1.0	32	1.0
*	8	32	1.0	32	1.0	32	1.0	32	1.0
*	10	32	1.0	32	1.0	32	1.0	32	1.0
*	12	32	1.0	32	1.0	32	1.0	32	1.0
7-10	0-1	46	1.4	46	1.4	46	1.4	46	1.4
	2	38	1.2	38	1.2	38	1.2	38	1.2
	3	34	1.1	34	1.1	34	1.1	34	1.1
	4	32	1.0	32	1.0	32	1.0	32	1.0
	6	32	1.0	32	1.0	32	1.0	32	1.0
	8	32	1.0	32	1.0	32	1.0	32	1.0
	10	34	1.0	32	1.0	32	1.0	32	1.0
	12	36	1.0	32	1.0	32	1.0	32	1.0
Design Based on B - D Retardance									
11-20	0-1	48	1.5	48	1.5	48	1.5	48	1.5
	2	42	1.3	40	1.3	40	1.3	40	1.3
	3	42	1.2	38	1.2	38	1.2	38	1.2
	4	50	1.0	36	1.1	36	1.1	36	1.1
	6	70	1.0	48	1.0	32	1.0	32	1.0
	8	na	na	58	1.0	36	1.0	32	1.0
	10	na	na	68	1.0	42	1.0	40	1.0
21-30	0-1	50	1.5	50	1.5	50	1.5	50	1.5
	2	44	1.3	44	1.3	44	1.3	44	1.3
	3	48	1.2	40	1.2	40	1.2	40	1.2
	4	70	1.0	46	1.1	38	1.2	38	1.2
	6	na	na	62	1.0	38	1.0	34	1.1
	8	na	na	80	1.0	50	1.0	36	1.0

* The dimensions for waterways in this line may be changed to T=20 ft. and d=0.75 ft. if the criteria for Special Treatment Areas in the 412 Standard is met.

GRASSED WATERWAY DESIGN CHARTS									
South Region RCN = 82 z=8									
DA	WW Slope	Allowable Stress							
Acres	Per Cent	Easily Eroded		Erodible		Erosion Resistant		Very Erosion	
		Top Width	Depth	Top Width	Depth	Top Width	Depth	Top Width	Depth
Design Based on B - C Retardance									
0-6	0-1	44	1.4	44	1.4	44	1.4	44	1.4
	2	38	1.2	38	1.2	38	1.2	38	1.2
*	3	34	1.1	34	1.1	34	1.1	34	1.1
*	4	32	1.0	32	1.0	32	1.0	32	1.0
*	6	32	1.0	32	1.0	32	1.0	32	1.0
*	8	32	1.0	32	1.0	32	1.0	32	1.0
*	10	32	1.0	32	1.0	32	1.0	32	1.0
*	12	32	1.0	32	1.0	32	1.0	32	1.0
7-10	0-1	46	1.4	46	1.4	46	1.4	46	1.4
	2	40	1.2	40	1.2	40	1.2	40	1.2
	3	36	1.1	36	1.1	36	1.1	36	1.1
	4	34	1.0	34	1.0	34	1.0	34	1.0
	6	32	1.0	32	1.0	32	1.0	32	1.0
	8	40	1.0	32	1.0	32	1.0	32	1.0
	10	44	1.0	32	1.0	32	1.0	32	1.0
	12	50	1.0	36	1.0	36	1.0	32	1.0
Design Based on B - D Retardance									
11-20	0-1	50	1.6	50	1.6	50	1.6	50	1.6
	2	44	1.4	44	1.4	44	1.4	44	1.4
	3	54	1.2	40	1.2	40	1.2	40	1.2
	4	70	1.0	46	1.1	38	1.2	38	1.2
	6	na	na	62	1.0	38	1.0	34	1.1
	8	na	na	80	1.0	50	1.0	36	1.0
	10	na	na	na	na	58	1.0	56	1.0
21-30	0-1	52	1.6	52	1.6	52	1.6	52	1.6
	2	52	1.4	46	1.4	46	1.4	46	1.4
	3	72	1.2	48	1.3	42	1.3	42	1.3
	4	na	na	66	1.1	40	1.3	40	1.3
	6	na	na	na	na	54	1.0	38	1.1
	8	na	na	na	na	70	1.0	52	1.0

* The dimensions for waterways in this line may be changed to T=20 ft. and d=0.75 ft. if the criteria for Special Treatment Areas in the 412 Standard is met.

GRASSED WATERWAY DESIGN CHARTS									
North Region RCN = 75 z=8									
DA	WW Slope	Allowable Stress							
Acres	Per Cent	Easily Eroded		Erodible		Erosion Resistant		Very Erosion	
		Top Width	Depth	Top Width	Depth	Top Width	Depth	Top Width	Depth
Design Based on B - C Retardance									
0-6	0-1	42	1.3	42	1.3	42	1.3	42	1.3
	2	36	1.1	36	1.1	36	1.1	36	1.1
*	3	32	1.0	32	1.0	32	1.0	32	1.0
*	4	32	1.0	32	1.0	32	1.0	32	1.0
*	6	32	1.0	32	1.0	32	1.0	32	1.0
*	8	32	1.0	32	1.0	32	1.0	32	1.0
*	10	32	1.0	32	1.0	32	1.0	32	1.0
*	12	32	1.0	32	1.0	32	1.0	32	1.0
7-10	0-1	44	1.4	44	1.4	44	1.4	44	1.4
	2	38	1.2	38	1.2	38	1.2	38	1.2
	3	34	1.1	34	1.1	34	1.1	34	1.1
	4	32	1.0	32	1.0	32	1.0	32	1.0
	6	32	1.0	32	1.0	32	1.0	32	1.0
	8	32	1.0	32	1.0	32	1.0	32	1.0
	10	32	1.0	32	1.0	32	1.0	32	1.0
	12	32	1.0	32	1.0	32	1.0	32	1.0
Design Based on B - D Retardance									
11-20	0-1	48	1.5	48	1.5	48	1.5	48	1.5
	2	42	1.3	40	1.3	40	1.3	40	1.3
	3	38	1.2	38	1.2	38	1.2	38	1.2
	4	44	1.0	34	1.1	34	1.1	34	1.1
	6	62	1.0	42	1.0	32	1.0	32	1.0
	8	74	1.0	50	1.0	32	1.0	32	1.0
	10	na	na	58	1.0	36	1.0	36	1.0
21-30	0-1	50	1.6	50	1.6	50	1.6	50	1.6
	2	44	1.3	42	1.3	42	1.3	42	1.3
	3	48	1.2	40	1.2	40	1.2	40	1.2
	4	62	1.0	42	1.1	38	1.1	38	1.1
	6	na	na	56	1.0	34	1.0	34	1.0
	8	na	na	70	1.0	42	1.0	32	1.0

* The dimensions for waterways in this line may be changed to T=20 ft. and d=0.75 ft. if the criteria for Special Treatment Areas in the 412 Standard is met.

GRASSED WATERWAY DESIGN CHARTS									
North Region RCN = 82 z=8									
DA	WW Slope	Allowable Stress							
Acres	Per Cent	Easily Eroded		Erodible		Erosion Resistant		Very Erosion	
		Top Width	Depth	Top Width	Depth	Top Width	Depth	Top Width	Depth
Design Based on B - C Retardance									
0-6	0-1	44	1.4	44	1.4	44	1.4	44	1.4
	2	38	1.2	38	1.2	38	1.2	38	1.2
*	3	34	1.0	34	1.0	34	1.0	34	1.0
*	4	32	1.0	32	1.0	32	1.0	32	1.0
*	6	32	1.0	32	1.0	32	1.0	32	1.0
*	8	32	1.0	32	1.0	32	1.0	32	1.0
*	10	32	1.0	32	1.0	32	1.0	32	1.0
*	12	32	1.0	32	1.0	32	1.0	32	1.0
7-10	0-1	46	1.4	46	1.4	46	1.4	46	1.4
	2	40	1.2	40	1.2	40	1.2	40	1.2
	3	36	1.1	36	1.1	36	1.1	36	1.1
	4	34	1.0	34	1.0	34	1.0	34	1.0
	6	32	1.0	32	1.0	32	1.0	32	1.0
	8	36	1.0	32	1.0	32	1.0	32	1.0
	10	40	1.0	32	1.0	32	1.0	32	1.0
	12	44	1.0	32	1.0	32	1.0	32	1.0
Design Based on B - D Retardance									
11-20	0-1	48	1.5	48	1.5	48	1.5	48	1.5
	2	42	1.3	42	1.3	42	1.3	42	1.3
	3	48	1.2	40	1.2	40	1.2	40	1.2
	4	62	1.0	42	1.1	38	1.1	36	1.1
	6	na	na	58	1.0	36	1.0	34	1.1
	8	na	na	72	1.0	44	1.0	32	1.0
	10	na	na	na	na	50	1.0	50	1.0
21-30	0-1	54	1.7	54	1.7	54	1.7	54	1.7
	2	46	1.4	46	1.4	46	1.4	46	1.4
	3	66	1.2	44	1.3	42	1.3	42	1.3
	4	na	na	58	1.1	40	1.2	40	1.2
	6	na	na	78	1.0	48	1.0	36	1.1
	8	na	na	na	na	62	1.0	46	1.0

* The dimensions for waterways in this line may be changed to T=20 ft. and d=0.75 ft. if the criteria for Special Treatment Areas in the 412 Standard is met.

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Waterway Design for Flat Waterways with Out-of-Bank Flow

For waterways with slopes of less than 1 percent, out-of-bank flow will be permitted if the flow will not cause erosion. The minimum capacity of the vegetated portion of the waterway shall be the expected runoff from a 2-year - 24-hour storm. The velocity of the flow outside of the vegetated waterway, based on the runoff expected from a 10-year - 24-hour storm, will not exceed 1.5 fps for easily eroded and erodible soils or 2.0 fps for erosion resistant and very erosion resistant soils, as defined on pages IA7 - 10(1-7). Following are the minimum steps which must be documented in the design for these waterways:

1. The waterway design grade must be less than 1 percent.
2. Document the soil type and determine its soil erodibility category.
3. Determine the allowable out-of-bank flow depth from Table 1 on page IA7-20(15).

4 A. For Trapezoidal Waterways

a. Design the waterway for the Q_2 storm using the Waterway Design Tool (WDT).
b. Determine the dimensions for a Q_{10} waterway. In the WDT, set the minimum bottom width to the design bottom width for the Q_2 waterway. (step a.)
c. Add D_2 (depth of the Q_2 waterway) to the $d_{allowable}$ from Table 1. (step 3.)
d. If the value obtained in step c. is equal to or greater than D_{10}, then the design is ok.
e. If D_{10} is greater than the value from step c., then the design is not adequate. Go back to step a. and increase the flow for the "Q_2" design. Then go through steps a. through d. again. Repeat the process until the condition in step d. is met.

4 B. For Parabolic Waterways

a. Design the waterway for the Q_2 storm using the WDT. Record the top width, depth, and parabolic channel coefficient.
b. Determine the dimensions for a Q_{10} waterway using the WDT. Record the top width, depth, and parabolic channel coefficient.
c. Using the WDT, do a trial and error process to determine the dimensions of a waterway to carry the Q_{10} which has the same parabolic channel coefficient as the Q_2 waterway. To do this, keep the inputs the same as step b. Then go to the channel properties screen and input a flow width that is less than the Q_{10} waterway width. For a first guess, try a width that is 10 ft less than the Q_{10} width. Do a simulation. Compare the parabolic channel coefficient to the Q_2 coefficient from step a. If the numbers are not the same, change the top width and do another simulation. When the coefficients are approximately the same, record the "revised" Q_{10} waterway dimensions.
d. Add D_2 from step a. and $d_{allowable}$ from step 3.

e. Compare this value to D_{10}. If the value obtained in step d. is greater than or equal to $D_{10,}$ the design is ok.
f. If D_{10} is greater than the value from step d., then the design is not adequate. Go back to step a. and increase the flow for the "Q_2" design. Then go through steps a. through e. again. Repeat the process until the condition in step e. is met.

For example designs see pages IA7-20(16-25).

Sometimes it is difficult to design waterways with reasonable dimensions that also meet the requirements of the standard. In those cases it is acceptable to design waterways based on a capacity which is equal to or larger than Q_2 but less than Q_{10}. The following table gives the maximum depth for out of bank flow that results in non-erosive velocities.

TABLE 1. Maximum depths in feet for non-erosive flows ($d_{allowable}$).

Rows parallel to waterway (n = 0.035)		
S	V_{max} = 1.5 fps*	V_{max} = 2.0 fps**
0.1 %	1.18	1.82
0.2 %	0.70	1.08
0.3 %	0.52	0.80
0.4 %	0.42	0.64
0.5 %	0.35	0.54
0.6 %	0.31	0.47
0.7 %	0.27	0.42
0.8 %	0.25	0.38
0.9 %	0.23	0.35
1.0 %	0.21	0.32

Rows perpendicular to waterway (n = 0.040)		
S	V_{max} = 1.5 fps*	V_{max} = 2.0 fps**
0.1 %	1.44	2.22
0.2 %	0.86	1.32
0.3 %	0.63	0.97
0.4 %	0.51	0.79
0.5 %	0.43	0.66
0.6 %	0.38	0.58
0.7 %	0.34	0.52
0.8 %	0.30	0.47
0.9 %	0.28	0.43
1.0 %	0.26	0.40

***** For soils with an erosion category of “easily eroded” or “erodible”

****** For soils with an erosion category of “erosion resistant” or “very erosion resistant”

EXAMPLE 1.

Design a waterway for a field in Story County, Iowa. The drainage area of the waterway is measured to be 88 acres and the runoff curve number is calculated to be 78. The survey shows that the waterway slope is 0.9 percent. The hydraulic length of the watershed is 2,450 feet and the average watershed slope is 2.6 percent. The producer has indicated that the rows will run perpendicular to the waterway and that he will not normally mow the waterway. Use a trapezoidal waterway with 8:1 side slopes.

Step 1. The waterway is 0.9 percent. It is allowable to use this procedure.

Step 2. The peak discharges from EFH 2 are: (See page IA7-20(17))

Q_2 = 67 cfs

Q_{10} = 145 cfs

Step 3. The soil type is a Webster. The erosion category is "very erosion resistant."

(See page IA7-10(7))

Step 4. The allowable flow depth for out-of bank flow is 0.43 feet ($d_{allowable}$).

(See Table 1)

Step 5. Dimensions for a Q_2 waterway. (See page IA7-20(18))

b_2 = 10 ft D_2 = 1.82 ft

Step 6. Dimensions for a Q_{10} waterway. (See page IA7-20(19))

b_{10} = 10 ft D_{10} = 2.21 ft

Step 7. Add $d_{allowable}$ from Table 1 to D_2

0.43 + 1.82 = 2.25 ft

Step 8. Compare this to D_{10}:

2.25 ft > 2.21 ft The design is ok.

Construct a trapezoidal waterway with a 10 foot bottom width, 8:1 side slopes, and 1.8 feet deep.

Client: Example 1
County: STORY State: IA
Practice: Grassed Waterway
Calculated By: MJJ Date: 4/13/2011
Checked By: _____ Date: _____

Drainage Area:	88	Acres (user entered value)
Curve Number:	78	(user entered value)
Watershed Length:	2450	Feet
Watershed Slope:	2.6	Percent
Time of Concentration:	0.72	Hours (calculated value)
Rainfall Type:	II	

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	2	5	10	25	50	100	
24-Hr rainfall (in)	3.10	4.00	4.70	5.40	6.00	6.60	
Ia/P Ratio	0.18	0.14	0.12	0.10	0.09	0.09	0.00
Used	0.18	0.14	0.12	0.10	0.10	0.10	0.00
Runoff (in)	1.20	1.89	2.46	3.05	3.58	4.11	
(ac-ft)	8.80	13.86	18.04	22.37	26.25	30.14	0.00
Unit Peak Discharge (cfs/acre/in)	0.631	0.656	0.669	0.678	0.681	0.681	0.000
Peak Discharge (cfs)	67	109	145	182	214	247	

Story County Example 1: Starting Station 0+00, Ending Station 16+50.0

Input

Channel Data

Bank Slopes, z1,z2: 8.0, 8.0	**Bed Slope:** 0.903%	**Freeboard:** NA	**Min Bed Width:** 10.00 ft
Flow Depth: NA	**Flow Width:** NA	**Discharge:** 67.0 cfs	

Soil Data

Grain Roughness: 0.0156

Allowable Stress: Very Erosion Resistant - 0.070 lb/sq.ft

Vegetal Data

	Stem Length	Density	Ret Curve Index	Vegetal Cover Factor
Stability			4.44 (D)	Turf grasses (Buffalo grass, 0.87)
Capacity			7.64 (B)	

Outputs

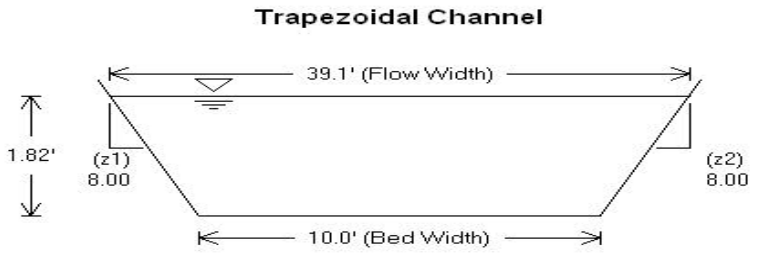
Bed Width determined by specified minimum value for Stability Conditions (Stress not the limiting factor)

Flow Conditions with Minimum cover (Stability)

Manning's n	Average Velocity	Flow Depth	Effect. Soil Stress	Flow Width
0.0408	2.95 ft/sec	1.17 ft	0.013 lb/sq.ft	28.7 ft
X-sect. Area	**Hydraulic Radius**		**Bed Width**	**Flow Width w/Fb**
22.7 sq.ft	0.79 ft		10.0 ft	NA

Capacity Flow Conditions

Manning's n	Average Velocity	Flow Depth		Flow Width
0.1026	1.50 ft/sec	1.82 ft		39.1 ft
X-sect. Area	**Hydraulic Radius**		**Bed Width**	**Flow Width w/Fb**
44.6 sq.ft	1.13 ft		10.0 ft	NA



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Story County Example 1 - Q10: Starting Station 0+00, Ending Station 16+50.0

Input

Channel Data

Bank Slopes, z1,z2: 8.0, 8.0	**Bed Slope:** 0.903%	**Freeboard:** NA	**Min Bed Width:** 10.00 ft
Flow Depth: NA	**Flow Width:** NA	**Discharge:** 145.0 cfs	

Soil Data

Grain Roughness: 0.0156

Allowable Stress: Very Erosion Resistant - 0.070 lb/sq.ft

Vegetal Data

	Stem Length	Density	Ret Curve Index	Vegetal Cover Factor
Stability			4.44 (D)	Turf grasses (Buffalo grass, 0.87)
Capacity			7.64 (B)	

Outputs

Bed Width determined by specified minimum value for Stability Conditions (Stress not the limiting factor)

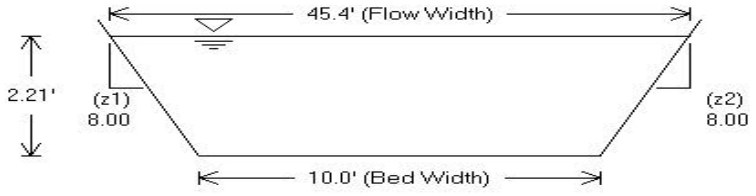
Flow Conditions with Minimum cover (Stability)

Manning's n	Average Velocity	Flow Depth	Effect. Soil Stress	Flow Width
0.0351	4.06 ft/sec	1.58 ft	0.023 lb/sq.ft	35.3 ft
X-sect. Area	**Hydraulic Radius**		**Bed Width**	**Flow Width w/Fb**
35.7 sq.ft	1.01 ft		10.0 ft	NA

Capacity Flow Conditions

Manning's n	Average Velocity	Flow Depth		Flow Width
0.0727	2.37 ft/sec	2.21 ft		45.4 ft
X-sect. Area	**Hydraulic Radius**		**Bed Width**	**Flow Width w/Fb**
61.2 sq.ft	1.34 ft		10.0 ft	NA

Trapezoidal Channel



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EXAMPLE 2.

Design a reach of a parabolic waterway for a field in Grundy County, Iowa. The drainage area of the waterway is measured to be 477 acres and the runoff curve number is calculated to be 78. The survey indicates that the waterway slope is 0.3 percent. The hydraulic length of the watershed is 8,800 feet and the average watershed slope is 2.4 percent. The producer has indicated that the rows will run parallel to the waterway and that he will normally mow the waterway.

Step 1. The waterway is 0.3 percent, which is less than 1 percent; therefore, it is allowable to use this procedure.

Step 2. The peak discharges from EFH 2 are: (See page IA7-20(21))
Q_2 = 182 cfs
Q_{10} = 382 cfs

Step 3. The soil type is a Clyde silty clay loam. The erosion category for a Clyde soil is "erosion resistant." (See page IA7-10(2))

Step 4. The allowable flow depth ($d_{allowable}$) for out-of bank flow is 0.80 ft. (See Table 1)

Step 5. Dimensions for a Q_2 waterway from the WDT. (See page IA7-20(22))
Top width = 66.6 ft D_2 = 2.09 ft Parabolic Channel Coefficient = 0.00189

Step 6. Dimensions of a Q_{10} waterway from the WDT. (See page IA7-20(23))
Top width = 85.6 ft D_{10} = 2.53 ft Parabolic Channel Coefficient = 0.00138

Step 7. Use a trial and error procedure with the waterway design tool to find the dimensions of a Q_{10} waterway with the same Parabolic Channel Coefficient as the Q_2 waterway.

Q_{10}		T	D	P Channel Coeff	See Page
382		85.6	2.53	0.00138 < 0.00189	
	Try	80	2.61	0.00163 < 0.00189	IA7-20(24)
	Try	75	2.68	0.00191 ~ 0.00189	IA7-20(25)

0.00191 ~ 0.00189 Therefore, the D_{10} depth is 2.68 ft.

Step 8. $D_2 + d_{allowable}$ = 2.09 + 0.80 = 2.89 ft
2.89 ft > D_{10} = 2.68 ft Therefore, the design is good.

Construct a parabolic waterway with T = 68 ft and depth = 2.1 ft.

Client: Example 2
County: GRUNDY State: IA
Practice: Grassed Waterway
Calculated By: MJJ Date: 4/13/2011
Checked By: _____ Date: _____

Drainage Area:	477	Acres (user entered value)
Curve Number:	78	(user entered value)
Watershed Length:	8800	Feet
Watershed Slope:	2.4	Percent
Time of Concentration:	2.07	Hours (calculated value)
Rainfall Type:	II	

Storm Number	1	2	3	4	5	6	7
Frequency (yrs)	2	5	10	25	50	100	
24-Hr rainfall (in)	3.10	4.00	4.60	5.30	5.80	6.50	
Ia/P Ratio	0.18	0.14	0.12	0.11	0.10	0.09	0.00
Used	0.18	0.14	0.12	0.11	0.10	0.10	0.00
Runoff (in)	1.20	1.89	2.38	2.97	3.40	4.02	
(ac-ft)	47.70	75.13	94.61	118.06	135.15	159.80	0.00
Unit Peak Discharge (cfs/acre/in)	0.319	0.331	0.337	0.342	0.344	0.344	0.000
Peak Discharge (cfs)	182	298	382	484	558	660	

Grundy Q2: Starting Station 6+00, Ending Station 15+00

Input

Channel Data

Limiting BS, z:1: 8.0	**Bed Slope:** 0.300%	**Freeboard:** NA	:
Flow Depth: NA	**Flow Width:** NA	**Discharge:** 182.0 cfs	
	Offsets 1,2,3: 0.00, 0.00, 0.00		

Soil Data

Grain Roughness: 0.0156

Allowable Stress: Erosion Resistant - 0.050 lb/sq.ft

Vegetal Data

	Stem Length	Density	Ret Curve Index	Vegetal Cover Factor
Stability			4.44 (D)	Turf grasses (Buffalo grass, 0.87)
Capacity			5.60 (C)	

Outputs

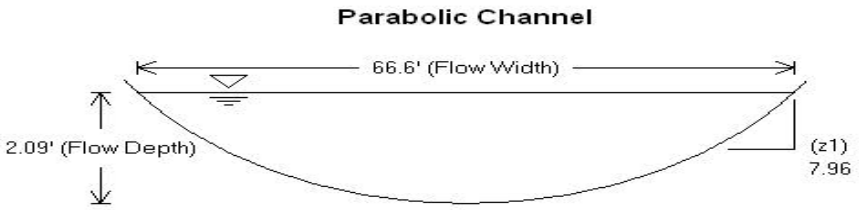
Parabolic Channel Coefficient determined by specified bank slope limit for Capacity Conditions (Stress not the limiting factor)

Flow Conditions with Minimum cover (Stability)

Manning's n	Average Velocity	Flow Depth	Effect. Soil Stress	Flow Width
0.0397	2.36 ft/sec	1.85 ft	0.007 lb/sq.ft	62.6 ft
X-sect. Area	**Hydraulic Radius**	**Bank Slope, z:1**	**P-Channel Coeff**	**Flow Width w/Fb**
77.2 sq.ft	1.23 ft	8.45	0.00189	NA

Capacity Flow Conditions

Manning's n	Average Velocity	Flow Depth		Flow Width
0.0519	1.96 ft/sec	2.09 ft		66.6 ft
X-sect. Area	**Hydraulic Radius**	**Bank Slope, z:1**	**P-Channel Coeff**	**Flow Width w/Fb**
92.9 sq.ft	1.39 ft	7.96	0.00189	NA



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Grundy Q10: Starting Station 6+00, Ending Station 15+00

Input

Channel Data

Limiting BS, z:1: 8.0	**Bed Slope:** 0.300%	**Freeboard:** NA	:
Flow Depth: NA	**Flow Width:** NA	**Discharge:** 382.0 cfs	
	Offsets 1,2,3: 0.00, 0.00, 0.00		

Soil Data

Grain Roughness: 0.0156

Allowable Stress: Erosion Resistant - 0.050 lb/sq.ft

Vegetal Data

	Stem Length	Density	Ret Curve Index	Vegetal Cover Factor
Stability			4.44 (D)	Turf grasses (Buffalo grass, 0.87)
Capacity			5.60 (C)	

Outputs

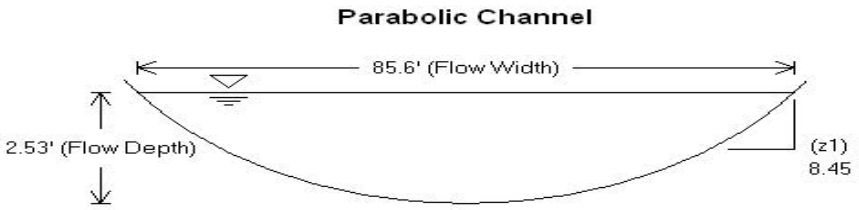
Parabolic Channel Coefficient determined by specified bank slope limit for Capacity Conditions (Stress not the limiting factor)

Flow Conditions with Minimum cover (Stability)

Manning's n	Average Velocity	Flow Depth	Effect. Soil Stress	Flow Width
0.0349	3.09 ft/sec	2.28 ft	0.011 lb/sq.ft	81.3 ft
X-sect. Area	**Hydraulic Radius**	**Bank Slope, z:1**	**P-Channel Coeff**	**Flow Width w/Fb**
123.6 sq.ft	1.52 ft	8.88	0.00138	NA

Capacity Flow Conditions

Manning's n	Average Velocity	Flow Depth		Flow Width
0.0438	2.64 ft/sec	2.53 ft		85.6 ft
X-sect. Area	**Hydraulic Radius**	**Bank Slope, z:1**	**P-Channel Coeff**	**Flow Width w/Fb**
144.7 sq.ft	1.69 ft	8.45	0.00138	NA



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Grundy Q10 80: Starting Station 6+00, Ending Station 15+00

Input

Channel Data

Limiting BS, z:1: 8.0	**Bed Slope:** 0.300%	**Freeboard:** NA	:
Flow Depth: NA	**Flow Width:** 80.0	**Discharge:** 382.0 cfs	
	Offsets 1,2,3: 0.00, 0.00, 0.00		

Soil Data

Grain Roughness: 0.0156

Allowable Stress: Erosion Resistant - 0.050 lb/sq.ft

Vegetal Data

	Stem Length	Density	Ret Curve Index	Vegetal Cover Factor
Stability			4.44 (D)	Turf grasses (Buffalo grass, 0.87)
Capacity			5.60 (C)	

Outputs

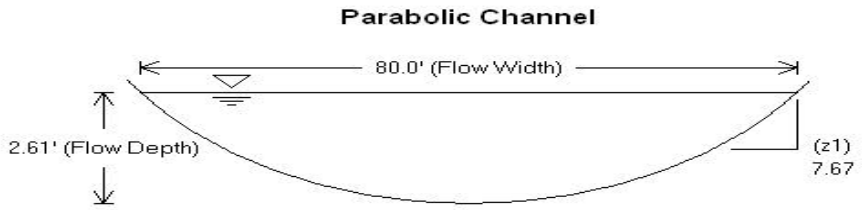
Parabolic Channel Coefficient determined by total stress on vegetal cover

Flow Conditions with Minimum cover (Stability)

Manning's n	Average Velocity	Flow Depth	Effect. Soil Stress	Flow Width
0.0344	3.20 ft/sec	2.35 ft	0.012 lb/sq.ft	76.0 ft
X-sect. Area	**Hydraulic Radius**	**Bank Slope, z:1**	**P-Channel Coeff**	**Flow Width w/Fb**
119.3 sq.ft	1.57 ft	8.07	0.00163	NA

Capacity Flow Conditions

Manning's n	Average Velocity	Flow Depth		Flow Width
0.0429	2.75 ft/sec	2.61 ft		80.0 ft
X-sect. Area	**Hydraulic Radius**	**Bank Slope, z:1**	**P-Channel Coeff**	**Flow Width w/Fb**
139.1 sq.ft	1.73 ft	7.67	0.00163	NA



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Grundy Q10 75: Starting Station 6+00, Ending Station 15+00

Input

Channel Data

Limiting BS, z:1: 8.0	**Bed Slope:** 0.300%	**Freeboard:** NA	:
Flow Depth: NA	**Flow Width:** 75.0	**Discharge:** 382.0 cfs	
	Offsets 1,2,3: 0.00, 0.00, 0.00		

Soil Data

Grain Roughness: 0.0156

Allowable Stress: Erosion Resistant - 0.050 lb/sq.ft

Vegetal Data

	Stem Length	Density	Ret Curve Index	Vegetal Cover Factor
Stability			4.44 (D)	Turf grasses (Buffalo grass, 0.87)
Capacity			5.60 (C)	

Outputs

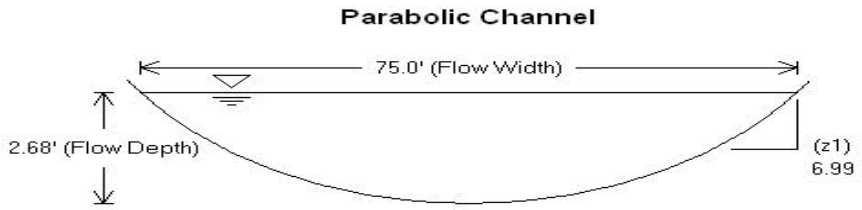
Parabolic Channel Coefficient determined by total stress on vegetal cover

Flow Conditions with Minimum cover (Stability)

Manning's n	Average Velocity	Flow Depth	Effect. Soil Stress	Flow Width
0.0339	3.31 ft/sec	2.43 ft	0.013 lb/sq.ft	71.3 ft
X-sect. Area	**Hydraulic Radius**	**Bank Slope, z:1**	**P-Channel Coeff**	**Flow Width w/Fb**
115.3 sq.ft	1.61 ft	7.35	0.00191	NA

Capacity Flow Conditions

Manning's n	Average Velocity	Flow Depth		Flow Width
0.0421	2.85 ft/sec	2.68 ft		75.0 ft
X-sect. Area	**Hydraulic Radius**	**Bank Slope, z:1**	**P-Channel Coeff**	**Flow Width w/Fb**
134.1 sq.ft	1.78 ft	6.99	0.00191	NA



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650.0705 Layout and construction

(a) Layout

The layout of the waterway should begin at a key point. Usually, this is the outlet, but it may be a point determined by a building, property boundary, gully, or other landscape feature.

(b) Adjustment and marking

After the centerline has been staked, check and move some stakes, if necessary, to avoid landscape features or to improve alignment. The waterway should then be staked for construction. Mark all existing vegetation (trees, shrubs) and other landscape features to be protected during construction.

(c) Site preparation

A good time to build waterways is when the site has a good cover so that runoff and sedimentation will be at a minimum. All debris and vegetation not marked for retention should be removed from the site and disposed of in such a manner that does not adversely affect the environment or proper function of the waterway. For typical design and construction survey notes, see EFH 650.01. Soil may also be used as berms along the sides of the waterway.

(d) Excavation

The soil removed from the waterway should be deposited where it will not interfere with the flow of water into the waterway. Normally, the soil can be shaped and graded to fill low spots in the nearby fields or mounded to create visual interest and screening or to reduce noise and control wind.

The topsoil may be saved and spread in the constructed waterway if necessary for obtaining a good vegetative cover. Where this is done, the waterway should be overexcavated to allow for replacement of the topsoil without encroaching on the design cross section.

(e) Equipment

Many kinds of farming and construction equipment are adapted to the construction of waterways. However, it may be necessary to use equipment that will load and transport the excavated material to locations where it is needed, such as low spots in the surrounding field or washes in the waterway. Although scrapers that can be pulled by farm tractors are satisfactory for waterway construction, large self-propelled scrapers, bulldozers, and motor graders are the preferred equipment.

(f) Appurtenant structures

Effective vegetated waterways are not subjected to low flows of long duration nor kept wet for long periods. Subsurface drains, underground outlets, stone center drains, or other means of providing drainage and protecting the center of the waterway should be considered where low flows or wet conditions are prolonged.

(1) Subsurface drains

Subsurface drains should parallel the center of the vegetated waterway but be offset from the centerline at least a fourth of the top width of the waterway. Two drains may be required in some cases, one on each side of the center. The principles outlined in EFH 650.14 should be followed in designing and installing the subsurface drains. The subsurface drains may be outletted through a drop structure at the end of the waterway or through a standard pipe outlet.

(2) Underground outlets

Underground outlets can be used to carry prolonged low flows. Buried conduits with surface inlets are frequently used downstream of highway culverts or other locations where low flows are concentrated. Blind inlets are sometimes used, but they frequently become a maintenance problem.

(3) Stone center drains

In areas where field stones or other sources of rock are plentiful, a stone center drain may be the best solution to problems of prolonged flow and wetness, A gravel bedding or filter fabric (nonwoven geotextile) is commonly used under the rock to prevent erosion of the underlying soil. These drains are installed as shown in figure 7–11. An alternate cross section would have a stone center that could carry the flow from a

1-year, 24-hour event. Required stone size can be computed using techniques for sizing riprap found in EFH 650.16 or Hydraulic Engineering Circular 11 (FHWA 1989).

(4) Filter fabric barriers

The stability of grassed waterways is based on the establishment of vegetation within the constructed channel's boundaries. Until grass can be established, the waterway is subject to failure from rainfall events significantly less than the design storm. Installing filter fabric in the waterway immediately after the waterway has been constructed is one approach used to minimize the erosive damage caused by untimely rainfall events before the vegetation is established. The barriers are a light weight nonwoven filter fabric (geotextile) plowed into the waterway perpendicular to the direction of flow at intervals ranging from 50 to 100 feet (fig. 7–12).

(g) Postconstruction protection of channel lining

If vegetation is to be used for erosion protection, it should be established as soon after construction as weather conditions permit. (Check Field Office Technical Guide for local planting dates.) Prepare a seedbed and seed with a mixture of grasses and legumes adapted to soil conditions and local climate. Most excavated areas will require fertilizers to establish good cover. If weather conditions are not favorable for permanent seeding, it may be necessary to use a temporary seeding, mulch, or lining. Irrigation may be needed to assure adequate germination and growth initially. If an immediate turf cover is desired or if it is difficult to establish turf from seed, it may be necessary to use sod. Sodding by sprigging or broadcasting root stalks and stolons gives good results with bermudagrass and other grasses in favorable climates. In other areas, direct planting of sod in strips is practical. Woody plantings may be appropriate on channel back slopes to improve screening, wildlife habitat, space definition, and climate control (fig. 7–13). Check Field Office Technical Guides for tree planting dates.

Mulching materials such as straw, hay, jute, paper, or plastic mesh should be used to protect new seeding. At least the center-third portion of the cross section should be anchored. If temporary seedings or nurse crops are used, they should be mowed to reduce competition to permanent seeding. All seeding, planting, sodding, and mulching should conform to standards as given in the local Field Office Technical Guide.

Figure 7–11 Installation of stone center drain

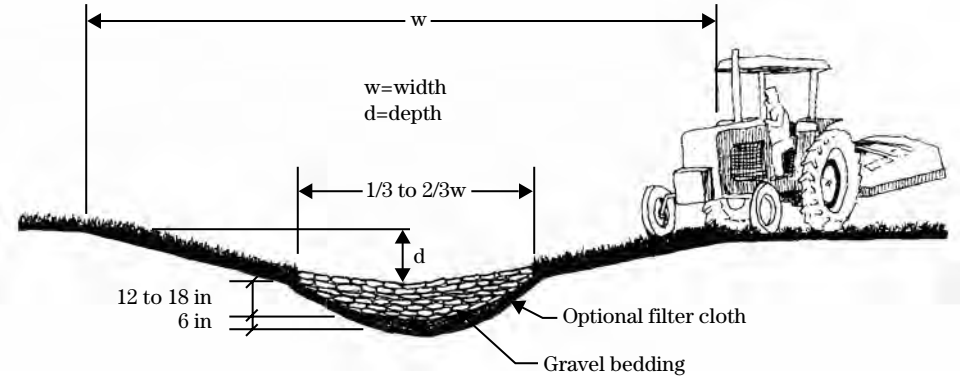
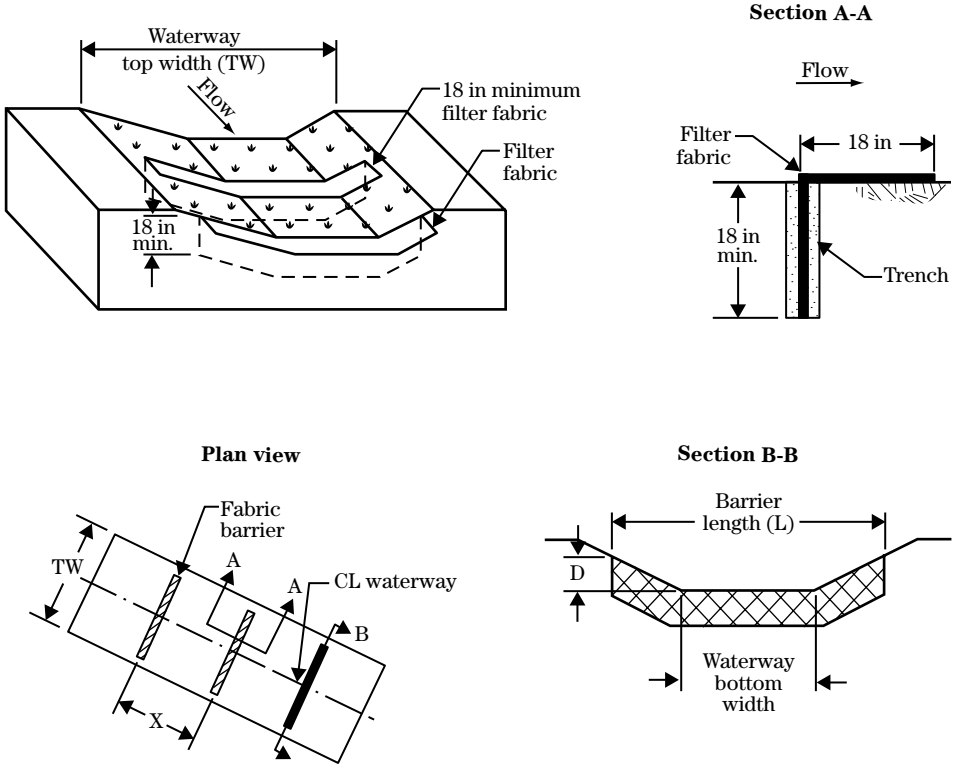


Figure 7–12 Fabric barrier



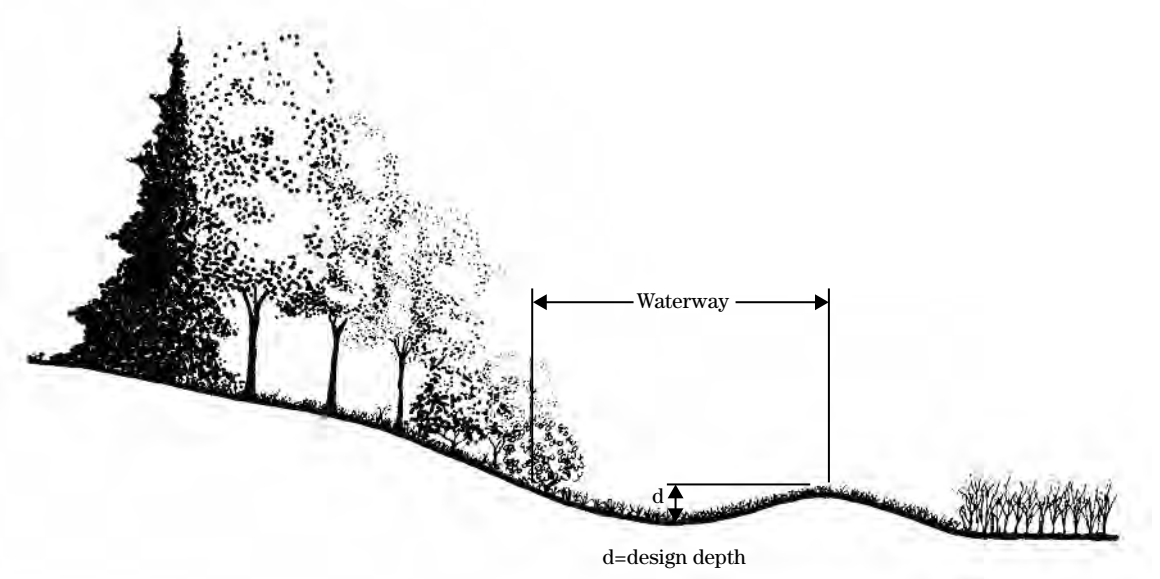
Barrier depth (D)
Barrier spacing (X)
Barrier length (L)

Notes
Fabric barriers are 36 inches wide with 18 inches of the fabric buried and anchored with compacted soil; lay the remaining 18 inches of fabric down the watercourse in the direction of the waterflow. After installation, compact the trench with rear tractor tire; the geotextile shall meet the requirements of NRCS Material Specification 592—Geotextile (ms592), class III nonwoven geotextile. Barriers need to be completed within 14 days after construction check-out. It is recommended that installation be done after seeding.

The waterway may be protected by using a combination of the following steps that best fits the needs of the site:

- Reduce the required capacity by dividing the runoff between two or more waterways.
- Construct and vegetate the waterway before any other channels or structures are allowed to discharge into it.
- Carry prolonged low flows in a subsurface drainage system or in a surface-protected section such as a stone center.
- When possible, divert major flows from the waterway during establishment period.
- Maintain vegetative cover by mowing, spraying, fertilizing, and performing other maintenance as needed.

Figure 7–13 Use of woody plantings



Geotextile Reinforced Vegetated Outlet (GVO)
Criteria and Design Procedure

Geotextile Reinforced Vegetated Outlets (GVO) provide an economical outlet for small watersheds. The Grassed Waterway Standard (412), Engineering Field Handbook Chapter 7, and the Waterway Design Tool were used as the basis for developing this procedure.

The use of this type of outlet is limited to watersheds with peak flows up to 100 cfs from a 10 year – 24 hour storm. It is also limited to soils which have an erosion category of erodible, erosion resistant, or very erosion resistant.

The cross section shape of the outlet shall be trapezoidal. Side slopes shall not be steeper than 3 horizontal to 1 vertical (3:1). Bottom widths shall be no more than 30 feet. The maximum amount of drop through a GVO shall be 10 feet.

Either the following chart or the Waterway Design Tool may be used to size the GVO. The chart is based on an allowable effective stress of 0.090. Vegetative retardance values used were "D" for stability and "B" for capacity.

Outlet Slope		Maximum Flow	Chute Depth Including 0.5 ft. Freeboard	Minimum Inlet Depth
%	H:V	cfs/ft.	Ft.	Ft.
8	12.5:1	5.4	1.4	1.4
10	10:1	4.6	1.3	1.3
12.5	8:1	3.9	1.2	1.3
16.7	6:1	3.2	1.1	1.3
20	5:1	2.8	1.1	1.3
25	4:1	2.5	1.0	1.2
33	3:1	2.1	1.0	1.2

The minimum GVO bottom width is determined by dividing the peak flow for the 10 year – 24 hour storm by the maximum flow per foot from the table for the desired outlet slope.

The inlet depth must be the larger of the value from the above table or the depth of the upstream waterway. The upstream waterway shall be designed with a slope of 4% or less for at least 100 feet. The waterway may be used for a transition section to change the bottom width and/or side slope to those that match the GVO inlet dimensions. The inlet shall be a minimum of 10 feet long and shall be of the same width as the chute section of the GVO.

It is intended that this design procedure be used with Iowa Standard Drawing IA-1402A, Geotextile Reinforced Vegetated Outlet - Geotextile with an Erosion Control Blanket, or Iowa Standard Drawing IA-1402B, Geotextile Reinforced Vegetated Outlet - Turf Reinforcement Mat.

The drawings show a riprap section at the downstream toe of the chute. If wet conditions exist higher than the flow line of the outlet, additional riprap may be needed up the slope of the GVO to ensure that the outlet is stable.

Depending on the outlet slope and design flow, the designer may choose one of two options for the type(s) of material to use for the GVO. Standard Drawing IA-1402A shows the option for using a geotextile with either an erosion control blanket or mulch with an erosion control netting. Standard Drawing IA-1402B shows the option for using either a turf reinforcement mat or an erosion control blanket.

650.0706 Maintenance

(a) General

Timely maintenance is important for keeping a waterway in good working condition. Recommended maintenance generally includes mowing of waterways and removing vegetation so as not to retard water flow and cause excessive sedimentation in the channel. Timely mowing is critical for wildlife. The cool-season grasses typically should be fertilized for hay production, while the native grasses may not need fertilizer. Very often herbicides in field runoff can kill introduced grass species, while native grasses may not be affected as much by this problem. Grazing, if permitted, should be rigidly controlled. Livestock should be excluded during wet periods. Vehicular traffic should be excluded except at designated crossings.

(b) Removal of sediment

The waterway channel may require maintenance to remove small sediment deposits. However, if the deposit extends over long reaches or for the full length of the waterway, the channel should be reconstructed by use of appropriate construction equipment. Sediment should be used onsite or disposed of properly.

(c) Repair work

Eroded areas or damage to lining materials should be repaired promptly. This will prevent or reduce further degradation of the waterway system.

The transition section of waterway outlets is the most susceptible to erosion damage. Repairs should be made promptly to prevent gullying from advancing up the waterway channel. If vegetation proves inadequate in the transition section, it may be necessary to line this section of channel or construct a grade stabilization structure.

Where underground outlets are used, it is important to keep the outlet free of trash that may plug it and cause failure.

650.0707 References

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