APPENDIX C

Riprap

DEFINITION

A revetment of loose rock or similar material installed on a cut or fill slope or a channel side slope to protect the slope from erosion.

PURPOSE

The purpose of the riprap is to provide a protective, non-erosive cover on a slope.

CONDITIONS

This standard applies to channels where velocities do not exceed 10 feet per second or to cut or fill slopes where soil conditions, water turbulence and velocity are such that it will not be stable.

DESIGN CRITERIA

An appropriate geotextile fabric shall be placed between the riprap and soil base. Use NRCS, DOT or the manufacturer's specifications for type and weight of fabric.

The toe of the revetment shall be entrenched in stable channel bottoms for a depth of 1.5 to 3 feet depending on the size of the riprap.

Riprap shall extend up the bank to an elevation where vegetation will provide adequate protection.

For channels, riprap shall be sized as required by channel velocity at full bank flow. Use Table C-1 and Figure C-1. The filter size is also shown in Table C-1.

Riprap shall not be placed on slopes steeper than 1.5 horizontal to 1.0 vertical.

The stone should be reasonably well graded within the gradation curves for each size designated, and any stone gradation, as determined from a field test sample, that lies within these limits shall be acceptable.

The designer should establish the size of graded quarry stone required for the project using acceptable design criteria. Consideration should then be given to using one of the standardized sizes contained in the following tables.

The thickness of the graded quarry stone layer and the gradation are interrelated. The thickness specified normally will vary form 1.0 to 1.5 times the maximum stone size in the gradation. In high turbulence areas, the layer thickness should be 1.5 times the maximum stone size. In low turbulence areas, the layer thickness can be reduced to the dimension of the largest stone in the gradation band.

CONSTRUCTION SPECIFICATIONS

The channel side slope and the toe excavation shall be prepared to the required lines and grades.

Filter material and riprap shall be placed in succession to the required thicknesses and elevations. Riprap shall be handplaced around structures to prevent damage to the structures.

Terminology:

Graded Riprap - durable, dense, specifically selected and graded, quarried stone, placed to prevent erosion.

Filter Bedding Stone - stone generally less than 6 inches in size, that may be placed under graded riprap stone in a layer or combination of layers, designed and installed in such a manner as to prevent loss of underlying soil or finer materials because of moving water.

Surge Stone - a quarry run ungraded, unscreened material which may or may not have fines.

The standard sizes of quarried stone for erosion control specifications may be produced by any suitable commercial quarrying method and by the use of any type of sizing device, necessary to produce the desired sizes.

Standard sizes of stone for erosion and sediment control are defined by their weight or square sieve openings. In Georgia two stone classification systems exist: the National Stone Association (N.S.A.) classification and the Department of Transportation (D.O.T.) classification system. Each system separates the stone sizes into two categories: graded

riprap stone sizes and filter bedding stone sizes.

N.S.A. Graded riprap stone sizes are shown in Table C-1.

N.S.A. Filter bedding stone sizes are shown in Table C-1 and C-2.

D.O.T. Graded riprap stone sizes are shown in Table C-3.

D.O.T. Filter bedding stone sizes are shown in Table C-4.

Data for stone center waterways are shown in Table C-5 and Figure C-3.

Table C-1 Graded Rip-Rap Stone

Flow Velocity (ft./sec.)	N.S.A. No.[1]	Size Inches (Sq. Opening)			Filter Stone N.S.A. No.[1]
		Max.	Avg.[2]	Min.	
2.5	R-1	1 1/2	3/4	No. 8	FS-1
4.5	R-2	3	1 1/2	1	FS-1
6.5	R-3	6	3	2	FS-2
9.0	R-4	12	6	3	FS-2
11.5	R-5	18	9	5	FS-2
13.0	R-6	24	12	7	FS-3
14.5	R-7	30	15	12	FS-3

[1] National Stone Association

[2] At least 50% of the individual stone particles must be equal or larger than this listed size

Table C-2. Fitter Bedding Stone

N.S.A. No[1]	Size Inches (Sq. opening)		
	Max.	Avg.[2]	Min.[3]
FS-1	3/8	#30 mesh	#100 mesh
FS-2	2	#4	#100 mesh
FS-3	6 1/2	2 1/2	#16

[1] National Stone Association

[2] At least 50% of the individual stone particles must be equal or larger than this listed size

[3] 85 - 100% of the individual stone particles may be less than listed size

Table C-3. Graded Rip-Rap Stone

D.O.T. No.[1]	Size inches (Sq. opening)			Common Uses
	Max.	Avg.	Min.	
Type 3	12	9	5	Creek Banks Pipe Outlets
Type 1	24	12	7	Lakes & Shorelines Rivers

[1] Georgia Department of Transportation

Table C-4. Filter Bedding Stone

D.O.T. No.[1]	Nominal Sizes (inches)
3	2" - 1"
4	1 1/2" - 3/4"
5	1" - 1/2"
6	3/4" - 3/8"
57	1" - No. 4

[1] Georgia Department of Transportation

Table C-5. - Gradation of Riprap

Maximum weight of stone required (lbs.)	Minimum and maximum range in weight of stones (lbs.)	Weight range of 75 percent of stones (lbs.)
150	25 - 150	50 - 150
200	25 - 200	50 - 200
250	25 - 250	50 - 250
400	25 - 400	100 - 400
600	25 - 600	150 - 600
800	25 - 800	200 - 800
1000	50 - 1000	250 - 1000
1300	50 - 1300	325 - 1300
1600	50 - 1600	400 - 1600
2000	75 - 2000	600 - 2000
2700	100 - 2700	800 - 2700
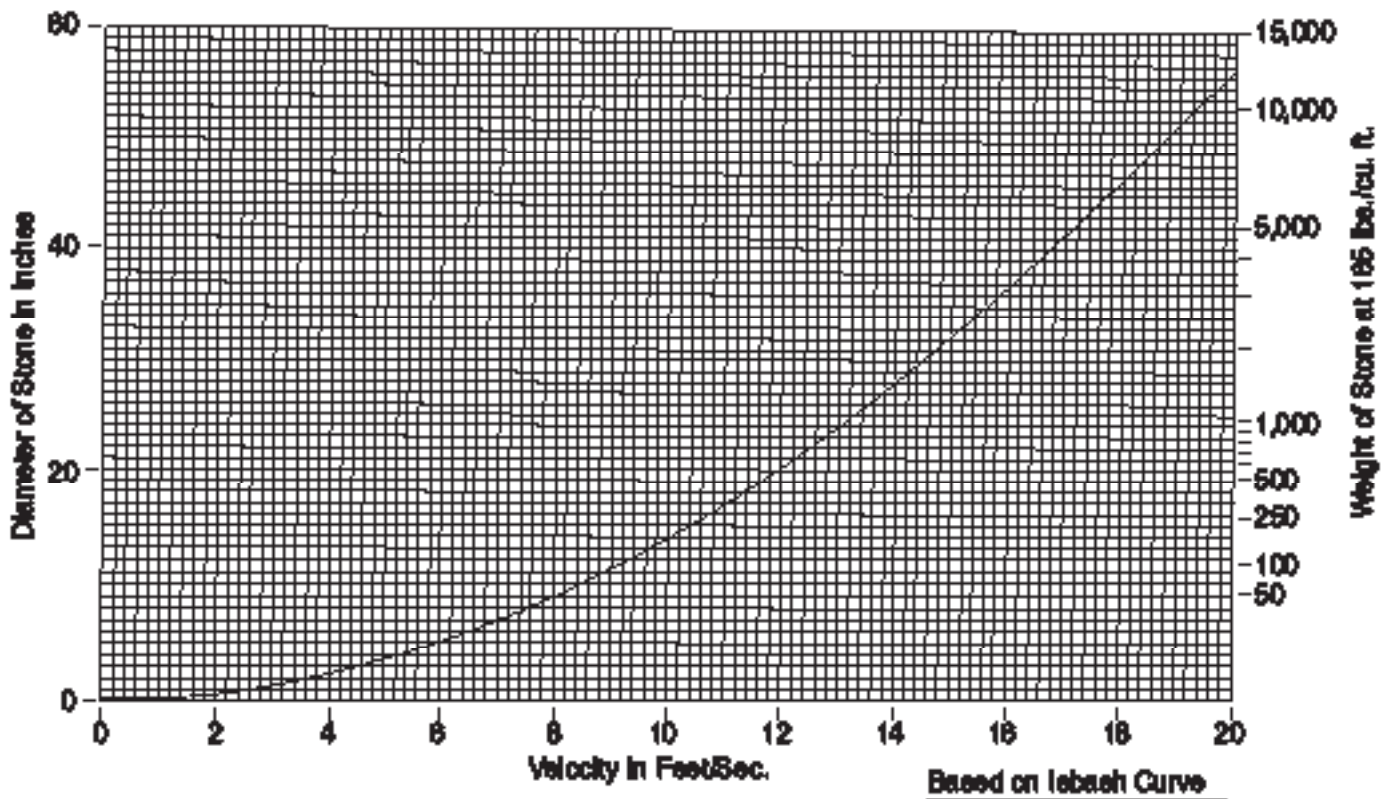
Figure C-1. - Maximum Stone Size for Riprap

Design depth "d" in feet

3.0
2.5
2.0
1.5
1.0 — d = 1.0 ft.
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2

Max. Size - "D"$_{75}$ 75% of the Rock in inches

100.0
50.0
40.0
30.0
20.0
15.0
10.0 — D$_{75}$ = 7.9 in.
5.0
4.0
3.0
2.0
1.0
0.5
0.4
0.3
0.2
0.1

Slope "S" of Drain in %

20.0
15.0
10.0
S = 5.0%
5.0
4.0
3.0
2.0
1.5
1.0
0.5
0.4
0.3
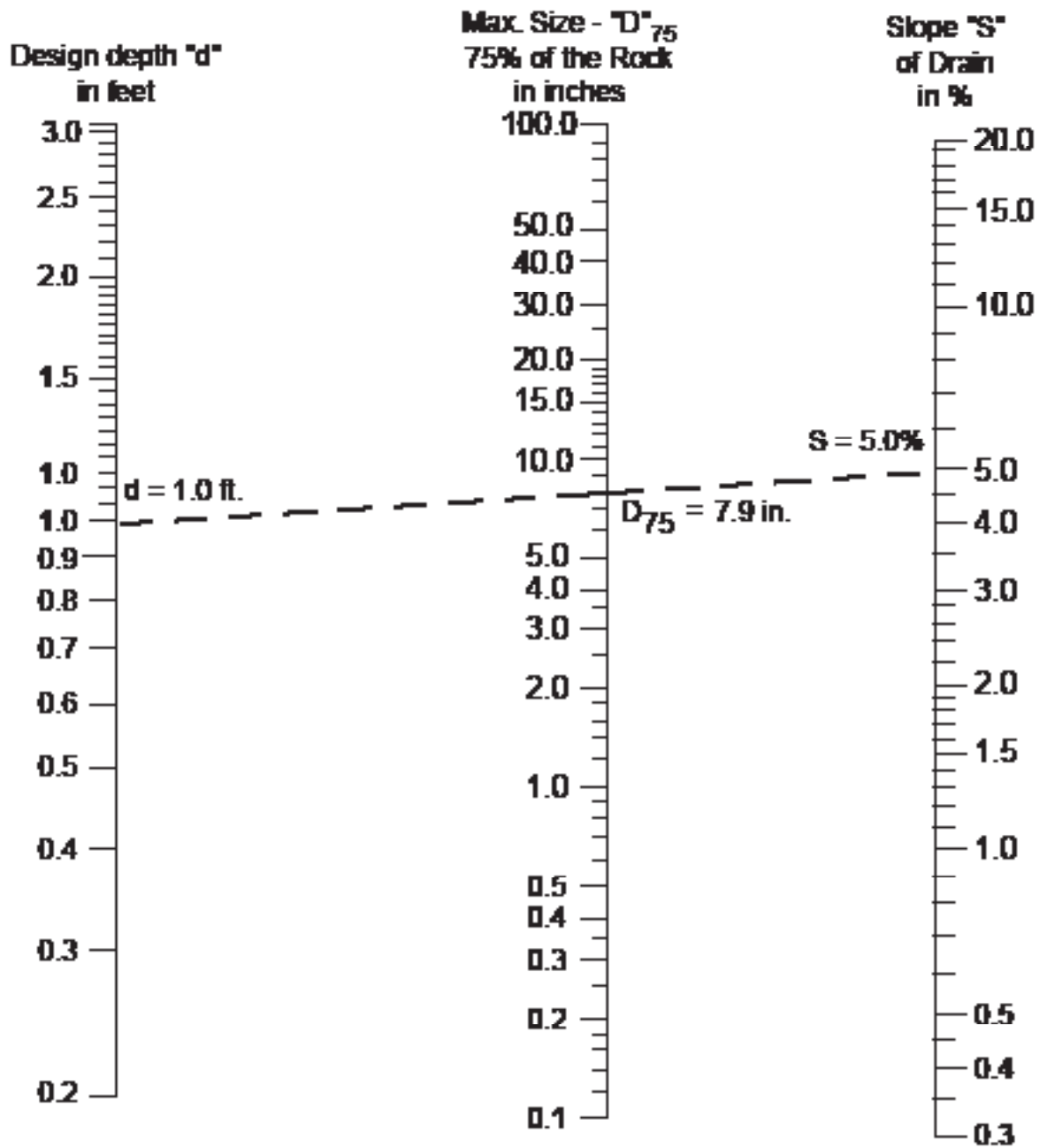
EXAMPLE: "d" = 1.0 Feet   "S" = 5%
Place straight edge at "d" value in Design Depth Column and at "S" value in Slope column. Read rock size in middle column 7.9 inches. Say 8 inches.

FOR DESIGN:
25% of the rock by volume should be in sizes of 8 inches or slightly larger. The remaining 75% or less should be of well graded material, smaller than 8 inches, including suffiecient sands and gravels to fill the voids between the larger rock.

**Figure C-2. - Determination of Rock Size for Stone Center Waterway**

Table C-6. - Velocity, Top Width and Depth for Parabolic Stone Center Waterways

Grade	6 Percent		8 Percent		10 Percent		12 Percent		15 Percent	
V	8.0	10	8.0	10	8.0	10.0	8.0	10.0	8.0	10.0
D	1.3	1.6	1.1	1.3	1.0	1.2	0.9	1.1	0.8	0.9
Q					Top Widths					
20							5		5	
25					5		6		6	4
30			5		6		7		7	5
35			6		7		8	5	8	6
40	6		7		8	5	9	6	10	7
45	7		8		9	6	10	6	11	7
50	7		9	6	10	7	11	7	12	8
55	8		9	6	11	7	12	8	13	9
60	9		10	7	12	8	13	8	14	9
65	9		11	7	12	9	14	9	16	11
70	10	7	12	8	13	9	15	10	17	11
75	11	7	13	9	14	10	16	10	18	12
80	12	8	14	9	15	10	18	11	19	13
90	13	9	15	10	17	12	20	13	21	15
100	14	10	17	11	19	13	22	14	24	16
110	16	11	19	13	21	14	24	15	26	18
120	17	11	21	14	23	16	26	17	29	20
130	19	12	22	15	25	17	29	18	31	21
140	20	13	24	16	27	18	31	19	33	23
150	22	14	26	17	29	20	33	21	36	24
160	23	15	27	18	31	21	35	22	38	26
170	25	16	29	19	33	22	37	24	40	28
180	26	17	31	20	34	23	39	25	43	29
190	27	18	32	22	36	25	42	26	45	31
200	29	19	34	23	38	26	44	28	47	33
220	32	21	38	25	42	29	48	31	52	38
240	35	23	41	27	46	31	53	33	57	39
260	38	25	44	30	50	34	57	36	62	42
280	40	27	48	32	54	36	61	39	67	45
300	43	29	51	34	57	39	66	42	71	49

STONE CENTER WATERWAYS
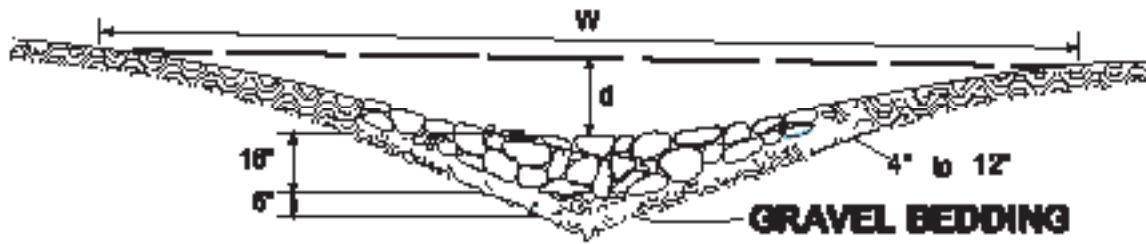
Waterway with stone center drain
V section shaped by motor patrol
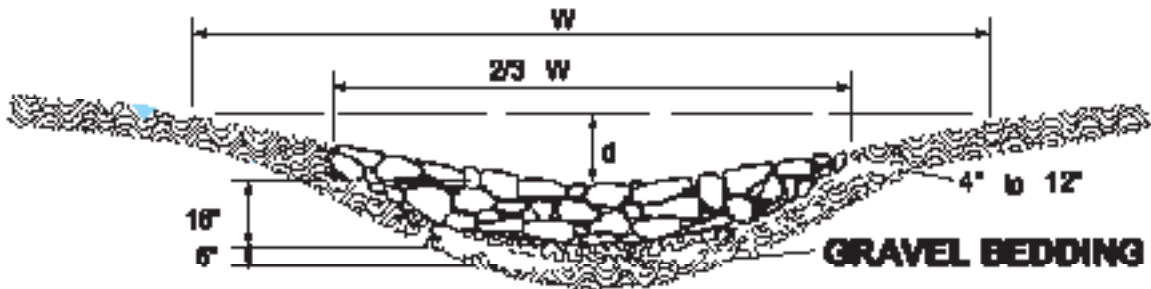
Waterway with stone center drain
Rounded section shaped by bulldozer

Figure C-3 - Waterway with Stone Center