SHAW-MC-CK11-0479

Shaw Environmental, Inc.
312 Directors Drive
Knoxville, TN 37923

Letter of Transmittal

To:	Lisa Holstein	From:	Troy Winton
	FTMC		Shaw Environmental, Inc.
		Date:	12/7/10

☐ Urgent ☐ As Discussed ☑ As Requested ☐ For Review

Item(s) Transmitted:

1. Four hardcopies and 1 CD of final *Stormwater Erosion Control Plan for Range 20,* dated August 26, 2010.

2. USFWS concurrence letter on final *Stormwater Erosion Control Plan for Range 20* is attached and an electronic (PDF) copy is provided on the CD.

cc: Central Files
Jeff Tarr

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Mountain Longleaf National Wildlife Refuge
664 Powers Avenue, Suite 200
Anniston, Alabama 36205

November 17, 2010

Mr. Scott Bolton
Site Manager
Department of the Army
681 Castle Avenue, Building 200
PO Box 5022
Fort McClellan, Alabama 36205

Dear Mr. Bolton:

The U.S. Fish and Wildlife Service (Service) has reviewed the U.S. Army's (Army) Stormwater Erosion Control Plan Range 20, Parcel 76Q-X at Fort McClellan, Alabama dated August 26, 2010. The Service approved the engineering controls outlined in this current proposal via email on June 29, 2010. The engineering controls as proposed should be more than sufficient to stabilize the site.

Long term stabilization of the site will depend on successful revegetation of the site and the absence of an extreme weather event prior to successful vegetation establishment. Despite Army reservations in the use of native species for stabilizing the site, the Service requires the use of native vegetation within this area due to the high quality natural areas which surround this site. Should the site fail to stabilize and this failure can be attributed to the native species used and not an extreme storm event, improper seedbed preparation, lack of adequate moisture or other poor site conditions; the Service will take responsibility for revegetating the site as needed.

The following native seed mixture planted at a rate of 15 lbs/acre should be sufficient to stabilize the soils in the area provided proper seedbed preparation is done and adequate moisture is provided after seeding. For seedbed preparation, the Service recommends mowing the wheat followed by seed planting using a native warm season grass seed drill.

- 30% Little Bluestem
- 15% Switchgrass
- 15% Indiangrass
- 10% Big Bluestem
- 10% Virginia Wild Rye
- 5% Partridge Pea
- 5% Foxtail Barley
- 5% Purple Top

TAKE PRIDE IN AMERICA

- 5% Largeflower Tickseed

Any future correspondence on this site should be addressed to Mr. Dwight Cooley at Wheeler National Wildlife Refuge. Mr. Cooley can be reached at 256-353-7243.

Sincerely

Steve Miller
Refuge Manager
Mountain Longleaf NWR

Stormwater Erosion Control Plan
Range 20, Parcel 76Q-X
Fort McClellan, Alabama
August 26, 2010

Stormwater from significant rain events after the completion of the Range 20 Soil Removal Action at Fort McClellan, Alabama has eroded site soils and the existing erosion gullies. The erosion problems were exacerbated by the failure of grass seed (sown as part of the initial removal action) to grow over a significant portion of the site. To prevent further erosion and stabilize the soil and gullies, the following Erosion Control Plan was developed using engineering controls specifically developed for the site.

This report includes attachments provided under the section headings of Drawings, Calculations, and Specifications. The four gullies requiring upgrade are identified in the text and drawings as the Primary Gully and Secondary Gullies 1, 2, and 3. The following text is ordered according to suggested construction sequence.

1. Upgradient Roadside Ditch and Berm
A ditch and berm will divert runoff away from the southern-most area of Range 20. The system will be installed upgradient along the access road located at the eastern border of the site (See Site Plan attached under Drawings). The ditch will be constructed on the west side of the access road starting at the ridgeline approximately 50 feet south of Secondary Gully 3 diverting runoff approximately 150 feet south down to a natural drainage feature.

The ditch will control runoff from the southeast. The associated berm will be constructed of spoils from ditch excavation. Details are attached under Drawings. Peak runoff calculations used for sizing the ditch are attached under Calculations.

The grass-lined ditch and berm will be armored with Turf Reinforcement Matting (TRM) for establishing and maintaining perennial vegetation. Installation details are attached under Specifications. The TRM is installed after applying permanent seed.

A discharge apron will be constructed at the ditch end to control erosion; the apron will be 10 feet wide by 30 feet long by 2 feet deep and constructed of Alabama Department of Transportation (ALDOT) Class 2 riprap and non-woven filter fabric. The top of the apron will be installed at grade.

2. Purge Pools
Purge pools will be excavated near the outfalls of the Main Gully and Gullies # 1 and #3 to dissipate energy before release to the natural drainage features. The locations are provided on the Site Plan and construction details can be found on Drawings 3, 4, and 5. Spoils from the excavation will be used for purge pool construction (if needed) or spread onsite.

3. Stormwater Channels
Channel design for the gullies was according to the peak design flow and velocity of 31 cubic feet per second (cfs) and 10 feet per second (fps), respectively (see Calculations). Based on the calculations, construct the primary and secondary erosion gullies according to detail provided

under Drawings and extend each gully to the existing, nearest drain. Armor the Main and Secondary gullies with Class 2 riprap (ALDOT, 2008) according to provided details.

4. Rock Ditch Check Dams
Install Ditch Rock Check Dams for energy dissipation every 100 feet within the gullies simultaneously to gully armoring. The check dams will be constructed of Class 2 riprap. See Drawings and Specifications for construction detail and dimensions.

5. Grading and Diversion Berms
Areas at the Range 20 Soil Removal Action that did not establish a healthy stand of grass will be re-graded according to *Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas* (Alabama, 2009). After grading, apply seed, soil amendments, fertilizer, and mulch, then track-compact the area using heavy construction equipment.

Simultaneous to site re-grade, construct diversion berms at the mouth of the gullies to direct runoff from the slope to the armored channels. The locations of the berms are shown on the attached Site Plan and construction details are provided under Drawings. These will be armored with TRM.

If a seep is discovered, an underdrain from the seep will be buried and day-lighted at the nearest gully.

6. Temporary and Permanent Seeding
Seeding preparation will be according to *Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas* (Alabama, 2009; see attached specifications for temporary and permanent seeding). The existing topsoil will be tilled (if required) and additional topsoil applied where needed. If necessary, based on soil nutrient analysis, the application of soil amendments will either follow the specific recommendations from the soils analysis or a typical local application rate of 1-2 tons of lime applied per acre (based on soil texture) and 400 pounds of 8-24-24 NPK fertilizer per acre.

Temporary seeding will take place before October 15; permanent seeding will be performed early Spring 2011 or as otherwise specified. Temporary seeding will be performed by hydroseeding including HydraCX2 matrix (see attached specification). The seed mix applied with the HydraCX2 will be certified wheat seed at a rate of 3-4 bushels/acre. If necessary, after seedlings are established, additional fertilizer shall be applied separately by hydroseeding (400 pounds per acre of 8-24-24 NPK fertilizer per acre). Watering will be performed after seeding and resume as needed until a stand of wheat is established.

The procedure for permanent seeding should include mowing the wheat in early spring and then planting native warm season grasses via hydroseeding or broadcast. The native grass mixture will be verified with USFWS at a future date but may include:

- Sideoats gramma (El Reno cultivar)
- Little bluestem (Aldous cultivar)
- Indiangrass (cultivars Osage, Newberry, or Rumsey)

The native grass shall be applied at a rate of 12 pounds of pure live seed per acre. If necessary, after seedlings are established, additional fertilizer shall be applied separately by hydroseeding (400 pounds per acre of 8-24-24 NPK fertilizer per acre).

Seeds shall be certified by an Official Seed Certifying Agency and tested within nine months prior to use. Each kind of seed shall be separately packed and delivered to the project in a seed-tight bag. Each bag shall bear a tag or label bearing the seal of the Official Seed Certifying Agency. The analysis of the seed (percent pure seed, germination, date tested, etc.) shall be attached to each bag.

Once the grass stand has emerged, an additional 30 pounds of nitrogen per acre may be applied to areas where there is patchy growth.

Application methodology for the lime, fertilizer and seed will be determined in the field and may include hand, tractor or hydroseeding applications.

Watering will be performed after seeding and resume as needed until a stand of grass is established.

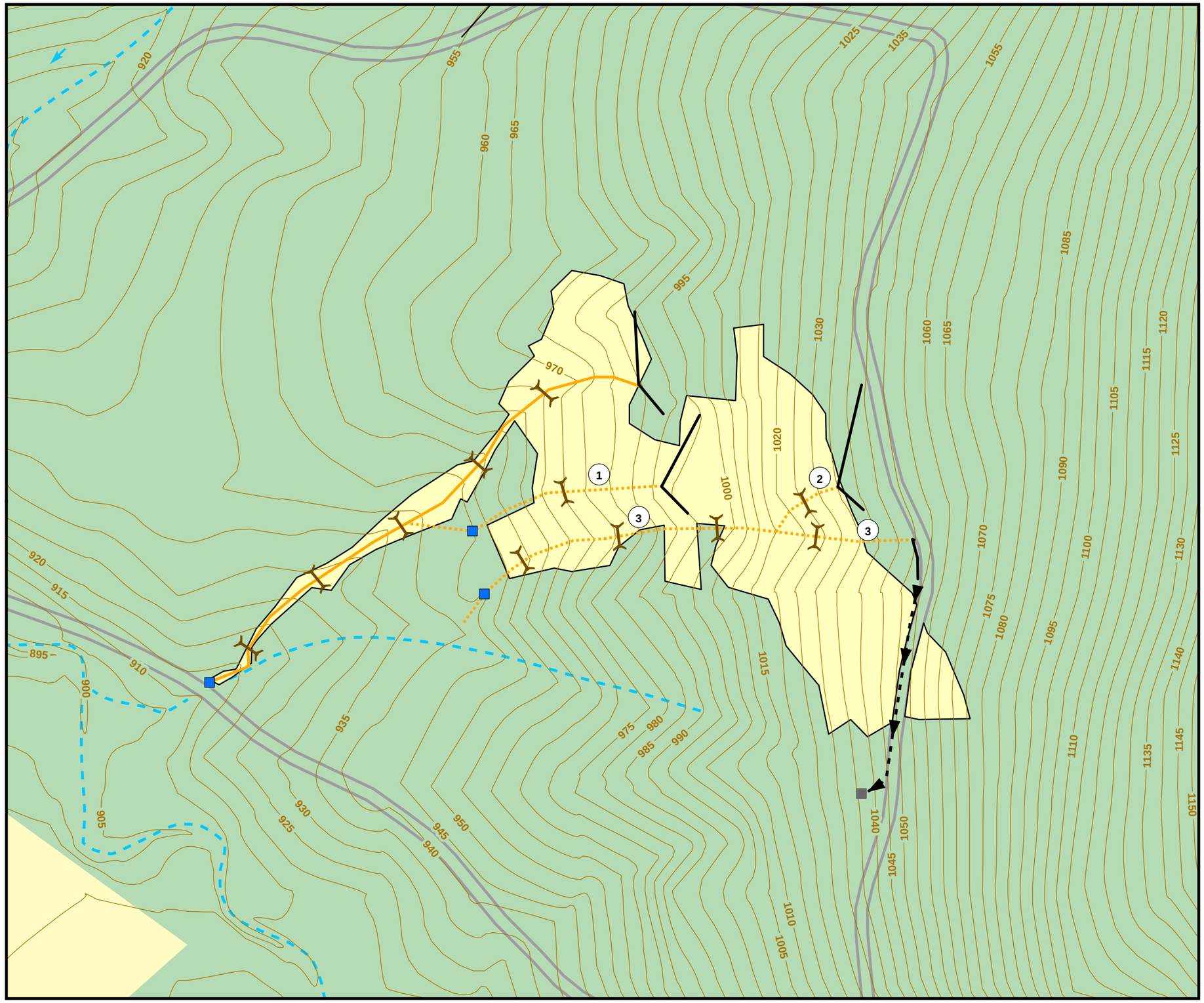
7. References

State of Alabama Department of Transportation (ALDOT), 2008, ***Standard Specifications for Highway Construction.***

State of Alabama Soil & Water Conservation Committee (Alabama), 2009, ***Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas***, March.

DRAWINGS

Erosion Control Site Plan
Range 20, Parcel 76Q-X,



Legend

- Excavation Boundary
- Gully Number
- Rip Rap Gully
  - Primary Gully
  - Secondary Gully
  - Stone Rip Rap Energy Dissipater (Approximately Every 100')
  - Discharge Apron
  - Plunge Pool
  - Roadside Trench and Berm
  - Diversion Berm
  - Topographic Contour (5-foot interval)
  - Wooded
  - Not Wooded
  - Roads
  - Surface Drainage Feature (Dashed where Intermittent)

100 0 100 Feet

NAD83 State Plane Coordinates

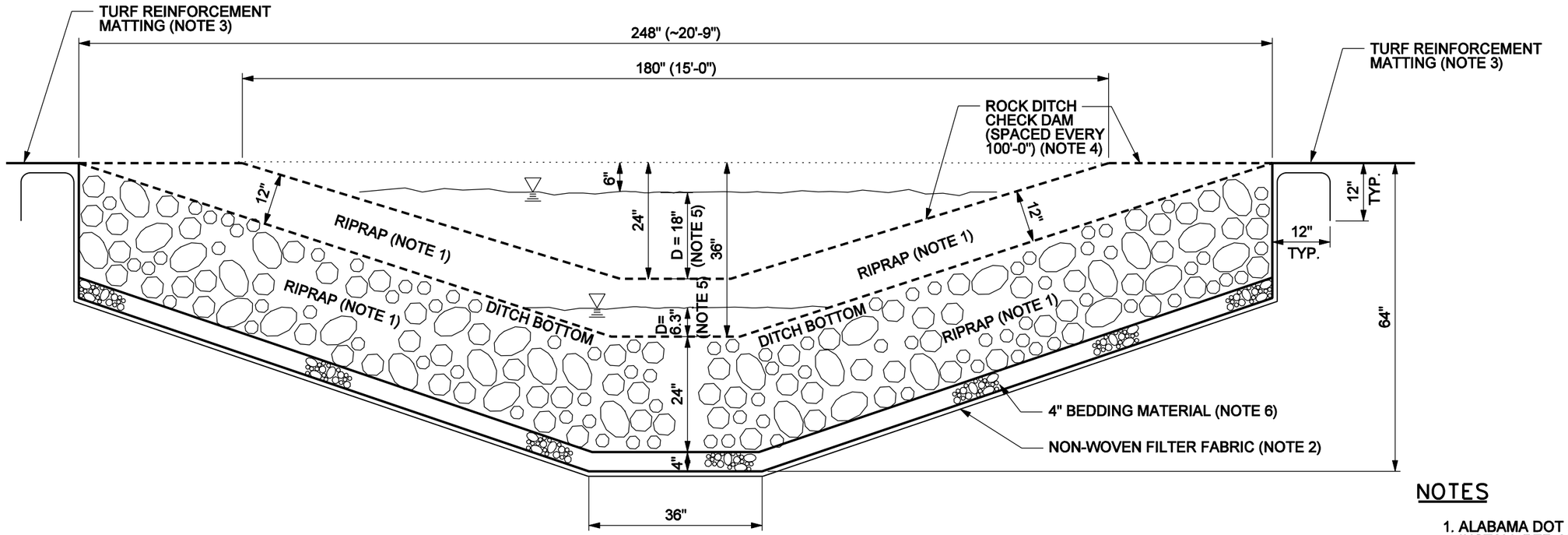
N

Shaw Environmental, Inc.

U.S. Army Corps of Engineers Mobile District

Contract No. DACA21-96-D-0018

c:/ftmc/mxd/range20/Attachment1_Range20_Topo.mxd



ARMORED GULLY DETAIL

SCALE: 1/2"=1'-0"

NOTES

1. ALABAMA DOT CLASS 2 RIPRAP, INSTALL PER ALABAMA DOT, 2008.
2. MIRAFI 180N OR EQUAL. INSTALL PER ALABAMA DOT, 2002.
3. NORTH AMERICAN GREEN VMAX SC250 OR EQUAL. INSTALL PER MANFR. RECOMMENDATIONS.
4. ROCK DITCH CHEDK DAM CONSTRUCTED OF CLASS 2 RIPRAP, LOCATED APPROX. EVERY 100 FEET ALONG GULLY.
5. WATER DEPTH FOR PEAK RUNOFF FLOW RATE.
6. ALDOT #4 STONE.

DETAIL 1

STORM WATER EROSION CONTROL DETAILS
RANGE 20, PARCEL 76Q-X
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA

0 1' 2' 4' 6'

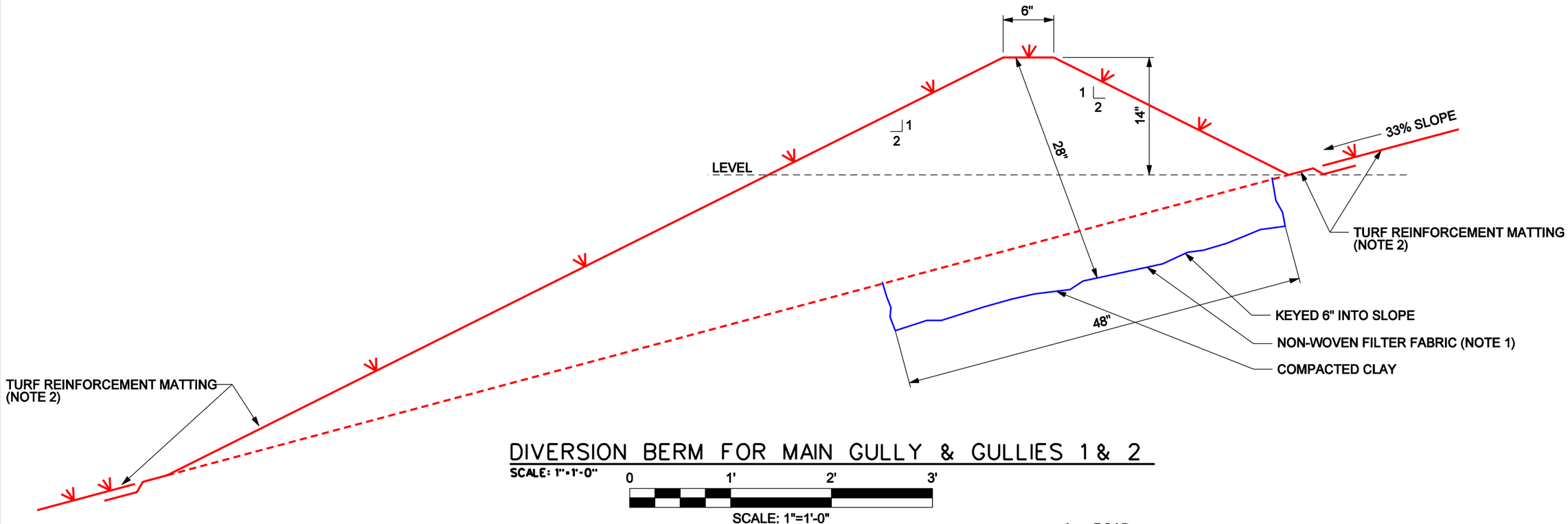
SCALE: 1/2"=1'-0"

Shaw® Shaw Environmental, Inc.

STARTING DATE: 06/03/2010	DATE LAST REV.: 06/18/2010	DRAFT. CHCK. BY: G. SWANSON	DWG. NO.: Detail 1 06 21 2010.dgn
DRAWN BY: R. HUBBARD	DRAWN BY: R. HUBBARD	ENGR. CHCK. BY: R. HUBBARD	PROJ. MGR.: T. WINTON
		INITIATOR: G. SWANSON	PROJ. NO.: 800486

6/22/2010 8:30:27 AM PE_Pen.tbl

rhubbard pe_printer.plt Detail 1 06 21 2010.dgn

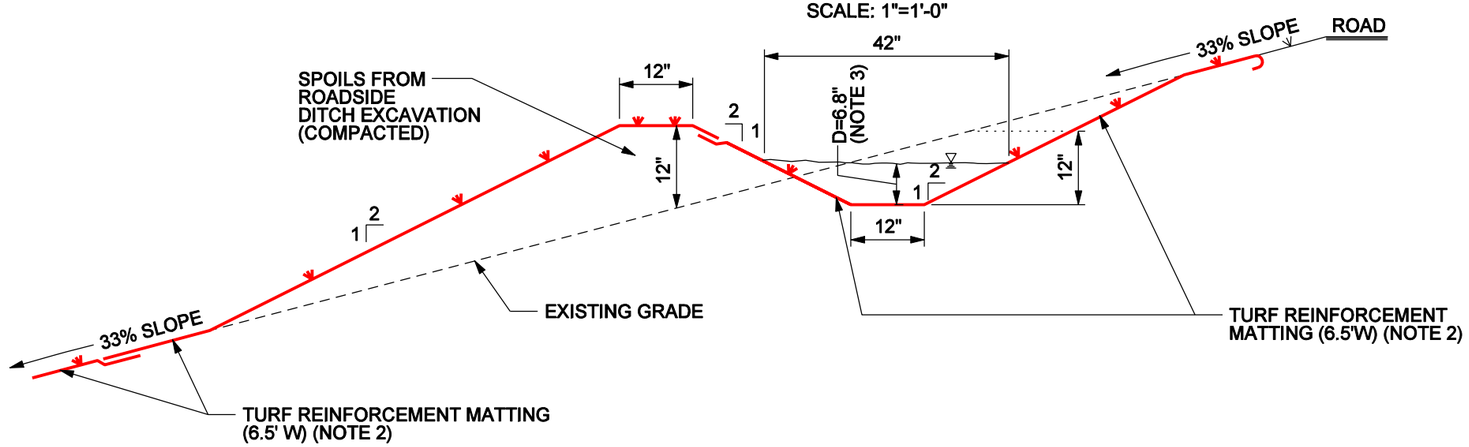


DIVERSION BERM FOR MAIN GULLY & GULLIES 1 & 2

SCALE: 1"=1'-0"

0 1' 2' 3'

SCALE: 1"=1'-0"



ROADSIDE DIVERSION DITCH AND BERM

SCALE: 1"=20'-0"

0 10' 20' 40' 60'

SCALE: 1"= 20'

NOTES

1. MIRAFI 180N OR EQUAL. INSTALL PER ALABAMA DOT, 2002.
2. NORTH AMERICAN GREEN VMAX SC250 OR EQUAL. INSTALL PER MANFR. RECOMMENDATIONS.
3. WATER DEPTH FOR PEAK RUNOFF FLOW RATE.

DETAIL 2

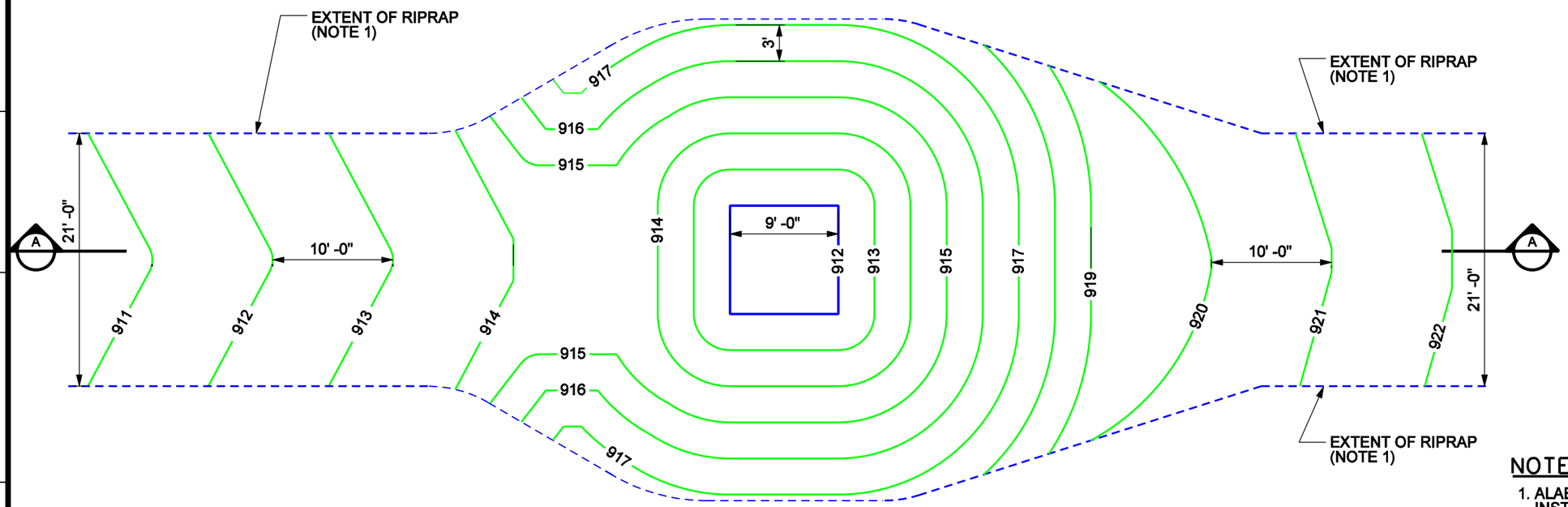
STORM WATER EROSION CONTROL DETAILS
RANGE 20, PARCEL 76Q-X
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA

Shaw® Shaw Environmental, Inc.

STARTING DATE: 06/03/2010 | DATE LAST REV.: 06/24/2010 | DRAFT. CHCK. BY: G. SWANSON | INITIATOR: G. SWANSON | DWG. NO.: $$$$FILE$$$$
DRAWN BY: R. HUBBARD | DRAWN BY: R. HUBBARD | ENGR. CHCK. BY: R. HUBBARD | PROJ. MGR.: T. WINTON | PROJ. NO.: 800486

$$$$DATE$$$$
$$$$PENTBL$$$$
$$$$TIME$$$$

$$$$USER$$$$
$$$$PLTDRV$$$$
$$$$FILE$$$$

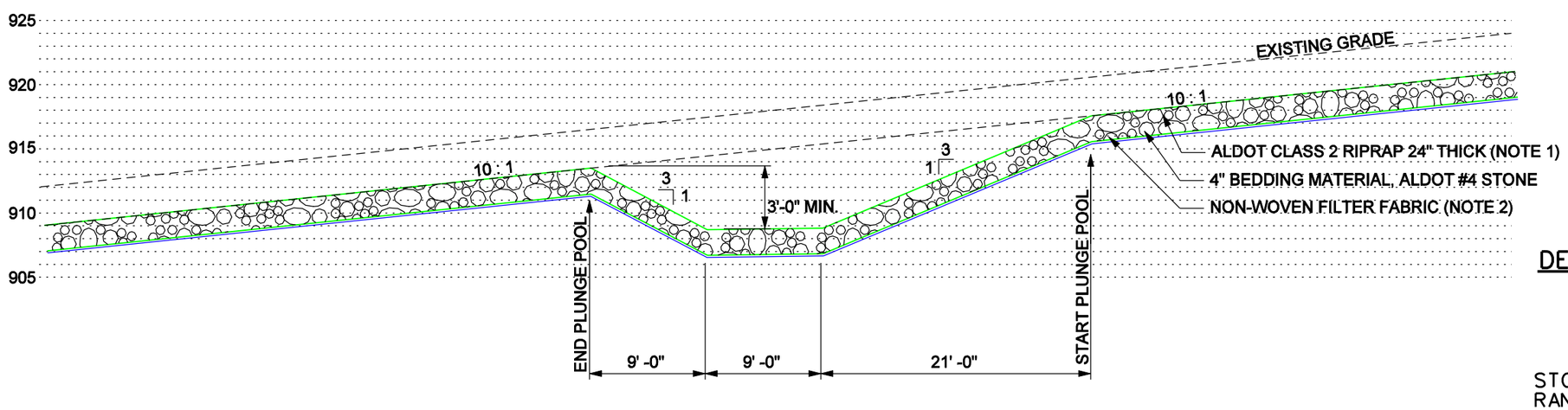


PLUNGE POOL PLAN VIEW - PRIMARY GULLY

SCALE: 1"=10'-0"

NOTES

1. ALABAMA DOT CLASS 2 RIPRAP, INSTALL PER ALABAMA DOT, 2008.
2. MIRAFI 180N OR EQUAL. INSTALL PER ALABAMA DOT, 2002.



PLUNGE POOL CROSS SECTION A-A - PRIMARY GULLY

SCALE: 1"=10'-0"

DETAIL 3

0 5' 10' 20' 30'

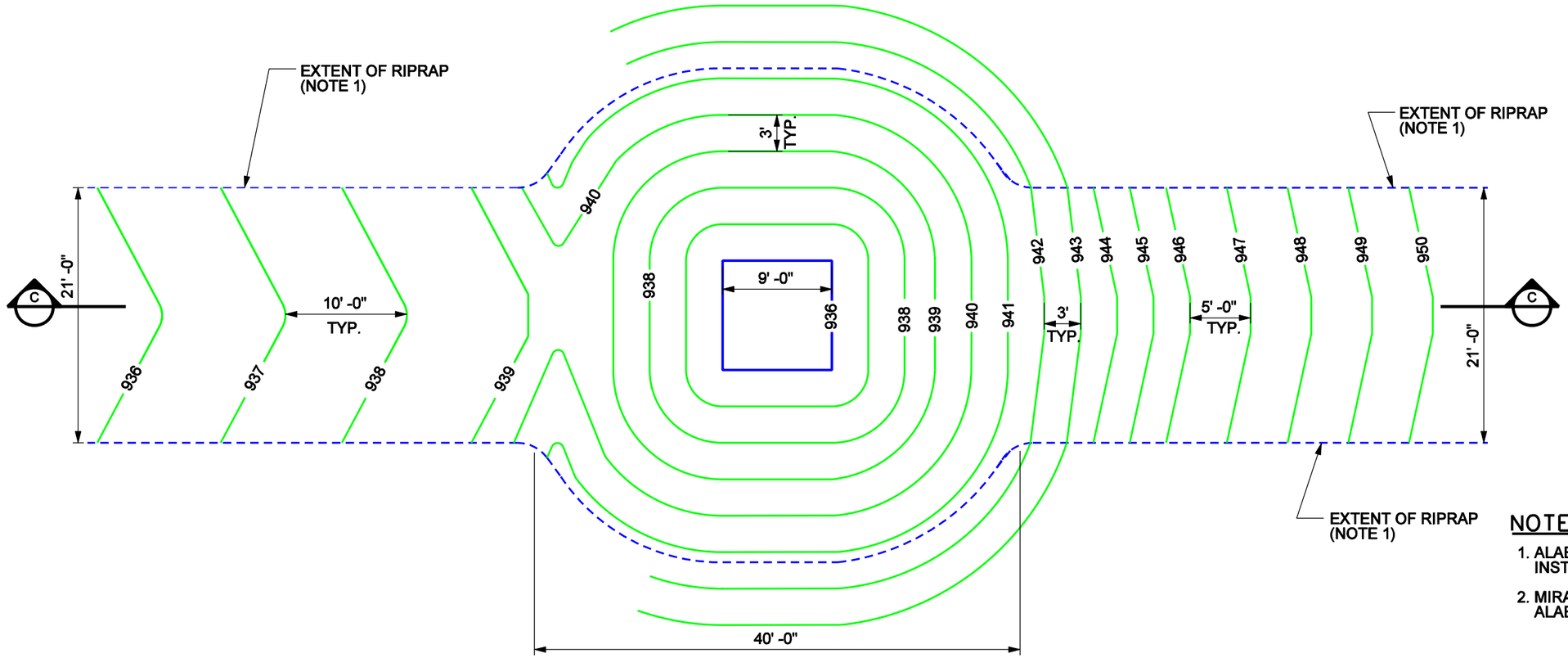
SCALE: 1"= 10'

STORM WATER EROSION CONTROL DETAILS
RANGE 20, PARCEL 76Q-X
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA

Shaw Environmental, Inc.

STARTING DATE: 06/03/2010 | DATE LAST REV.: 06/18/2010 | DRAFT. CHCK. BY: G. SWANSON | INITIATOR: G. SWANSON | DWG. NO.: $$$$FILE$$$$
DRAWN BY: R. HUBBARD | DRAWN BY: R. HUBBARD | ENGR. CHCK. BY: G. SWANSON | PROJ. MGR.: T. WINTON | PROJ. NO.: 800486

$$$$DATE$$$$ $$$$PENTBL$$$$ $$$$TIME$$$$
$$$$USER$$$$ $$$$PLTDRVS$$$$ $$$$FILE$$$$

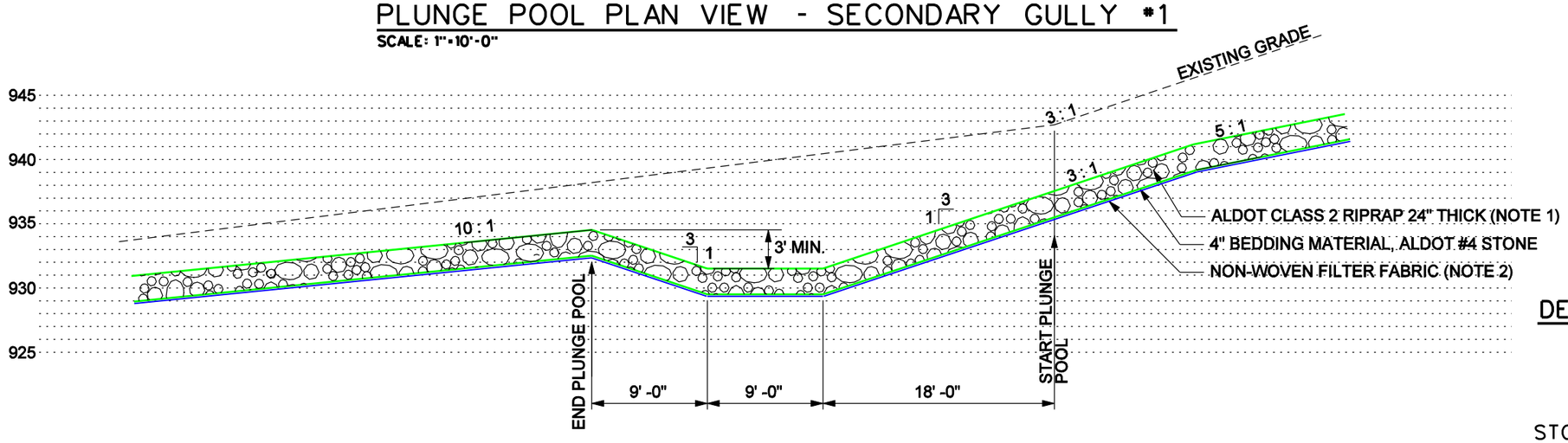


PLUNGE POOL PLAN VIEW - SECONDARY GULLY #1

SCALE: 1"=10'-0"

NOTES

1. ALABAMA DOT CLASS 2 RIPRAP, INSTALL PER ALABAMA DOT, 2008.
2. MIRAFI 180N OR EQUAL. INSTALL PER ALABAMA DOT, 2002.



PLUNGE POOL CROSS SECTION C-C - SECONDARY GULLY #1

SCALE: 1"=10'-0"

DETAIL 4

STORM WATER EROSION CONTROL DETAILS
RANGE 20, PARCEL 76Q-X
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA

0 5' 10' 20' 30'

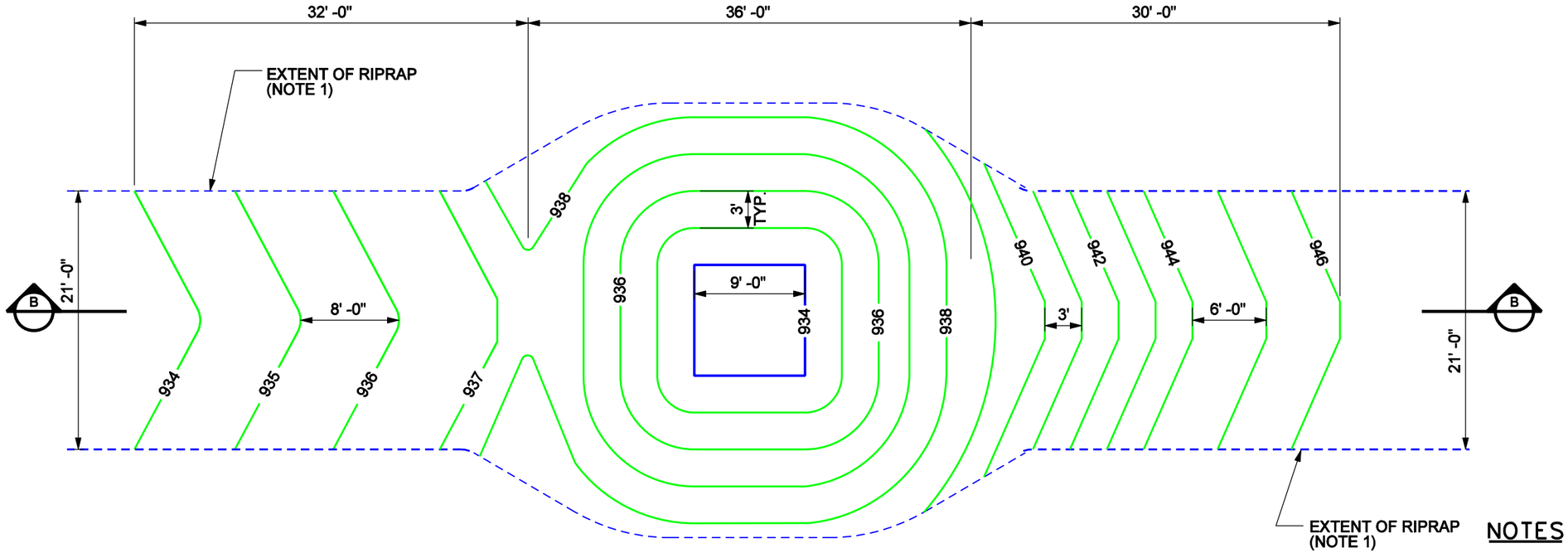
SCALE: 1"= 10'

Shaw® Shaw Environmental, Inc.

STARTING DATE: 06/03/2010	DATE LAST REV.: 06/18/2010	DRAFT. CHCK. BY: G. SWANSON	DWG. NO.: $$$$$FILE$$$$$
DRAWN BY: R. HUBBARD	DRAWN BY: R. HUBBARD	ENGR. CHCK. BY: G. SWANSON	PROJ. MGR.: T. WINTON
		INITIATOR: G. SWANSON	PROJ. NO.: 800486

$$$$$DATE$$$$$
$$$$$PENTBL$$$$$
$$$$$TIME$$$$$

$$$$$USER$$$$$
$$$$$PLTDRV$$$$$
$$$$$FILE$$$$$

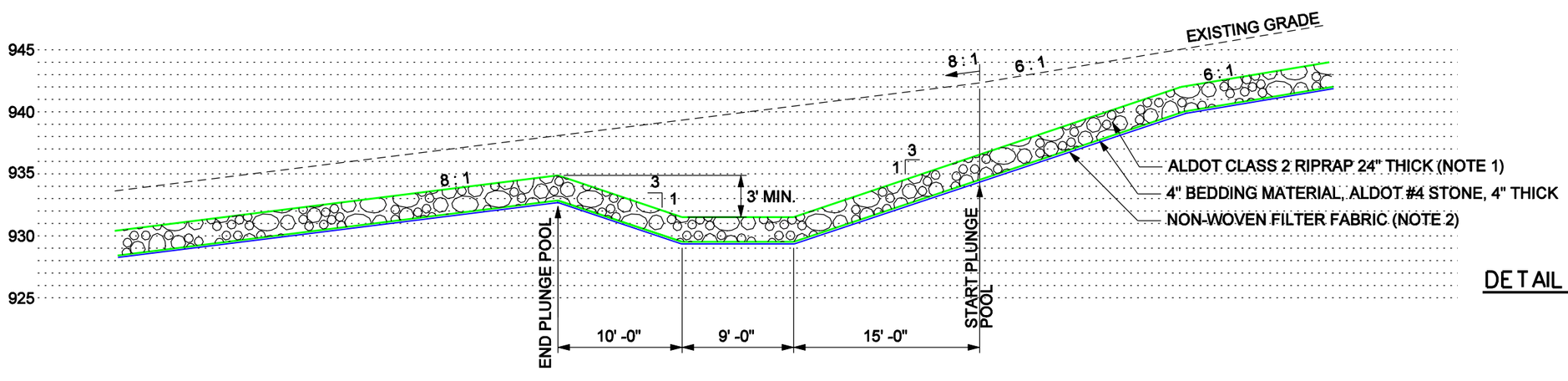


PLUNGE POOL PLAN VIEW - SECONDARY GULLY #3

SCALE: 1"=10'-0"

NOTES

1. ALABAMA DOT CLASS 2 RIPRAP, INSTALL PER ALABAMA DOT, 2008.
2. MIRAFI 180N OR EQUAL. INSTALL PER ALABAMA DOT, 2002.



DETAIL 5

PLUNGE POOL CROSS SECTION B-B - SECONDARY GULLY #3

SCALE: 1"=10'-0"

0 5' 10' 20' 30'

SCALE: 1"= 10'

STORM WATER EROSION CONTROL DETAILS
RANGE 20, PARCEL 76Q-X
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA

Shaw Shaw Environmental, Inc.

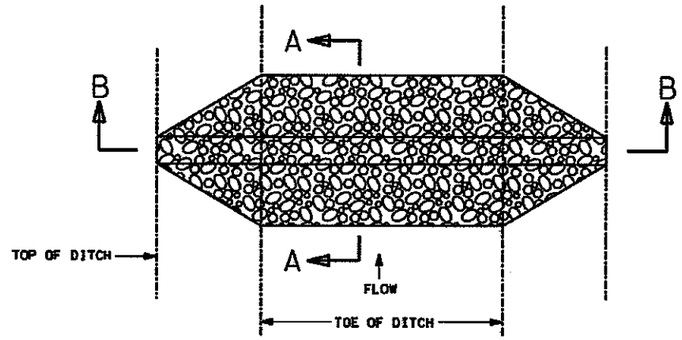
STARTING DATE: 06/03/2010	DATE LAST REV.: 06/18/2010	DRAFT. CHCK. BY: G. SWANSON	INITIATOR: G. SWANSON	DWG. NO.: $$$$FILE$$$$	
DRAWN BY: R. HUBBARD	DRAWN BY: R. HUBBARD	ENGR. CHCK. BY: G. SWANSON	PROJ. MGR.: T. WINTON	PROJ. NO.: 800486	

$$$$DATE$$$$
$$$$PENTBL$$$$
$$$$TIME$$$$

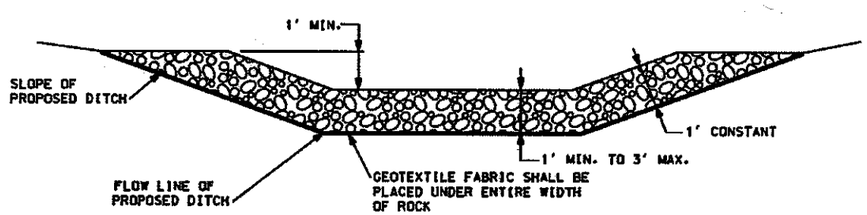
$$$$USER$$$$
$$$$PLTDRV$$$$
$$$$FILE$$$$

REFERENCE PROJECT NO	FISCAL YEAR	SHEET NO

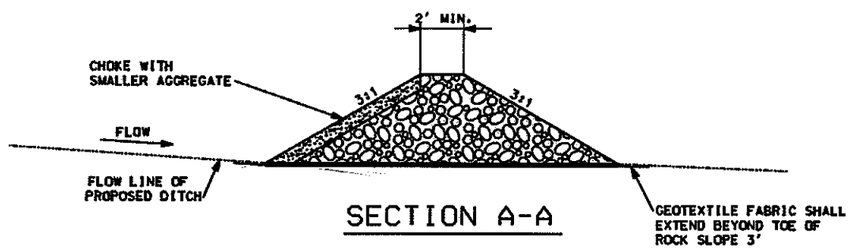
AL DOT 2008



PLAN VIEW
DETAIL FOR TRAPEZOIDAL DITCH

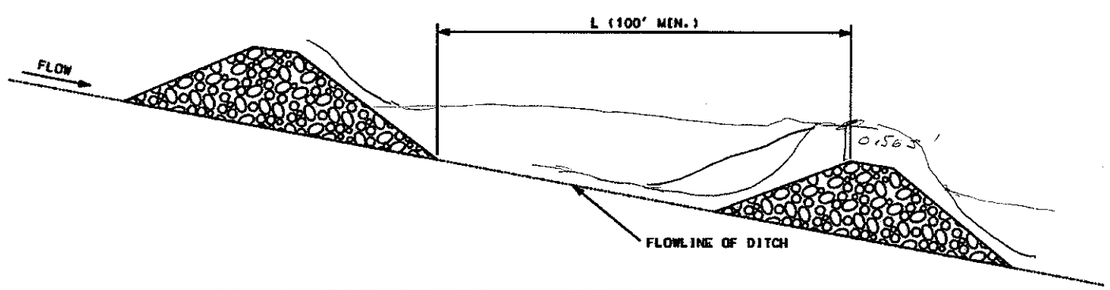


SECTION B-B



SECTION A-A

TEMPORARY ROCK DITCH CHECKS IN ROADSIDE DITCHES



DETAIL FOR SPACING BETWEEN DITCH CHECKS

NOTES:
1. MINIMUM SPACING FOR ROCK DITCH CHECKS SHALL BE 100 FEET OR AS DIRECTED BY THE ENGINEER. SEE SPACING GUIDANCE ON SHT.1 OF 7.
2. ROCK DITCH CHECKS MAY ALSO BE CHOKED WITH FABRIC.

ROCK DITCH CHECK SELECTION GUIDELINES

THE TYPE AND SIZE OF ROCK USED TO CONSTRUCT THE CHECK WILL BE SELECTED BY THE DESIGNER AND SHOWN ON THE PLANS. THE SIZE OF ROCK CHOSEN WILL BE PROPORTIONAL TO EXPECTED FLOWS AND VELOCITIES. SEDIMENT TRAPPING EFFECTIVENESS MAY BE ADJUSTED BY CHOKING.

--SPECIFICATIONS--
CURRENT ALABAMA DEPARTMENT OF TRANSPORTATION

THIS DRAWING REPRESENTS DESIGNS PREPARED FOR USE BY THE ALABAMA DEPARTMENT OF TRANSPORTATION AND IS NOT TO BE COPIED, REPRODUCED, ALTERED, OR USED BY ANYONE, OR ANY ORGANIZATION, WITHOUT THE EXPRESSED WRITTEN CONSENT OF THE ALABAMA DEPARTMENT OF TRANSPORTATION REPRESENTATIVE AUTHORIZED TO APPROVE THIS USE. ANYONE MAKING UNAUTHORIZED USE OF THIS DRAWING MAY BE PROSECUTED TO THE FULLEST EXTENT OF THE LAW.

REVISIONS

ALABAMA DEPARTMENT OF TRANSPORTATION
1409 COLISEUM BOULEVARD
MONTGOMERY, AL 36130-3050

DESIGN BUREAU SPECIAL DRAWING

ROCK DITCH CHECK

DRAWN BY:
DATE DRAWN: 2006

SPECIAL DRAWING NO.: ESC-300 (SHEET 6 OF 7)

INDEX NO.: 1162-E

NOT TO SCALE

CALCULATIONS

Calculations - Stormwater Channel Design
Fort McClellan
Range 20, Parcel 76Q-X
June 14, 2010

1. Problem Statement: Design erosion control channel for Primary and Secondary Gullies at Range 20, Parcel 76Q-X, Fort McClellan, Alabama.

2. Given:
Site plan provided by Fort McClellan Shaw Environmental (Shaw, 2010).

3. Assumptions:
Use conservative runoff coefficient of 0.4.
Trapezoidal channel

4. Calculations:
a. Determine area contributing runoff to stormwater erosion channel.

Area	Length 1, ft	Length 2, ft	Width 1, ft	Width 2, ft	Shape Factor	Area, sf	
A' &A	395	350	160	140	1	55,875	
B'	385	395	180	165	1	67,275	
C'	300	385	280	300	1	99,325	
D	300	305	175	165	1	51,425	
E	305	270	320	260	1	83,375	
F	250	165	135	130	1	27,494	
G	110		165		0.5	9,075	
H	130		150		0.5	9,750	
					TOTAL	403,594	sf
						9.3	acres

Calculations - Stormwater Channel Design
Fort McClellan
Range 20, Parcel 76Q-X
June 14, 2010

b. Use the Rational Formula to determine peak flow.
Q=CIA
where
Q = the peak runoff rate (cfs)
C = Runoff Coefficient, for forested and pasture, range is 0.05 to 0.3 (Lindeburg, 1992), use 0.4 for conservative max runoff.
I = the average rainfall intensity (in/hr), lasting for a critical period of time tc.
A = the size of the drainage area (acres)

tc = time of concentration, duration betweeen the start of rainfall and the time of peak flow. Used to determine rainfall intensity. Typical duration values for areas less than 50 acres range from 5 to 30 minutes, typically can assume 10 minutes (Lindeburg, 1992). The duration is usually equivalent to the tc of the drainage area.

Determine tc.
Two flow paths -
tc1 from uppermost back road to mouth of primary gully - 760 ft, 33% slope, from attached Figure 5-4, velocity is 1.5 fps
tc2 primary gully to existing surface drainage feature - 580 ft, 13% slope , from calcs, velocity is 8 fps.

	velocity, fps	Flow path, ft	tc, minutes	
tc1	1.5	760	8.4	
tc2	8	580	1.2	
total tc			9.7	use 10 minutes for duration

From NOAA, 1977 for a 100 year storm, interpolation of 5 and 15 minute precipitation estimates
a rainfall intensity for a 10-minute duration of 1.4 inches/hour
or 60-minute duration of 8.4 inches/hour for Calhoun County, Alabama.

C =	0.4	unitless
I=	8.4	inches/hr
A =	9.3	acres
Q =	31.1	cfs

d. Use Mannings equation to determine channel dimensions.
Mannings equation is used for channel design
$Q=(1.49/n)\ (r_H{}^{2/3})\ (A)\ (S^{0.5})$
where
Q = Peak Flow, cfs
n = Mannings roughness constant, use 0.03 for rip rap (Chow, 1959)
rH = Hydraulic Radius, sf/ft
A = Flow Area, sf
S = channel slope, ft/ft

and
b= bottom width, ft
D= depth of water, ft

the hydraulic radius is
rH = A/P
where
P= wetted perimeter, ft

Calculations - Stormwater Channel Design
Fort McClellan
Range 20, Parcel 76Q-X
June 14, 2010

Determine Slope (S)

Length =		580	ft
Top Elevation =		985	ft
Bottom Elev. =		912	ft
S =		0.13	ft/ft

Using Brater & King, 1982 to find depth of flow (b)

K' = (Q*n)/(b^8/3*S^1/2) where b is known, find D

Q=	31.1	cfs
n=	0.03	
S=	0.13	ft/ft
b=	3	ft

2: 1 horizontal to vertical sideslopes of channel

K' = 0.5700 Go to Brater & King, 1982 to find D/b, pg 7-45

Note: most efficient trapezoidal channel has D/b of 0.87 (Lindeburg, 1992, p5-6).

from Brater & King, 1982

3: 1 horizontal to vertical sideslopes of channel

D/b =	0.21	from Brater & King, 1982		
D=	0.63	ft		
D=	7.6	in		

e. Check

see Brater & King, 1982, p 7-3.

b=	3	ft	
D=	0.63	ft	
H:V factor	3.00		
e=	1.89	ft	
A=	3.08	sf	
p=	6.98	ft	
r_H=	0.44	ft	
Q=	31.4	cfs	ok
V=	10.2	fps	

Calculations - Stormwater Channel Design
Fort McClellan
Range 20, Parcel 76Q-X
June 14, 2010

f. Determine D_{50} of Riprap

from pg 235 Alabama, 2009.

For swale slopes between 10% and 40%: $d50 = [q\ (S^{0.58})/3.93(10^{-2})]^{1/1.89}$

d50 = Particle size for which 50 % of the sample is finer, inch

S = Bed slope, ft./ft.

q = Unit discharge, ft3/s/ft (Total discharge / Bottom width)

S=	0.13	ft/ft
q=	10.4	cfs/ft
d50 =	10.1	inches
d50 =	0.8	feet

From Table RS-1 Alabama, 2009

D_{50} riprip less than 50 lbs, may use Class 1 riprap (Alabama DOT, 2002)

g. Check Hydraulic Jump at Rock Ditch Check Dams.

See attached calculations from www.onlinecalc.sdsu.edu

Height of water over ditch check dams is approximately

18-inches leaving available freeboard of 6 inches for 100 yr storm.

5. Recommendation:
Construct a channel with the following:
Estimated Flow for 100 year storm = 31.1 cfm
trapezoidal cross section
bottom width of channel (b) = 3 feet
top width of channel = 15 feet
depth of channel = 36 inches
sidewall slope = 3H:1V
Rip Rap layer thickness =24 inches
AL DOT Class #4 Stone, 4" bedding material.
Use Rip Rap Class 2 (Alabama DOT), conservative approach

6. References:
State of Alabama Department of Transportation (Alabama DOT), 2002, Standard Specifications for Highway Construction.
State of Alabama Soil & Water Conservation Committee (Alabama), 2009, Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas, March.
Brater & King, 1982, Handbook of Hydraulics
Chow, 1959, Open Channel Hydraulics.
Lindeburg, 1992, Civil Engineering Reference Manual, Sixth Edition.
NOAA, 1977, Five to 60 Minute Precipitation Frequency for the Eastern and Central United States, NOAA Technical Memorandum NWS HYDRO-35.
Shaw Environmental, 2010, Figure 1, Topographic Map Range 20, Parcel 76Q-X.
Van Haveren, 1986, Water Resource Measurements, A Handbook for Hydrologists and Engineers, AWWA.
Viessman et al, 1977, Introduction to Hydrology, Second Edition.

Calculations - Stormwater Channel Design
Fort McClellan
Range 20, Parcel 76Q-X
June 14, 2010

1. Problem Statement: Design erosion control channel for Roadside Ditch at Range 20, Parcel 76Q-X, Fort McClellan, Alabama.

2. Given:
Site plan provided by Fort McClellan Shaw Environmental (Shaw, 2010).

3. Assumptions:
Use conservative runoff coefficient of 0.4.
Trapezoidal channel

4. Calculations:
a. Determine area contributing runoff to stormwater erosion channel.

Area	Length 1, ft	Length 2, ft	Width 1, ft	Width 2, ft	Shape Factor	Area, sf	
A"	150	140	65	85	1	10,875	
B"	165	160	85	65	1	12,188	
C"	300	290	160	85	1	36,138	
					TOTAL	59,200	sf
						1.4	acres

Calculations - Stormwater Channel Design
Fort McClellan
Range 20, Parcel 76Q-X
June 14, 2010

b. Use the Rational Formula to determine peak flow.
Q=CIA
where
Q = the peak runoff rate (cfs)
C = Runoff Coefficient, for forested and pasture, range is 0.05 to 0.3 (Lindeburg, 1992), use 0.4 for conservative max runoff.
I = the average rainfall intensity (in/hr), lasting for a critical period of time tc.
A = the size of the drainage area (acres)

tc = time of concentration, duration betweeen the start of rainfall and the time of peak flow. Used to determine rainfall intensity. Typical duration values for areas less than 50 acres range from 5 to 30 minutes, typically can assume 10 minutes (Lindeburg, 1992). The duration is usually equivalent to the tc of the drainage area.

Determine tc.
Two flow paths -
tc1 from uppermost back road to mouth of proposed roadside ditch - 580 ft, 33% slope, from attached Figure 5-4, velocity is 1.5 fps
tc2 roadside ditch to existing surface drainage feature - 200 ft, 2.5% slope , from calcs, velocity is 3 fps.

	velocity, fps	Flow path, ft	tc, minutes	
tc1	1.5	580	6.4	
tc2	8	160	0.3	
total tc			6.8	use 10 minutes for duration

From NOAA, 1977 for a 100 year storm, interpolation of 5 and 15 minute precipitation estimates
a rainfall intensity for a 10-minute duration of 1.4 inches/hour
or 60-minute duration of 8.4 inches/hour for Calhoun County, Alabama.

C =	0.4	unitless
I=	8.4	inches/hr
A =	1.4	acres
Q =	4.6	cfs

d. Use Mannings equation to determine channel dimensions.
Mannings equation is used for channel design
$Q=(1.49/n)\ (r_H{}^{2/3})\ (A)\ (S^{0.5})$
where
Q = Peak Flow, cfs
n = Mannings roughness constant, use 0.03 for rip rap (Chow, 1959)
rH = Hydraulic Radius, sf/ft
A = Flow Area, sf
S = channel slope, ft/ft

and
b= bottom width, ft
D= depth of water, ft

the hydraulic radius is
rH = A/P
where
P= wetted perimeter, ft

Calculations - Stormwater Channel Design
Fort McClellan
Range 20, Parcel 76Q-X
June 14, 2010

Determine Slope (S)

Length =		200	ft
Top Elevation =		1050	ft
Bottom Elev. =		1045	ft
S =		0.03	ft/ft

Using Brater & King, 1982 to find depth of flow (b)

K' = (Q*n)/(b^8/3*S^1/2) where b is known, find D

Q=	4.6	cfs
n=	0.03	
S=	0.03	ft/ft
b=	1	ft

K' = 0.8664 Go to Brater & King, 1982 to find D/b, pg 7-45

Note: most efficient trapezoidal channel has D/b of 0.87 (Lindeburg, 1992, p5-6).

from Brater & King, 1982

2: 1 horizontal to vertical sideslopes of channel

D/b =	0.57	from Brater & King, 1982		
D=	0.57	ft		
D=	6.8	in		

e. Check

see Brater & King, 1982, p 7-3.

b=	1	ft	
D=	0.57	ft	
H:V factor	1.00		
e=	0.57	ft	
A=	0.89	sf	
p=	2.61	ft	
r_H=	0.34	ft	
Q=	3.4	cfs	ok
V=	3.8	fps	

f. Determine D_{50} of Riprap (if needed)

from pg 235 Alabama, 2009.

For swale slopes between 10% and 40%: $d50 = [q\ (S^{0.58})/3.93(10^{-2})]^{1/1.89}$

d50 = Particle size for which 50 % of the sample is finer, inch

S = Bed slope, ft./ft.

q = Unit discharge, ft3/s/ft (Total discharge / Bottom width)

S=	0.03	ft/ft
q=	4.6	cfs/ft
d50 =	4.0	inches
d50 =	0.3	feet

From Table RS-1 Alabama, 2009

D_{50} riprip less than 50 lbs, may use Class 1 riprap (Alabama DOT, 2002)

5. Recommendation:

Construct a channel with the following:
Estimated Flow for 100 year storm = 4.6 cfm
trapezoidal cross section
bottom width of channel (b) = 12 inches
top width of channel = 60 inches
depth of channel = 12 inches
Armor with Turf Reinforcement Matting - North American Green VMax SC250 or equal

6. References:

State of Alabama Department of Transportation (Alabama DOT), 2002, Standard Specifications for Highway Construction.
State of Alabama Soil & Water Conservation Committee (Alabama), 2009, Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas, March.
Brater & King, 1982, Handbook of Hydraulics
Chow, 1959, Open Channel Hydraulics.
Lindeburg, 1992, Civil Engineering Reference Manual, Sixth Edition.
NOAA, 1977, Five to 60 Minute Precipitation Frequency for the Eastern and Central United States, NOAA Technical Memorandum NWS HYDRO-35.
Shaw Environmental, 2010, Figure 1, Topographic Map Range 20, Parcel 76Q-X.
Van Haveren, 1986, Water Resource Measurements, A Handbook for Hydrologists and Engineers, AWWA.

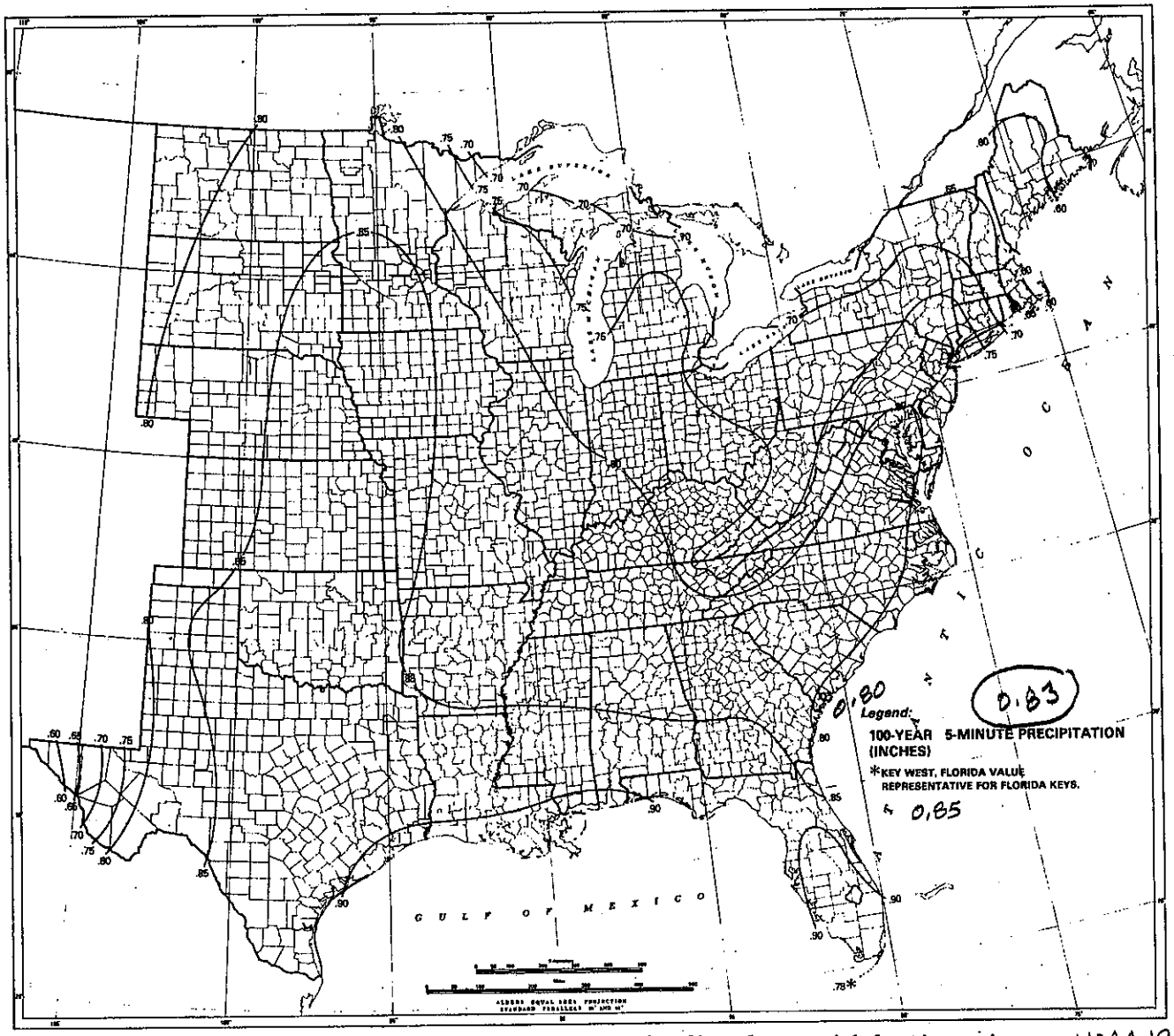


Figure 7.--100-year 5-minute precipitation (inches)--adjusted to partial-duration series. NOAA 1977

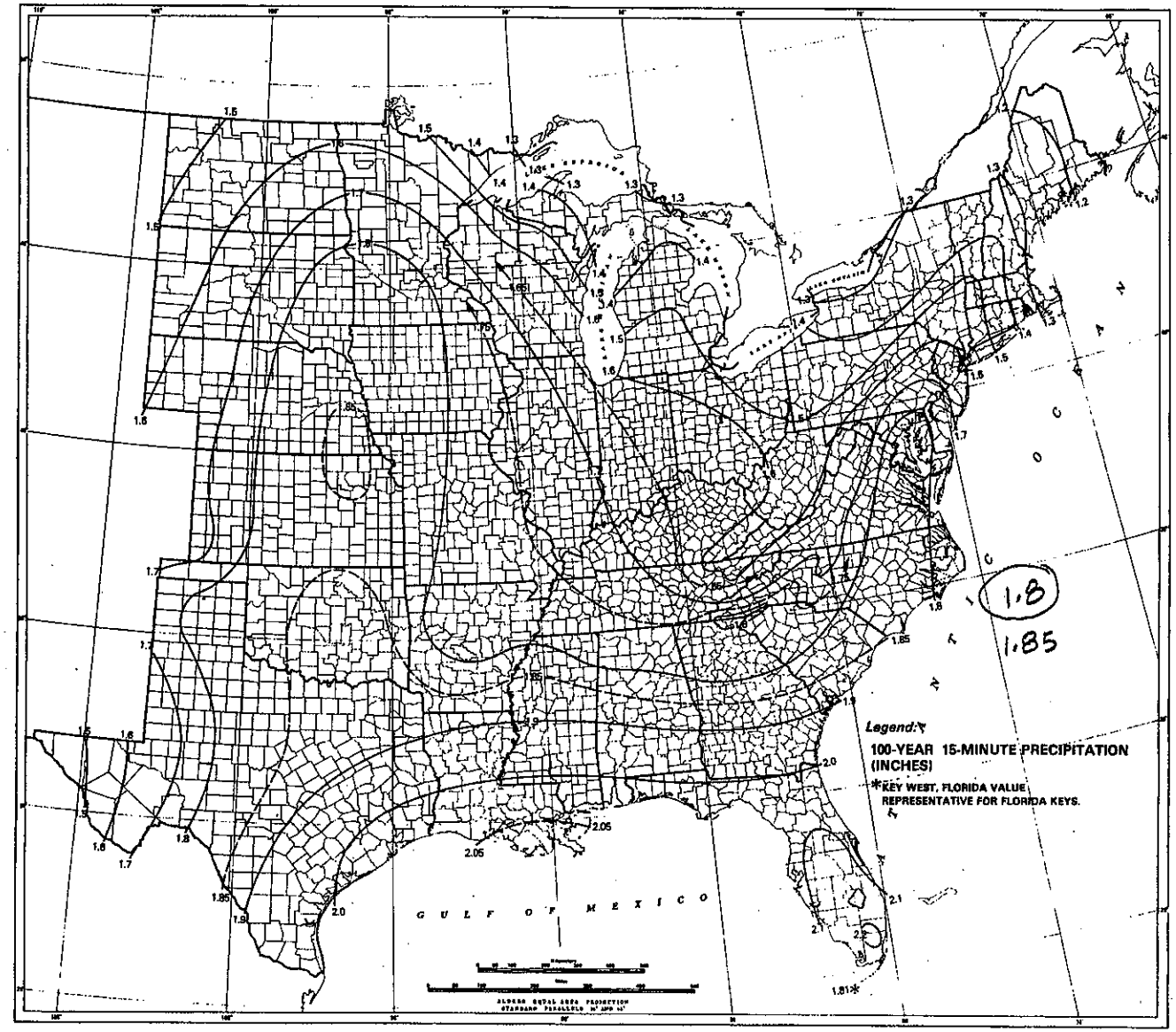


Figure 9.--100-year 15-minute precipitation (inches)--adjusted to partial-duration series.

NOAA, 1977

Section 5: Time of Concentration

Description

Several common hydrologic methods require an estimation of the time of concentration. This section provides guidance on ways to estimate time of concentration and covers the following topics: description, flow components, and procedure estimate time of concentration. For additional information on time of concentration, refer to the TR55. You may use oth published methods at your discretion subject to the documented limitations of the methods.

Time of Concentration

The time of concentration (t_c) is the time at which the entire watershed begins to contribute to runoff; this is calculated a the time taken for runoff to flow from the most hydraulically remote point of the drainage area to the point under investigation. Use of the rational formula requires the time of concentration for each design point within the drainage basin. The duration of rainfall is then set equal to the time of concentration and is used to estimate the design average rainfall intensity (I). There may be a number of possible paths to consider in determining the longest travel time. Identif the flow path along which the longest travel time is likely to occur. This is a trial and error process.

Generally, it is reasonable to consider three following components of flow that can characterize the progression of runof along a travel path: overland flow (sheet flow), shallow concentrated flow, and conduit and open channel flow (or concentrated channel flow).

One way to estimate the overland flow time is to use Figure 5-4 through Figure 5-7 to estimate overland flow velocity fo a chosen path length. The path length divided by the velocity yields a travel time. For design conditions that do not involve complex drainage conditions, use Figure 5-4 and Figure 5-5. This method is most appropriate for distances of up to 525 ft. (160 m) over open paved and grassed areas such as parking lots, roadways, verges, and landscaped areas.

For each drainage area, determine the distance (L) from the outlet of the drainage area to the most remote point. Determine the average slope (S) for the same distance. Refer to Section 6 for discussion of the runoff coefficient(C).

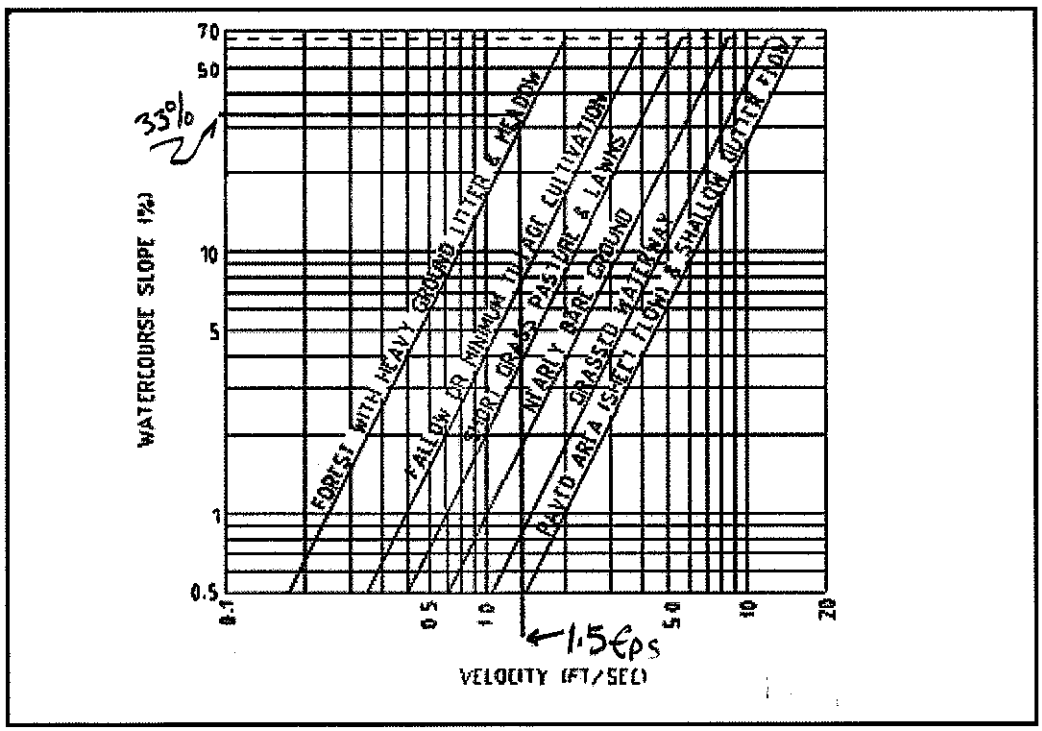


Figure 5-4. Velocities for Upland Method of Estimating Time of Concentration--English (Adapted from the National Engineering Handbook Volume 4)

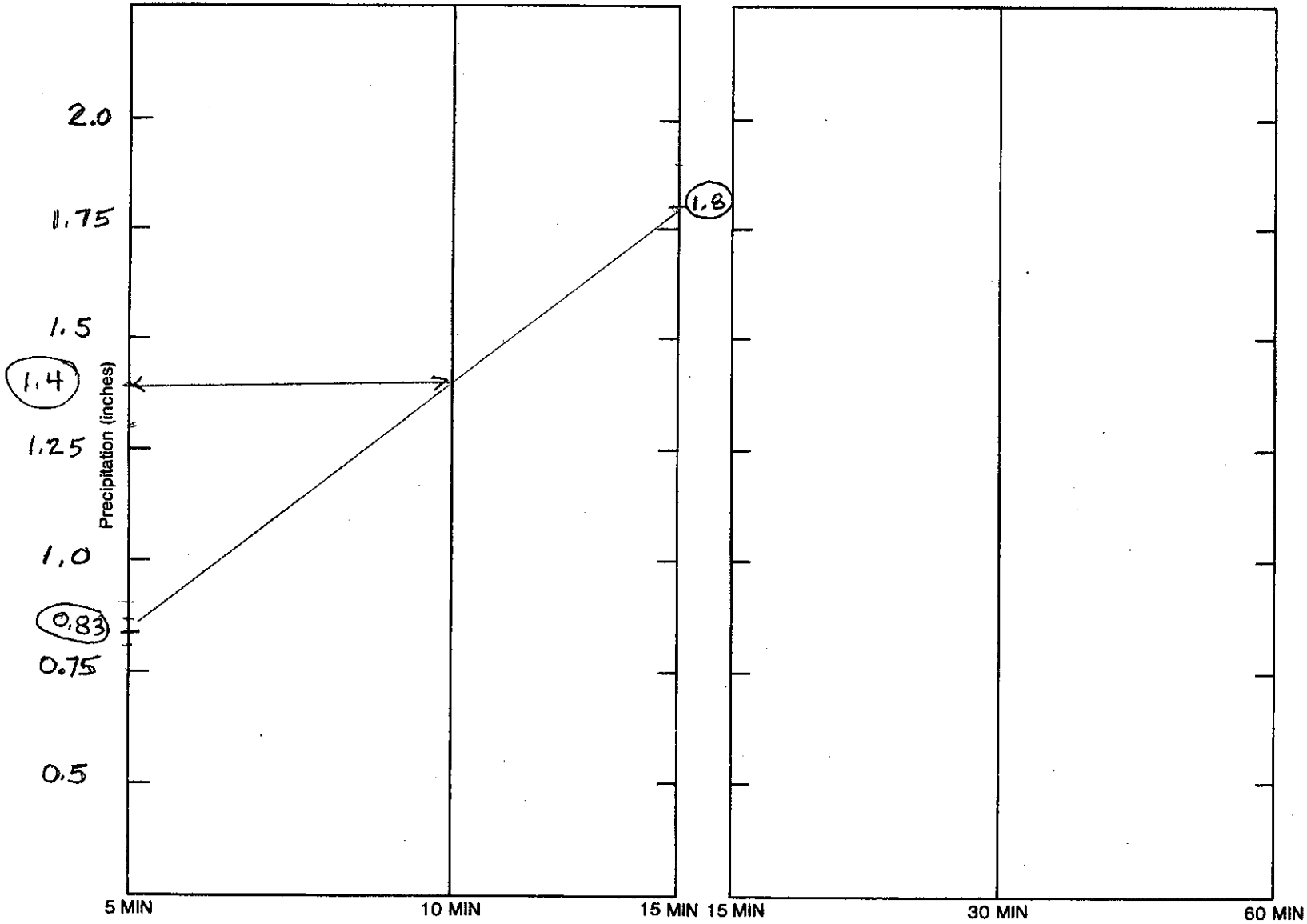


Figure 10.--Duration-interpolation diagram for 10- and 30-min estimates.

NOAA, 1977

LINDEBURG, 1992

Appendix A: Rational Method Runoff Coefficients

C

more severe events

categorized by surface	≈10yr	≈25-50yr
forested	0.059–0.2	
asphalt	0.7–0.95	
brick	0.7–0.85	
concrete	0.8–0.95	
shingle roof	0.75–0.95	
lawns, well drained (sandy soil)		
up to 2% slope	0.05–0.1	
2% to 7% slope	0.10–0.15	
over 7% slope	0.15–0.2	
lawns, poor drainage (clay soil)		
up to 2% slope	0.13–0.17	
2% to 7% slope	0.18–0.22	
over 7% slope	0.25–0.35	
driveways, walkways	0.75–0.85	

categorized by use	
farmland	0.05–0.3
pasture	0.05–0.3
unimproved	0.1–0.3
parks	0.1–0.25
cemeteries	0.1–0.25
railroad yard	0.2–0.40
playgrounds (except asphalt or concrete)	0.2–0.35
business districts	
neighborhood	0.5–0.7
city (downtown)	0.7–0.95
residential	
single family	0.3–0.5
multi-plexes, detached	0.4–0.6
multi-plexes, attached	0.6–0.75
suburban	0.25–0.4
apartments, condominiums	0.5–0.7
industrial	
light	0.5–0.8
heavy	0.6–0.9

Chow, 1959

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n
(**Boldface** figures are values generally recommended in design)

Type of channel and description	Minimum	Normal	Maximum
A. CLOSED CONDUITS FLOWING PARTLY FULL			
A-1. Metal			
a. Brass, smooth	0.009	**0.010**	0.013
b. Steel			
1. Lockbar and welded	0.010	0.012	0.014
2. Riveted and spiral	0.013	0.016	0.017
c. Cast iron			
1. Coated	0.010	0.013	0.014
2. Uncoated	0.011	0.014	0.016
d. Wrought iron			
1. Black	0.012	0.014	0.015
2. Galvanized	0.013	0.016	0.017
e. Corrugated metal			
1. Subdrain	0.017	0.019	0.021
2. Storm drain	0.021	**0.024**	0.030
A-2. Nonmetal			
a. Lucite	0.008	0.009	0.010
b. Glass	0.009	**0.010**	0.013
c. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
d. Concrete			
1. Culvert, straight and free of debris	0.010	0.011	0.013
2. Culvert with bends, connections, and some debris	0.011	**0.013**	0.014
3. Finished	0.011	0.012	0.014
4. Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
5. Unfinished, steel form	0.012	0.013	0.014
6. Unfinished, smooth wood form	0.012	**0.014**	0.016
7. Unfinished, rough wood form	0.015	0.017	0.020
e. Wood			
1. Stave	0.010	0.012	0.014
2. Laminated, treated	0.015	0.017	0.020
f. Clay			
1. Common drainage tile	0.011	**0.013**	0.017
2. Vitrified sewer	0.011	0.014	0.017
3. Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
4. Vitrified subdrain with open joint	0.014	**0.016**	**0.018**
g. Brickwork			
1. Glazed	0.011	0.013	0.015
2. Lined with cement mortar	0.012	0.015	0.017
h. Sanitary sewers coated with sewage slimes, with bends and connections	0.012	0.013	0.016
i. Paved invert, sewer, smooth bottom	0.016	0.019	0.020
j. Rubble masonry, cemented	0.018	0.025	0.030

TABLE 5-6. VALUES OF THE ROUGHNESS COEFFICIENT n (*continued*)

Type of channel and description	Minimum	Normal	Maximum
B. LINED OR BUILT-UP CHANNELS			
B-1. Metal			
a. Smooth steel surface			
1. Unpainted	0.011	**0.012**	0.014
2. Painted	0.012	0.013	0.017
b. Corrugated	0.021	0.025	0.030
B-2. Nonmetal			
a. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
b. Wood			
1. Planed, untreated	0.010	0.012	0.014
2. Planed, creosoted	0.011	0.012	0.015
3. Unplaned	0.011	0.013	0.015
4. Plank with battens	0.012	0.015	0.018
5. Lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. Trowel finish	0.011	**0.013**	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	
8. On irregular excavated rock	0.022	0.027	
d. Concrete bottom float finished with sides of			
1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. Glazed	0.011	**0.013**	0.015
2. In cement mortar	0.012	**0.015**	0.018
g. Masonry			
1. Cemented rubble	0.017	0.025	0.030
2. Dry rubble	0.023	0.032	0.035
h. Dressed ashlar	0.013	0.015	0.017
i. Asphalt			
1. Smooth	0.013	0.013	
2. Rough	0.016	0.016	
j. Vegetal lining	0.030	.....	0.500

BRATER & KING, 1982

The *wetted perimeter* p is the length of the line of intersection of the plane of the cross section with the wetted surface of the channel, the line *abc* (Fig. 7-1).

The *hydraulic radius* $r = a/p$ is the area divided by the wetted perimeter.

The *depth* D (Fig. 7-1), if not specified otherwise, refers to the maximum depth of water in the cross section.

The *top width* T (Fig. 7-1) is the term used to designate the width of cross section at the water surface.

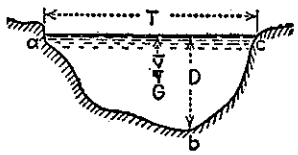


FIG. 7-1. Cross section of open channel.

The *mean depth* $D_m = a/T$ is the area of cross section divided by the top width. This term will be applied generally to all sections, but it is not literally descriptive of channels with overhanging sides, such as circular conduits flowing more than half full.

The *depth to center of gravity* $\bar{y}$ (Fig. 7-1) is the depth to the center of gravity of the cross section of the stream.

The above terms and symbols are all used in the discussions and formulas contained in this and the following section. The hydraulic radius enters into formulas involving velocity or discharge. The mean depth occurs in the criterion for indicating when flow in a channel is at critical depth (p. 8-8). The depth to center of gravity of a cross section is employed in determining hydrostatic pressures in problems involving sudden changes in depth of flow.

Sectional Forms. Most of the sectional forms used for open channels are shown in Fig. 7-2. It is convenient to have tables which facilitate the determination of numerical values of the elements of a cross section. The equations used in deriving these tables are shown for trapezoidal sections only. Similar equations were derived and used for developing the tables for circular and parabolic sections.

The *trapezoidal section* (Fig. 7-2*a*) is always used for earth canals. Ordinary earth sections have relatively flat side slopes, usually not steeper than 1:1 in cut and 1½:1 in fill. In rock, hardpan, or other indurated material and for lined canals, trapezoidal sections with very steep side slopes are often employed. It is not uncommon to have different side slopes on

the two sides of a canal. Often the uphill side of an earth canal will have a steeper slope than the downhill side.

As indicated in Fig. 7-2*a*, D is the maximum depth of water and b is the bottom width of the canal. The area of the

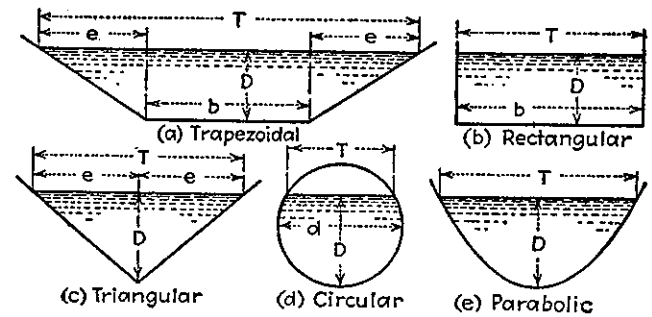


FIG. 7-2. Simple forms of channel sections.

trapezoidal section is

$$a = eD + bD \tag{7-1}$$

and letting

$$z = \frac{e}{D} \tag{7-2}$$

and

$$x = \frac{D}{b} \tag{7-3}$$

then

$$a = \left(z + \frac{1}{x}\right) D^2 \tag{7-4}$$

The wetted perimeter is

$$p = b + 2(e^2 + D^2)^{1/2} \tag{7-5}$$

or substituting for b and e as above,

$$p = \left[\frac{1}{x} + 2(z^2 + 1)^{1/2}\right] D \tag{7-6}$$

Then

$$r = \frac{a}{p} = \frac{1/x + z}{[1/x + 2(z^2 + 1)^{1/2}]} D = C_r D \tag{7-7}$$

Values of C_r as functions of x and z are presented in Table 7-1. The top width is

$$T = b + 2e = \left(\frac{1}{x} + 2z\right) D \tag{7-8}$$

Depth & width

BRATER & KING, 1982

Table 7-10. Values of K in Formula $Q = \frac{K}{n} D^{8/3} s^{1/2}$ for Trapezoidal Channels (*Concluded*)

D = depth of water b = bottom width of channel

$\frac{D}{b}$	Side slopes of channel, ratio of horizontal to vertical									
	Vertical	¼–1	½–1	¾–1	1–1	1½–1	2–1	2½–1	3–1	4–1
1.81	.296	.543	.817	1.10	1.37	1.90	2.41	2.91	3.40	4.36
1.82	.293	.540	.813	1.09	1.37	1.90	2.41	2.91	3.39	4.36
1.83	.291	.537	.810	1.09	1.37	1.90	2.41	2.90	3.39	4.35
1.84	.289	.534	.807	1.09	1.36	1.89	2.40	2.90	3.39	4.35
1.85	.286	.531	.804	1.08	1.36	1.89	2.40	2.90	3.38	4.34
1.86	.284	.528	.801	1.08	1.36	1.89	2.40	2.89	3.38	4.34
1.87	.282	.525	.797	1.08	1.35	1.88	2.39	2.89	3.38	4.34
1.88	.279	.522	.794	1.07	1.35	1.88	2.39	2.88	3.37	4.33
1.89	.277	.520	.791	1.07	1.35	1.88	2.39	2.88	3.37	4.33
1.90	.275	.517	.788	1.07	1.34	1.87	2.38	2.88	3.37	4.33
1.91	.273	.514	.785	1.06	1.34	1.87	2.38	2.87	3.36	4.32
1.92	.270	.512	.782	1.06	1.34	1.87	2.38	2.87	3.36	4.32
1.93	.268	.509	.779	1.06	1.33	1.86	2.37	2.87	3.36	4.32
1.94	.266	.506	.776	1.05	1.33	1.86	2.37	2.86	3.35	4.31
1.95	.264	.504	.774	1.05	1.33	1.86	2.37	2.86	3.35	4.31
1.96	.262	.501	.771	1.05	1.32	1.85	2.36	2.86	3.35	4.31
1.97	.260	.499	.768	1.04	1.32	1.85	2.36	2.85	3.34	4.30
1.98	.258	.496	.765	1.04	1.32	1.85	2.36	2.85	3.34	4.30
1.99	.256	.494	.762	1.04	1.31	1.84	2.35	2.85	3.34	4.30
2.00	.254	.491	.760	1.04	1.31	1.84	2.35	2.84	3.33	4.29
2.01	.252	.489	.757	1.03	1.31	1.84	2.35	2.84	3.33	4.29
2.02	.250	.487	.754	1.03	1.30	1.83	2.34	2.84	3.33	4.29
2.03	.248	.484	.752	1.03	1.30	1.83	2.34	2.84	3.32	4.28
2.04	.247	.482	.749	1.02	1.30	1.83	2.34	2.83	3.32	4.28
2.05	.245	.480	.746	1.02	1.30	1.82	2.33	2.83	3.32	4.28
2.06	.243	.477	.744	1.02	1.29	1.82	2.33	2.83	3.31	4.28
2.07	.241	.475	.741	1.02	1.29	1.82	2.33	2.82	3.31	4.27
2.08	.239	.473	.739	1.01	1.29	1.82	2.33	2.82	3.31	4.27
2.09	.237	.471	.736	1.01	1.28	1.81	2.32	2.82	3.31	4.27
2.10	.236	.469	.734	1.01	1.28	1.81	2.32	2.81	3.30	4.26
2.11	.234	.466	.732	1.006	1.28	1.81	2.32	2.81	3.30	4.26
2.12	.232	.464	.729	1.004	1.28	1.81	2.31	2.81	3.30	4.26
2.13	.231	.462	.727	1.001	1.27	1.80	2.31	2.81	3.29	4.26
2.14	.229	.460	.724	.999	1.27	1.80	2.31	2.80	3.29	4.25
2.15	.227	.458	.722	.996	1.27	1.80	2.31	2.80	3.29	4.25
2.16	.226	.456	.720	.994	1.27	1.79	2.30	2.80	3.29	4.25
2.17	.224	.454	.718	.991	1.26	1.79	2.30	2.80	3.28	4.24
2.18	.223	.452	.715	.989	1.26	1.79	2.30	2.79	3.28	4.24
2.19	.221	.450	.713	.987	1.26	1.79	2.29	2.79	3.28	4.24
2.20	.219	.448	.711	.984	1.26	1.78	2.29	2.79	3.28	4.24
2.21	.218	.446	.709	.982	1.25	1.78	2.29	2.78	3.27	4.23
2.22	.216	.444	.706	.980	1.25	1.78	2.29	2.78	3.27	4.23
2.23	.215	.442	.704	.977	1.25	1.78	2.28	2.78	3.27	4.23
2.24	.213	.440	.702	.975	1.25	1.77	2.28	2.78	3.26	4.23
2.25	.212	.439	.700	.973	1.24	1.77	2.28	2.77	3.26	4.22
∞	.000	.091	.274	.500	.743	1.24	1.74	2.23	2.71	3.67

Know D,
Find b.

$K' = \frac{Qn}{b^{8/3} s^{1/2}}$ find D

Table 7-11. Values of K' in Formula $Q = \frac{K'}{n} b^{8/3} s^{1/2}$ for Trapezoidal Channels

D = depth of water b = bottom width of channel

$\frac{D}{b}$	Side slopes of channel, ratio of horizontal to vertical									
	Vertical	¼–1	½–1	¾–1	1–1	1½–1	2–1	2½–1	3–1	4–1
.01	.00068	.00068	.00069	.00069	.00069	.00069	.00069	.00069	.00070	.00070
.02	.00213	.00215	.00216	.00217	.00218	.00220	.00221	.00222	.00223	.00225
.03	.00414	.00419	.00423	.00426	.00428	.00433	.00436	.00439	.00443	.00449
.04	.00660	.00670	.00679	.00685	.00691	.00700	.00708	.00716	.00723	.00736
.05	.00946	.00964	.00979	.00991	.01002	.01019	.01033	.01047	.01060	.01086
.06	.0127	.0130	.0132	.0134	.0136	.0138	.0141	.0143	.0145	.0150
.07	.0162	.0166	.0170	.0173	.0175	.0180	.0183	.0187	.0190	.0197
.08	.0200	.0206	.0211	.0215	.0219	.0225	.0231	.0236	.0240	.0250
.09	.0241	.0249	.0256	.0262	.0267	.0275	.0282	.0289	.0296	.0310
.10	.0284	.0294	.0304	.0311	.0318	.0329	.0339	.0348	.0358	.0376
.11	.0329	.0343	.0354	.0364	.0373	.0387	.0400	.0413	.0424	.0448
.12	.0376	.0393	.0408	.0420	.0431	.0450	.0466	.0482	.0497	.0527
.13	.0425	.0446	.0464	.0480	.0493	.0516	.0537	.0556	.0575	.0613
.14	.0476	.0502	.0524	.0542	.0559	.0587	.0612	.0636	.0659	.0706
.15	.0528	.0559	.0585	.0608	.0627	.0662	.0692	.0721	.0749	.0805
.16	.0582	.0619	.0650	.0676	.0700	.0740	.0777	.0811	.0845	.0912
.17	.0638	.0680	.0716	.0748	.0775	.0823	.0866	.0907	.0947	.1026
.18	.0695	.0744	.0786	.0822	.0854	.0910	.0960	.1008	.1055	.1148
.19	.0753	.0809	.0857	.0899	.0936	.1001	.1059	.1115	.1169	.1277
.20	.0812	.0876	.0931	.0979	.1021	.1096	.1163	.1227	.1290	.1414
.21	.0873	.0945	.101	.106	.111	.120	.127	.135	.142	.156
.22	.0934	.1015	.109	.115	.120	.130	.139	.147	.155	.171
.23	.0997	.1087	.117	.124	.130	.141	.150	.160	.169	.187
.24	.1061	.1161	.125	.133	.140	.152	.163	.173	.184	.204
.25	.1125	.1236	.133	.142	.150	.163	.176	.188	.199	.222
.26	.119	.131	.142	.152	.160	.175	.189	.202	.215	.241
.27	.126	.139	.151	.162	.171	.188	.203	.218	.232	.260
.28	.132	.147	.160	.172	.182	.201	.217	.234	.249	.281
.29	.139	.155	.170	.182	.194	.214	.232	.250	.268	.302
.30	.146	.163	.179	.193	.205	.228	.248	.267	.287	.324
.31	.153	.172	.189	.204	.218	.242	.264	.285	.306	.347
.32	.160	.180	.199	.215	.230	.256	.281	.304	.327	.371
.33	.167	.189	.209	.227	.243	.271	.298	.323	.348	.396
.34	.174	.198	.219	.238	.256	.287	.316	.343	.370	.423
.35	.181	.207	.230	.251	.269	.303	.334	.363	.392	.450
.36	.189	.216	.241	.263	.283	.319	.353	.385	.416	.478
.37	.196	.225	.252	.275	.297	.336	.372	.406	.440	.507
.38	.203	.234	.263	.288	.312	.353	.392	.429	.465	.537
.39	.211	.244	.274	.301	.326	.371	.413	.452	.491	.568
.40	.218	.253	.286	.315	.341	.389	.434	.476	.518	.600
.41	.226	.263	.297	.328	.357	.408	.456	.501	.546	.633
.42	.233	.273	.309	.342	.373	.427	.478	.526	.574	.668
.43	.241	.283	.321	.357	.389	.447	.501	.553	.603	.703
.44	.248	.293	.334	.371	.405	.467	.525	.580	.633	.740
.45	.256	.303	.346	.386	.422	.488	.549	.607	.664	.777

Know b,
Find D.

$\frac{5280 \text{ ft}}{\text{mi}}$

Depth of Flow

Table RS-1 Size of Riprap Stones

Weight (lbs)	Mean Spherical Diameter (feet)	Rectangular Shape	
		Length	Width, Height (feet)
50	0.8	1.4	0.5
100	1.1	1.75	0.6
150	1.3	2.0	0.67
300	1.6	2.6	0.9
500	1.9	3.0	1.0
1000	2.2	3.7	1.25
1500	2.6	4.7	1.5
2000	2.75	5.4	1.8
4000	3.6	6.0	2.0
6000	4.0	6.9	2.3
8000	4.5	7.6	2.5
20000	6.1	10.0	3.3

Table RS-2 Graded Riprap

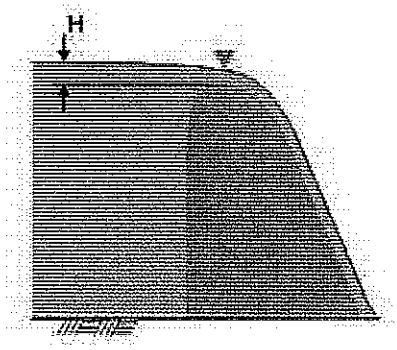
Class	Weight (lbs.)					
	d_{10}	d_{15}	d_{25}	d_{50}	d_{75}	d_{90}
1	10	-	-	50	-	100
2	10	-	-	80	-	200
3	-	25	-	200	-	500
4	-	-	50	500	1000	-
5	-	-	200	1000	-	2000

Velocities

Velocities should be computed by using Manning's Formula with a coefficient of roughness, "n", as follows: $n = 0.047(d_{50} \cdot S)^{0.147}$

ALABAMA, 2009

onlinechannel14.php: Discharge over a broad-crested weir



The broad-crested weir

Formulas:

$$C = (2/3)^{3/2}(g)^{1/2}$$

$$Q = CLH^{3/2}$$

INPUT DATA:

Select:
SI units (metric)
U.S. Customary units

SOLVED FOR—
Hydraulic head H: 1.4 ft

Weir length L: 6 ft

INTERMEDIATE CALCS:

Units selected: U.S. Customary

Grav. acceleration [g]: 32.17 ft s^{-2}

Discharge coefficient C: 3.087 $ft^{1/2}$ s^{-1}

OUTPUT:

GIVEN—
Discharge Q: 30.68 cfs

Press button to Calculate **or recalculate**

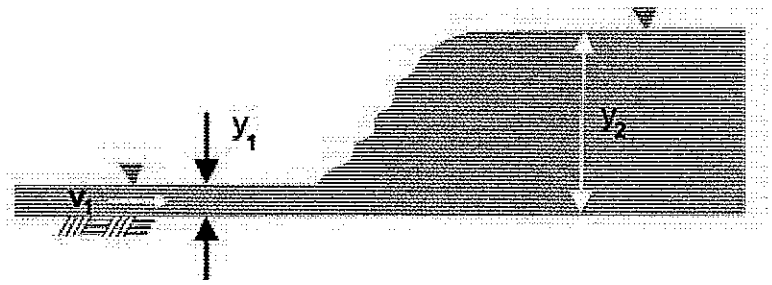
Your request was processed at 04:57:33 am on June 15th, 2010 [100615 04:57:33].

Thank you for running onlinechannel14.php. Please call again. [060203]

online calc

normal depth	critical depth	discharge in culvert	critical slope	normal and critical depth	tractive force
M1 wsprofile	M2 wsprofile	M3 wsprofile	S1 wsprofile	S2 wsprofile	S3 wsprofile
C1 wsprofile	H2 wsprofile	A2 wsprofile	C3 wsprofile	H3 wsprofile	A3 wsprofile
sequent depth	energy loss HJ	discharge sluice	discharge weir	discharge	initial sequent HJ

onlinechannel11.php: Calculation of the sequent depth [y_2] of a hydraulic jump



The hydraulic jump in a horizontal channel

Formulas:

$F_1 = v_1/(gy_1)^{1/2}$

$q = v_1 y_1$

$y_2 = (y_1/2)[(1 + 8F_1^2)^{1/2} - 1]$

$v_2 = q/y_2$

$F_2 = v_2/(gy_2)^{1/2}$

INPUT DATA:

Select:
SI units (metric)
U.S. Customary units

Flow depth y_1: .63 ft

Flow velocity v_1: 10.2 fps

INTERMEDIATE CALCS:

Units selected: U.S. Customary

Grav. accel. [g]: 32.17 ft s^{-2}

Discharge q: 6.426 cfs ft^{-1}

Froude number F_1: 2.265

OUTPUT:

Flow depth y_2: 1.728 ft

Flow velocity v_2: 3.718 fps

Froude number F_2: 0.498

Press button to Calculate or recalculate

Your request was processed at 04:51:47 am on June 15th, 2010 [100615 04:51:47].

Thank you for running onlinechannel11.php. Please call again. [060203]

BRATER & KING, 1982

Table 7-11. Values of K' in Formula $Q = \frac{K'}{n} b^{8/3} s^{1/2}$ for Trapezoidal Channels (*Continued*)

D = depth of water b = bottom width of channel

$\frac{D}{b}$	Side slopes of channel, ratio of horizontal to vertical									
	Vertical	¼–1	½–1	¾–1	1–1	1½–1	2–1	2½–1	3–1	4–1
.46	.264	.313	.359	.401	.439	.509	.574	.636	.696	.816
.47	.271	.323	.372	.416	.457	.531	.599	.665	.729	.856
.48	.279	.334	.385	.432	.474	.553	.625	.695	.763	.897
.49	.287	.344	.398	.447	.493	.575	.652	.725	.797	.939
.50	.295	.355	.412	.463	.511	.598	.679	.757	.833	.983
.51	.303	.366	.425	.480	.530	.622	.707	.789	.869	1.03
.52	.311	.377	.439	.496	.549	.646	.736	.822	.907	1.07
.53	.319	.388	.453	.513	.569	.671	.765	.856	.945	1.12
.54	.327	.399	.467	.531	.589	.696	.795	.891	.984	1.17
.55	.335	.410	.482	.548	.609	.722	.826	.926	1.025	1.22
.56	.343	.422	.497	.566	.630	.748	.857	.963	1.07	1.27
.57	.351	.433	.511	.584	.651	.775	.889	1.000	1.11	1.32
.58	.359	.445	.526	.602	.673	.802	.922	1.038	1.15	1.37
.59	.367	.456	.542	.621	.694	.830	.956	1.077	1.20	1.43
.60	.375	.468	.557	.640	.717	.858	.990	1.117	1.24	1.49
.61	.383	.480	.573	.659	.739	.887	1.02	1.16	1.29	1.54
.62	.391	.492	.588	.678	.762	.916	1.06	1.20	1.33	1.60
.63	.399	.504	.604	.698	.785	.946	1.10	1.24	1.38	1.66
.64	.408	.516	.620	.718	.809	.977	1.13	1.28	1.43	1.72
.65	.416	.529	.637	.738	.833	1.008	1.17	1.33	1.48	1.79
.66	.424	.541	.653	.759	.857	1.04	1.21	1.37	1.53	1.85
.67	.433	.553	.670	.780	.882	1.07	1.25	1.42	1.59	1.91
.68	.441	.566	.687	.801	.907	1.10	1.29	1.47	1.64	1.98
.69	.449	.579	.704	.822	.933	1.14	1.33	1.51	1.69	2.05
.70	.457	.592	.722	.844	.959	1.17	1.37	1.56	1.75	2.12
.71	.466	.604	.739	.866	.985	1.21	1.41	1.61	1.81	2.19
.72	.474	.617	.757	.889	1.012	1.24	1.46	1.66	1.86	2.26
.73	.483	.631	.775	.911	1.039	1.28	1.50	1.71	1.92	2.34
.74	.491	.644	.793	.934	1.067	1.31	1.54	1.77	1.98	2.41
.75	.499	.657	.811	.957	1.095	1.35	1.59	1.82	2.05	2.49
.76	.508	.670	.830	.981	1.12	1.39	1.63	1.87	2.11	2.57
.77	.516	.684	.849	1.005	1.15	1.43	1.68	1.93	2.17	2.65
.78	.525	.698	.868	1.029	1.18	1.46	1.73	1.99	2.24	2.73
.79	.533	.711	.887	1.053	1.21	1.50	1.78	2.04	2.30	2.81
.80	.542	.725	.906	1.078	1.24	1.54	1.83	2.10	2.37	2.90
.81	.550	.739	.925	1.10	1.27	1.58	1.88	2.16	2.44	2.98
.82	.559	.753	.945	1.13	1.30	1.62	1.93	2.22	2.51	3.07
.83	.567	.767	.965	1.15	1.33	1.67	1.98	2.28	2.58	3.16
.84	.576	.781	.985	1.18	1.36	1.71	2.03	2.34	2.65	3.25
.85	.585	.796	1.006	1.21	1.40	1.75	2.08	2.41	2.72	3.35
.86	.593	.810	1.03	1.23	1.43	1.79	2.14	2.47	2.80	3.44
.87	.602	.825	1.05	1.26	1.46	1.84	2.19	2.54	2.87	3.54
.88	.610	.839	1.07	1.29	1.49	1.88	2.25	2.60	2.95	3.63
.89	.619	.854	1.09	1.31	1.53	1.93	2.31	2.67	3.03	3.73
.90	.628	.869	1.11	1.34	1.56	1.98	2.36	2.74	3.11	3.83

$K' = \frac{Qn}{b^{8/3} s^{1/2}}$

Table 7-11. Values of K' in Formula $Q = \frac{K'}{n} b^{8/3} s^{1/2}$ for Trapezoidal Channels (*Continued*)

D = depth of water b = bottom width of channel

$\frac{D}{b}$	Side slopes of channel, ratio of horizontal to vertical									
	Vertical	¼–1	½–1	¾–1	1–1	1½–1	2–1	2½–1	3–1	4–1
.91	.636	.884	1.13	1.37	1.60	2.02	2.42	2.81	3.19	3.93
.92	.645	.899	1.15	1.40	1.63	2.07	2.48	2.88	3.27	4.04
.93	.653	.914	1.18	1.43	1.67	2.12	2.54	2.95	3.35	4.14
.94	.662	.929	1.20	1.46	1.70	2.17	2.60	3.02	3.44	4.25
.95	.671	.944	1.22	1.49	1.74	2.22	2.66	3.10	3.52	4.36
.96	.680	.960	1.24	1.52	1.78	2.27	2.73	3.17	3.61	4.47
.97	.688	.975	1.27	1.55	1.81	2.32	2.79	3.25	3.70	4.58
.98	.697	.991	1.29	1.58	1.85	2.37	2.85	3.33	3.79	4.70
.99	.706	1.006	1.31	1.61	1.89	2.42	2.92	3.40	3.88	4.81
1.00	.714	1.022	1.33	1.64	1.93	2.47	2.99	3.48	3.97	4.93
1.01	.723	1.04	1.36	1.67	1.97	2.53	3.05	3.56	4.06	5.05
1.02	.732	1.05	1.38	1.70	2.01	2.58	3.12	3.65	4.16	5.17
1.03	.741	1.07	1.41	1.73	2.05	2.63	3.19	3.73	4.26	5.30
1.04	.749	1.09	1.43	1.77	2.09	2.69	3.26	3.81	4.35	5.42
1.05	.758	1.10	1.46	1.80	2.13	2.75	3.33	3.90	4.45	5.55
1.06	.767	1.12	1.48	1.83	2.17	2.80	3.40	3.98	4.55	5.68
1.07	.776	1.14	1.50	1.86	2.21	2.86	3.48	4.07	4.66	5.81
1.08	.784	1.15	1.53	1.90	2.25	2.92	3.55	4.16	4.76	5.94
1.09	.793	1.17	1.56	1.93	2.29	2.98	3.62	4.25	4.86	6.07
1.10	.802	1.19	1.58	1.97	2.34	3.04	3.70	4.34	4.97	6.21
1.11	.811	1.20	1.61	2.00	2.38	3.10	3.78	4.43	5.08	6.35
1.12	.820	1.22	1.63	2.04	2.42	3.16	3.85	4.53	5.19	6.49
1.13	.829	1.24	1.66	2.07	2.47	3.22	3.93	4.62	5.30	6.63
1.14	.837	1.25	1.69	2.11	2.51	3.28	4.01	4.72	5.41	6.77
1.15	.846	1.27	1.71	2.14	2.56	3.35	4.09	4.81	5.52	6.92
1.16	.855	1.29	1.74	2.18	2.61	3.41	4.17	4.91	5.63	7.06
1.17	.864	1.31	1.77	2.22	2.65	3.47	4.25	5.01	5.75	7.21
1.18	.873	1.32	1.79	2.25	2.70	3.54	4.34	5.11	5.87	7.36
1.19	.882	1.34	1.82	2.29	2.75	3.61	4.42	5.21	5.99	7.52
1.20	.891	1.36	1.85	2.33	2.79	3.67	4.51	5.32	6.11	7.67
1.21	.899	1.38	1.88	2.37	2.84	3.74	4.59	5.42	6.23	7.83
1.22	.908	1.40	1.90	2.41	2.89	3.81	4.68	5.52	6.35	7.99
1.23	.917	1.41	1.93	2.44	2.94	3.88	4.77	5.63	6.48	8.15
1.24	.926	1.43	1.96	2.48	2.99	3.95	4.86	5.74	6.61	8.31
1.25	.935	1.45	1.99	2.52	3.04	4.02	4.95	5.85	6.73	8.48
1.26	.944	1.47	2.02	2.56	3.09	4.09	5.04	5.96	6.86	8.64
1.27	.953	1.49	2.05	2.60	3.14	4.16	5.13	6.07	6.99	8.81
1.28	.962	1.51	2.08	2.64	3.19	4.23	5.22	6.18	7.13	8.98
1.29	.971	1.52	2.11	2.69	3.24	4.31	5.32	6.30	7.26	9.16
1.30	.980	1.54	2.14	2.73	3.30	4.38	5.41	6.41	7.40	9.33
1.31	.989	1.56	2.17	2.77	3.35	4.46	5.51	6.53	7.53	9.51
1.32	.997	1.58	2.20	2.81	3.40	4.53	5.61	6.65	7.67	9.69
1.33	1.006	1.60	2.23	2.85	3.46	4.61	5.71	6.77	7.81	9.87
1.34	1.015	1.62	2.26	2.90	3.51	4.69	5.81	6.89	7.96	10.05
1.35	1.024	1.64	2.29	2.94	3.57	4.77	5.91	7.01	8.10	10.24

Know b

Find D

SPECIFICATIONS

MIRAFI®

TECHNICAL DATA SHEET

Mirafi® 180N

Mirafi® 180N is a nonwoven geotextile composed of polypropylene fibers, which are formed into a stable network such that the fibers retain their relative position. 180N is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Grab Tensile Strength	ASTM D 4632	kN (lbs)	0.9 (205)	0.9 (205)
Grab Tensile Elongation	ASTM D 4632	%	50	50
Trapezoid Tear Strength	ASTM D 4533	kN (lbs)	0.36 (80)	0.36 (80)
Mullen Burst Strength	ASTM D 3786	kPa (psi)	2618 (380)	
Puncture Strength	ASTM D 4833	kN (lbs)	0.58 (130)	
Apparent Opening Size (AOS)	ASTM D 4751	mm (U.S. Sieve)	0.180 (80)	
Permittivity	ASTM D 4491	sec^{-1}	1.2	
Permeability	ASTM D 4491	cm/sec	0.21	
Flow Rate	ASTM D 4491	$l/min/m^2$ ($gal/min/ft^2$)	3866 (95)	
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	70	

Physical Properties	Test Method	Unit	Typical Value
Weight	ASTM D 5261	g/m^2 (oz/yd^2)	278 (8.2)
Thickness	ASTM D 5199	mm (mils)	2.3 (90)
Roll Dimensions (width x length)	--	m (ft)	4.5 x 91 (15 x 300)
Roll Area	--	m^2 (yd^2)	418 (500)
Estimated Roll Weight	--	kg (lb)	124 (273)

Disclaimer: MIRAFI® Construction Products assumes no liability for the accuracy or completeness of this information or for the ultimate use by the purchaser. MIRAFI® disclaims any and all express, implied, or statutory standards, warranties or guarantees, including without limitation any implied warranty as to merchantability or fitness for a particular purpose or arising from a course of dealing or usage of trade as to any equipment, materials, or information furnished herewith. This document should not be construed as engineering advice.

Ten Cate Nicolon

HYDRACX2
EXTREME SLOPE MATRIX

SECTION 02925
Extreme Slope Matrix - ESM

1.0 GENERAL:

1.01 SUMMARY:

This Section specifies a hydraulically-applied Extreme Slope Matrix (ESM), which is a matrix composed of natural defribrated fibers, cross-linked insoluble hydro-colloidal tackifiers, and natural reinforcing fibers. The ESM does not require an extended curing period and immediately creates an intimate bond with the subgrade. The ESM is not intended for applications such as a stand alone channel liner with concentrated flow or ponding scenarios.

1.02 SUBMITTALS:

A. Product Testing: Manufacturer must submit the appropriate information as requested in this specification. Alterations to the specified testing standards will not be accepted.

B. Certifications: Manufacturer shall submit a letter of certification stating the product meets or exceeds all physical properties, performance requirements, and packaging requirements.

C. Material Quantities: Installation contractor shall provide invoices and empty bags to the site owner or general contractor to confirm that the proper quantity of ESM was used. Required quantities will be based on slope gradient and slope conditions as described in section 2.04 and 3.03-D.

1.03 DELIVERY, STORAGE AND HANDLING:

A. Product shall be delivered in packaging with UV inhibitors and the pallets shall be protected with a plastic cap. Store and handle the product in strict compliance with manufacturer's instructions and recommendations.

2.0 PRODUCTS:

2.01 ACCEPTABLE SUPPLIER & MANUFACTURER:

A. Supplier shall be North American Green, 14649 Highway 41N, Evansville, IN 47725, Phone: 800-772-2040, Fax: 812-867-0247 as manufactured by Mulch and Seed Innovations, 7265 Alabama Highway 9 South, Centre, AL 35960, Phone: 256-927-8823, Fax: 256-927-8824

2.02 MATERIALS:

A. Extreme Slope Matrix (ESM) combines both chemical and mechanical bonding agents to interlock the matrix to the underlying soil and must be hydraulically applied. This matrix establishes an intimate bond upon application with the soil's surface to create a continuous, porous, and absorbent matrix allowing for rapid germination and improved plant growth. The ESM shall be pre-packaged by the manufacturer to assure material performance and compliance in accordance to the requirement present below. The matrix shall conform to the following values when uniformly applied at a rate of 3,500 lbs/acre (3900 kg/ha), unless noted otherwise.

Physical Testing:

Property	Test Method	Desired Value
Mass per Unit Area	ASTM D-6475	13.5 oz/yd^2 (min)
Thickness	ASTM D-6525	0.181 inch (min)
Light Penetration	ASTM D-6567	2% (min)
C:N Ratio	Compost Analysis	75:1 (max)

Performance Testing:

Property	Test Method	Desired Value
C Factor	*ASTM D-6459	0.02 (max)
C Factor	**ASTM D-6459	0.04 (max)
Vegetation Establishment	***ECTC Test Method #4	500% (min)
Plant Height Improvement	***ECTC Test Method #4	135% (min)

Toxicity Testing:

Property	Test Method	Desired Value
Ceriodaphnia dubia	EPA-821-R-02-123	Pass
Daphnia magna	EPA-821-R-02-123	Pass
Pimephales promelas	EPA-821-R-02-123	Pass

*Testing must be pursuant to ASTM D-6459 with 3 replications. Each plot must undergo 20 minute rainfall durations with target intensities of 2, 4, 6 in/hr rain events respectively. The plot dimensions are to be a minimum of 6.5 ft x 26 ft at a slope gradient of 3H:1V. Each of the three rain events must successfully complete the 20 minute duration without any slope slumping during the rain event.

**Testing must be pursuant to ASTM D-6459 with 2 replications. Product is evaluated at an application rate of 4,000 lbs / acre. Each plot must undergo 20 minute rainfall durations with minimum intensities of 2, 4, 6 in/hr rain events respectively. The plot dimensions are to be a minimum of 8 ft x 40 ft at a slope gradient of 3H:1V. Raindrop size will vary as a function of rainfall intensity and wind speeds must be maintained below 3 mph. A rainfall height of 15 feet must be utilized.

***Modifications to ECTC Test Method #4 protocol will not be accepted. Testing may not utilize excessive seed counts or soil amendments such as fertilizers.

2.03 COMPOSITION:

A. All components of the HydraCX2 (ESM) shall be pre-packaged by the Manufacturer to assure material performance and in compliance with the following values. Under no circumstances will field mixing of additives or components be accepted.

Mechanically processed Straw – 65% ± 3%
Mechanically processed Cotton Plant Fibers and Byproducts– 25 % ± 3%
Proprietary Hydro-Colloid Tackifiers and Activators – 10% ± 1%

2.04 APPLICATION RATES:

A. The application rate shall be 3500 lbs/acre

3.0 EXECUTION:

3.01 GENERAL:

A. Utilize the ESM as pre-packaged by the manufacturer to assure material performance. Do not field mix additives or components such as polyacrylamides or tackifiers. Apply ESM to geotechnically stable slopes constructed so as runoff is diverted away from the face of the slope. Comply with the manufacturer's mixing recommendations and installation instructions.

B. Depending upon project sequencing and intended application, prepare seedbed in compliance with:

Section 01570 – Temporary Erosion and Sediment Control
Section 02300 – Earthwork; Establishment of Subgrade
Section 02370 – Erosion and Sedimentation Control
Section 02920 – Lawns and Grasses

3.02 EQUIPMENT:

A. Equipment for applying ESM shall be a mechanically agitated hydro-spraying machine with an appropriate nozzle tip. The equipment shall be so designed as to satisfactorily apply the product.

3.03 MIXING, AGITATION, AND APPLICATION:

A. Fill the tank of a mechanically agitated hydroseeding machine with sufficient water to suspend seed and fertilizers. Add seed and soil amendments. Continue to add water slowly while adding ESM at a steady rate. Mix at a rate of 50 pounds of ESM per 100 gallons of water. All ESM product should be loaded into the tank when the tank is approximately ¾ full in the water filling phase.

B. Agitate for a minimum of 15 minutes after adding the last amount of water and ESM.

C. If the application machine is equipped with variable speed agitation then the agitation speed should be reduced prior to beginning to pump the material. Before the material is pumped the agitator should be adjusted to a slow roll, and should be spinning only fast enough to keep the mulch in a homogenous slurry but no faster.

D. Apply seed, soil amendments, and ESM in a one-step process where seed, soil amendments, and mulch are applied simultaneously. ESM can be applied in a two step process where the seed and soil amendments are applied to the site then the hydromulch is applied secondly. The two step process is not necessary with ESM, but is acceptable if preferred by the applicator.

E. Apply in a uniform layer from 2 opposing directions in successive layers to reduce "shadowing" and to ensure complete soil coverage. Irregular surfaces may need slightly higher application rates to obtain adequate coverage. Application rates may need to be increased on highly erosive soils or chiseled, disked, furrowed or tracked slopes.

F. Use fan tip nozzles with a 40° to 65° spray pattern as shown by the figures below.

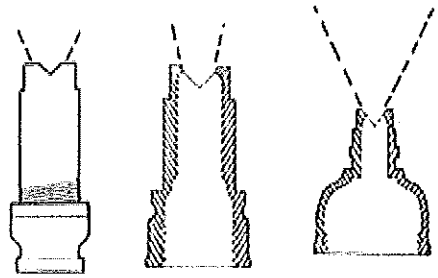


Figure 3.1

G. When using a hose the flow rate allowed by the nozzle should be a minimum of 40 GPM. When applying the material from the cannon the nozzle used should accommodate a minimum of 65 GPM.

H. See Figure3.2 for an example of a proper hose application. Spray the material directly into the soil to incorporate the slurry into the soil.

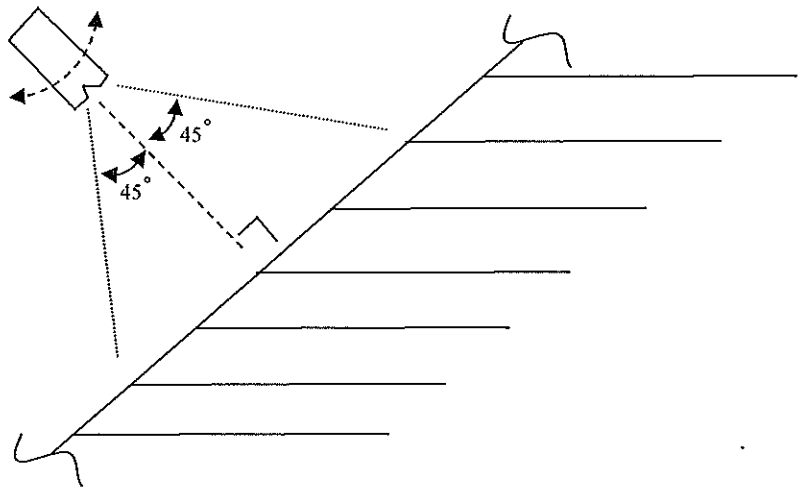


Figure 3.2

I. When spraying from the cannon, the slurry should be sprayed directly into the soil so that the slurry is thoroughly mixed and incorporated into the soil. The direction of spray should be positioned as shown in Figure 3.3.

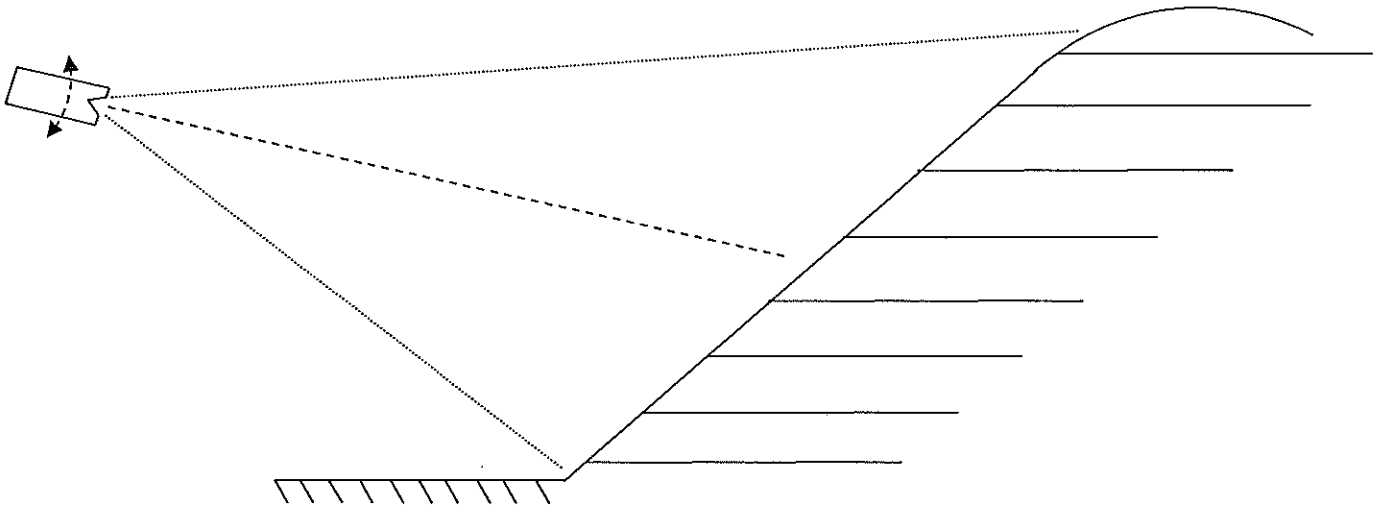


Figure 3.3

J. It is acceptable to spray the material into the air and allow it to fall down onto the site (see Figure 3.4) only after the majority of the material has been applied by incorporating the slurry into the soil as described in section 3.03 G and H. This method of application should only be used to finish off an area, fill in light application areas, or "cap" the site.

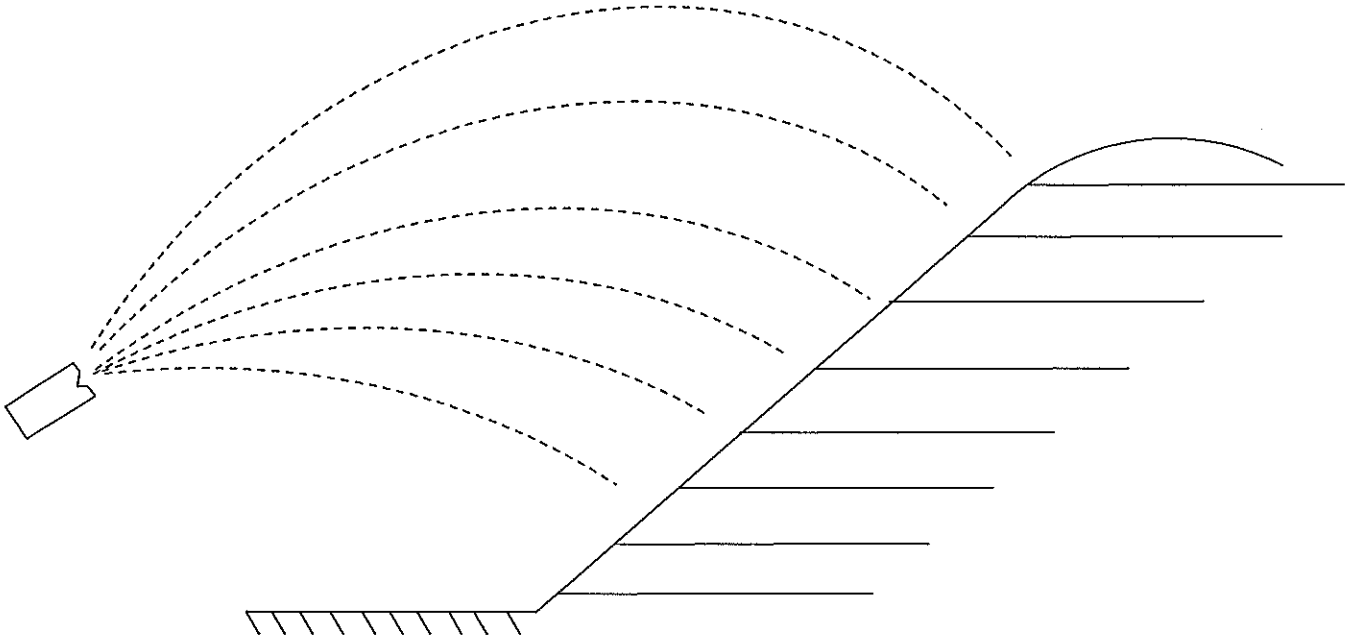


Figure 3.4

3.04 CLEANING AND PROTECTION:

A. Clean equipment properly to ensure ESM is removed from the pumps, tanks, and hoses.

B. Keep covered area protected from foot traffic.

C. Use caution on equipment. ESM will be slippery when mixed into a slurry.

NORTH AMERICAN GREEN®
EROSION CONTROL *Products*
Guaranteed SOLUTIONS

A tensar Company

14649 Highway 41 North
Evansville, IN. 47725
1.800.772-2040
www.nagreen.com

Material and Performance Specification Sheet

North American Green
14649 Highway 41 North
Evansville, IN 47725
800-772-2040
FAX: 812-867-0247
www.nagreen.com

A tensar Company

SC250 Turf Reinforcement Mat

The composite turf reinforcement mat (C-TRM) shall be a machine-produced mat of 70% straw and 30% coconut fiber matrix incorporated into a permanent three-dimensional turf reinforcement matting. The matrix shall be evenly distributed across the entire width of the matting and stitch bonded between a heavy duty UV stabilized netting with 0.50 x 0.50 inch (1.27 x 1.27 cm) openings, an ultra heavy UV stabilized, dramatically corrugated (crimped) intermediate netting with 0.5 x 0.5 inch (1.27 x 1.27 cm) openings, and covered by an heavy duty UV stabilized nettings with 0.50 x 0.50 inch (1.27 x 1.27 cm) openings. The middle corrugated netting shall form prominent closely spaced ridges across the entire width of the mat. The three nettings shall be stitched together on 1.50 inch (3.81cm) centers with UV stabilized polypropylene thread to form a permanent three-dimensional turf reinforcement matting.

The SC250 shall meet requirements established by the Erosion Control Technology Council (ECTC) Specification and the US Department of Transportation, Federal Highway Administration's (FHWA) *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-03 Section 713.18 as a type 5A, B, and C Permanent Turf Reinforcement Mat.*

Installation staple patterns shall be clearly marked on the turf reinforcement matting with environmentally safe paint. All mats shall be manufactured with a colored thread stitched along both outer edges (approximately 2-5 inches [5-12.5 cm] from the edge) as an overlap guide for adjacent mats.

Material Content		
Matrix	70% Straw / 30% Coconut fibers	0.35 lbs/yd² (0.19 kg/m²) / 0.15 lbs/yd² (0.08 kg/m²)
Nettings	Top and Bottom, UV stabilized Polypropylene	5 lb/1000 ft² (2.44 kg/100 m²)
	Middle, corrugated UV stabilized Polypropylene	24 lb/1000 ft² (11.7 kg/100 m²)
Thread	Polypropylene, UV stabilized	

SC250 is available in the following roll sizes:

Width	6.5 ft (2.0 m)
Length	55.5 ft (16.9 m)
Weight ± 10%	34 lbs (15.42 kg)
Area	40.0 yd² (33.4 m²)

Index Value Properties:

Property	Test Method	Typical	Net Only
Thickness	ASTM D6525	0.72 in (18.3 mm)	0.48 in
Resiliency	ASTM 6524	95.2%	---
Density	ASTM D792	0.53 oz/in³	---
Mass/Unit Area	ASTM 6566	17.88 oz/yd² (606 g/m²)	---
Porosity	ECTC Guidelines	99%	---
Stiffness	ASTM D1388	222.65 oz-in	---
Light Penetration	ECTC Guidelines	8.9%	---
UV Stability	ASTM D4355/ 1000 hr	100%	100%
Tensile Strength MD	ASTM D6818	620 lbs/ft (9.05 kN/m)	655 lbs/ft
Elongation MD	ASTM D6818	35%	25%
Tensile Strength TD	ASTM D6818	737 lbs/ft (10.75 kN/m)	666 lbs/ft
Elongation TD	ASTM D6818	16%	16%

Bench Scale Testing* (NTPEP):

Test Method	Parameters	Results
ECTC Method 2 Rainfall	50 mm (2 in)/hr for 30 min	SLR** = 18.25
	100mm (4 in)/hr for 30 min	SLR** = 20.97
	150 mm (6 in)/hr for 30 min	SLR** = 22.74
ECTC Method 3 Shear Resistance	**Shear at 0.50 inch soil loss**	**7.7 lbs/ft²**
ECTC Method 4 Germination	Top Soil, Fescue, 21 day incubation	523% improvement of biomass

* Bench Scale tests should not be used for design purposes

** Soil Loss Ratio = Soil loss with Bare Soil/Soil Loss with RECP (soil loss is based on regression analysis)

Updated 3/09

Performance Design Values:

Maximum Permissible Shear Stress		
	Short Duration	Long Duration
Phase 1 Unvegetated	3.0 lbs/ft² (144 Pa)	2.5 lbs/ft² (120 Pa)
Phase 2 Partially Veg.	8.0 lbs/ft² (383 Pa)	8.0 lbs/ft² (383 Pa)
Phase 3 Fully Veg.	10.0 lbs/ft² (480 Pa)	8.0 lbs/ft² (383 Pa)
Velocity Unveg	9.5 ft/s (2.9 m/s)	
Velocity Veg.	15 ft/s (4.6 m/s)	

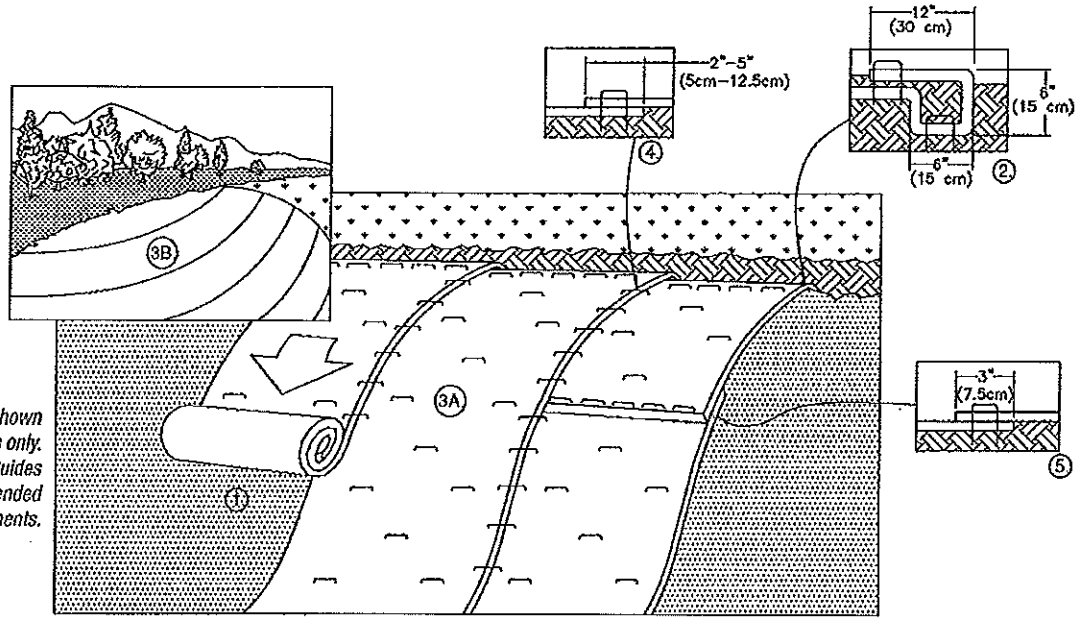
Slope Design Data: C Factors			
	Slope Gradients (S)		
Slope Length (L)	≤ 3:1	3:1 – 2:1	≥ 2:1
≤ 20 ft (6 m)	0.0010	0.0209	0.0507
20-50 ft	0.0081	0.0266	0.0574
≥ 50 ft (15.2 m)	0.0455	0.0555	0.081

Roughness Coefficients- Unveg.	
Flow Depth	Manning's n
≤ 0.50 ft (0.15 m)	0.040
0.50 – 2.0 ft	0.040 – 0.012
≥ 2.0 ft (0.60 m)	0.011

Product Participant of: QDOR

NORTH AMERICAN GREEN®
EROSION CONTROL Products Guaranteed SOLUTIONS
A tensar Company
14649 HIGHWAY 41 NORTH
EVANSVILLE, IN 47725
800-772-2040
www.nagreen.com

SLOPE INSTALLATION
APLICACIONES PARA TALUDES



Staple placements shown for illustrative purposes only. See Staple Pattern Guides for actual recommended placements.

1. PREPARE SOIL BEFORE INSTALLING ROLLED EROSION CONTROL PRODUCTS (RECP's), INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED.
2. BEGIN AT THE TOP OF THE SLOPE BY ANCHORING THE RECP's IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30cm) OF RECP's EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE RECP's WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30 CM) PORTION OF RECP's BACK OVER SEED AND COMPACTED SOIL. SECURE RECP's OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) APART ACROSS THE WIDTH OF THE RECP's.
3. ROLL THE RECP's (A.) DOWN OR (B.) HORIZONTALLY ACROSS THE SLOPE. RECP's WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL RECP's MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING THE DOT SYSTEM™, STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
4. THE EDGES OF PARALLEL RECP's MUST BE STAPLED WITH APPROXIMATELY 2" – 5" (5 CM – 12.5 CM) OVERLAP DEPENDING ON RECP's TYPE.
5. CONSECUTIVE RECP's SPLICED DOWN THE SLOPE MUST BE PLACED END OVER END (SHINGLE STYLE) WITH AN APPROXIMATE 3" (7.5 CM) OVERLAP. STAPLE THROUGH OVERLAPPED AREA, APPROXIMATELY 12" (30 CM) APART ACROSS ENTIRE RECP's WIDTH.

NOTE:
*IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY SECURE THE RECP's.

---

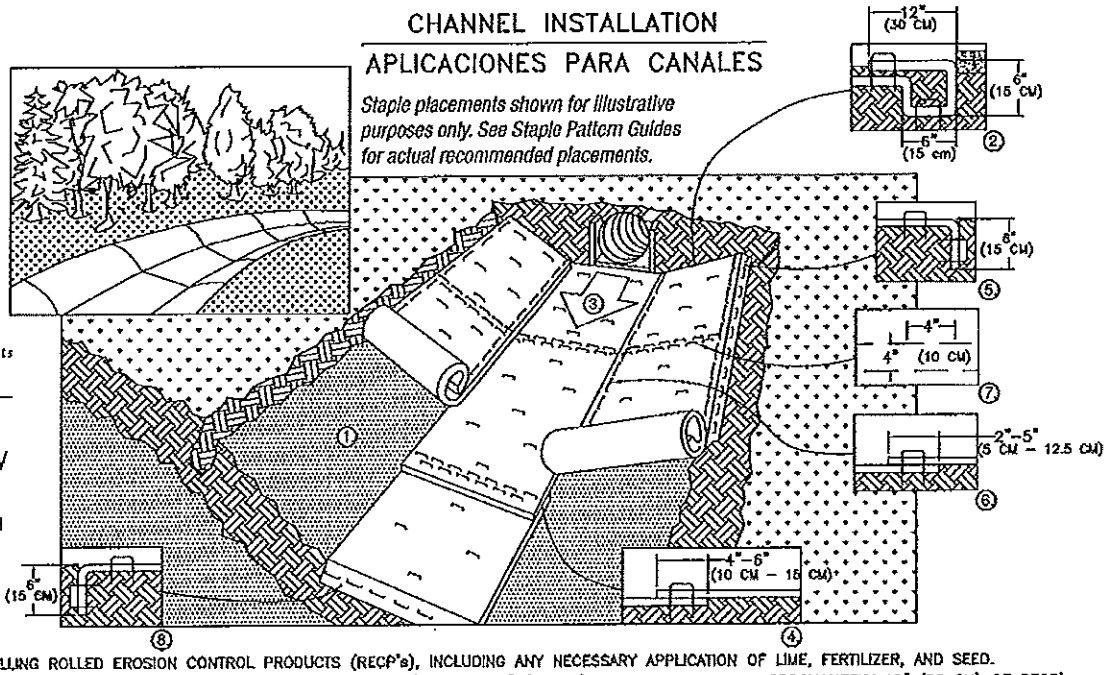
1. PREPARE EL TERRENO ANTES DE INSTALAR LAS MANTAS, INCLUYENDO LA APLICACION DE CAL, FERTILIZANTE Y SEMILLA.
2. COMIENCE EN LA CABECERA DEL TALUD SUJETANDO LA MANTA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD FOR 6" (15 CM) DE ANCHO CON APROXIMADAMENTE 12" (30 CM) DE LA MANTA EXTENDIDA MAS ALLA DE LA PENDIENTE ALTA DE LA ZANJA. SUJETE LA MANTA AL FONDO DE LA ZANJA CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30 CM) UNA DE LA OTRA. RELLENE Y COMPACTE LA ZANJA DESPUES DEL ENGRAPE. RIEGE LA SEMILLA EN EL SUELO COMPACTADO Y DOBLE LAS 12" (30 CM) REMANENTES DE MANTA SOBRE LA SEMILLA EL SUELO COMPACTADO. ASEGURE LA MANTA SOBRE EL SUELO CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30 CM) UNA DE LA OTRA A TRAVES DEL ANCHO DE LA MANTA.
3. DESENROLLE LAS MANTAS (3A) HACIA ABAJO U (3B) HORIZONTALMENTE A TRAVES DEL TALUD CON EL LADO APROPIADO HACIA LA SUPERFICIE DEL SUELO. TODAS LAS MANTAS DEBERAN ASEGURARSE A LA SUPERFICIE DEL SUELO POR MEDIO DE GRAPAS O ESTACAS EN LUGARES APROPIADOS TAL Y COMO SE INDICA EN EL PATRON GUIA DE ENGRAPADO. CUANDO ESTE USANDO EL DOT SYSTEM.™ LAS GRAPAS O ESTACAS DEBEN COLOCARSE A TRAVES DE CADU UNDO DE LOS PUNTOS CON COLOR CORRESPONDIENTES AL PATRON DE ENGRAPADO APROPIADO.
4. LOS BORDES DE LAS MANTAS PARALELAS TIENEN QUE ENGRAPARSE CON UN TRASLAPE DE APROXIMADAMENTE 2" – 5" (5 CM – 12.5 CM) DEPENDIENDO DEL TIPO DE MANTA.
5. MANTAS CONSECUTIVAS UNIDAS EN LA BAJADA DE LOS TALUDES, DEBEN COLOCARSE ORILLA SOBRE ORILLA (TIPO EXCALONADO) CON UN TRASLAPE DE APROXIMADAMENTE 3" (7.5 CM). ENGRAPE EL AREA TRASLAPADA CON UNA SEPARACION DE APROXIMADAMENTE 12" (30 CM) A TRAVES DE TODO EL ANCHO DE LA MANTA.

NOTA:
* EN CONDICIONES DE SUELTO, PUEDE QUE SE NECESITEN GRAPAS O ESTACAS DE MAS DE 6" (15 CM) DE LARGO PARA ASEGURAR LAS MANTAS CORRECTAMENTE.

CHANNEL INSTALLATION

APLICACIONES PARA CANALES

Staple placements shown for illustrative purposes only. See Staple Pattern Guides for actual recommended placements.



NORTH AMERICAN GREEN®

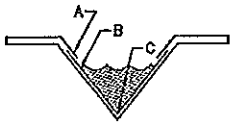
EROSION CONTROL Products Guaranteed SOLUTIONS

A tensar Company

14649 HIGHWAY 41 NORTH
EVANSVILLE, IN 47725
800-772-2040
www.nagreen.com

1. PREPARE SOIL BEFORE INSTALLING ROLLED EROSION CONTROL PRODUCTS (RECP's), INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED.
2. BEGIN AT THE TOP OF THE CHANNEL BY ANCHORING THE RECP's IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH WITH APPROXIMATELY 12" (30 CM) OF RECP's EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE RECP's WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMAPCT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30 CM) PORTION OF RECP's BACK OVER SEED AND COMPACTED SOIL. SECURE RECP's OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30 CM) ACROSS THE WIDTH OF THE RECP's.
3. ROLL CENTER RECP's IN DIRECTION OF WATER FLOW IN BOTTOM OF CHANNEL. RECP's WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL RECP's MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING THE DOT SYSTEM™, STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
4. PLACE CONSECUTIVE RECP's END OVER END (SHINGLE STYLE) WITH A 4" – 6" (10 CM –15 CM) OVERLAP. USE A DOUBLE ROW OF STAPLES STAGGERED 4" (10 CM) APART AND 4" (10 CM) ON CENTER TO SECURE RECP's.
5. FULL LENGTH EDGE OF RECP's AT TOP OF SIDE SLOPES MUST BE ANCHORED WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.
6. ADJACENT RECP's MUST BE OVERLAPPED APPROXIMATELY 2" – 5" (5 CM –12.5 CM) (DEPENDING ON RECP's TYPE) AND STAPLED.
7. IN HIGH FLOW CHANNEL APPLICATIONS, A STAPLE CHECK SLOT IS RECOMMENDED AT 30 TO 40 FOOT (9 M – 12 M) INTERVALS. USE A DOUBLE ROW OF STAPLES STAGGERED 4" (10 CM) APART AND 4" (10 CM) ON CENTER OVER ENTIRE WIDTH OF THE CHANNEL.
8. THE TERMINAL END OF THE RECP's MUST BE ANCHORED WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30 CM) APART IN A 6" (15 CM) DEEP X 6" (15 CM) WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.

NOTE:
* IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 CM) MAY BE NECESSARY TO PROPERLY ANCHOR THE RECP's.



CRITICAL POINTS

A. OVERLAPS AND SEAMS
B. PROJECTED WATER LINE
C. CHANNEL BOTTOM/SIDE SLOPE VERTICES

NOTE:
* HORIZONTAL STAPLE SPACING SHOULD BE ALTERED IF NECESSARY TO ALLOW STAPLES TO SECURE THE CRITICAL POINTS ALONG THE CHANNEL SURFACE.

** IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 cm) MAY BE NECESSARY TO PROPERLY ANCHOR THE RECP's.

PUNTOS CRITICOS

A. TRASLAPES Y JUNTAS
B. LINEAS DE AGUA PROYECTADA
C. FONDO DEL CANAL/VERTICES DE LAS PENDIENTES LATERALES

NOTA:
* LA SEPARACION HORIZONTAL DE LAS GRAPAS SE DEBE ALTERAR SI SE NECESITA, PARA PERMITIR QUE LAS GRAPAS ASEGUREN LOS PUNTOS CRITICOS A LO LARGO DE LA SUPERFICIE DEL CANAL.

** EN CONDICIONES DE SUELO SUELTO, PUEDE QUE SE NECESITEN GRAPAS O ESTACAS DE MAS DE 6" (15 CM) DE LARGO PARA ASEGURAR LAS MANTAS CORRECTAMENTE.

1. PREPARE EL SUELO DE COLOCAR LAS MANTAS, INCLUYENDO LA APLICASION DE CAL, FERTILIZANTE SEMILLA.
2. COMIENCE EN LA CABECERA DEL CANAL SUJETANDO LA MANTA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD POR 6" (15 CM). DE ANCHO CON APROXIMADAMENTE 12" (30 CM) DE LA MANTA EXTENDIDA MAS ALLA DE LA PENDIENTE ALTA DE LA ZANJA. SUJETE RELLENE Y COMPACTE LA ZANJA DESPUES DEL ENGRAPE. RIEGUE LA SEMILLA EN EL SUELO COMPACTADO Y DOBLE LAS 12" (30 CM) REMANENTES DE MANTA SOBRE LA SEMILLA Y EL SUELO COMPACTADO. ASEGURE LA MANTA SOBRE EL SUELO CON UNA LINEADE GRAPAS O ESTACAS APROXIMADAMENTE 12" (30 CM) UNA DE LA OTRA A TRAVES DEL ANCHO DE LA MANTA.
3. DESENROLLE LA MANTA DEL MEDIO EN EL FONDO DEL CANAL Y EN LA DIRECCION DEL FLUJO DE AGUA CON EL LADO APROPIADO HACIA LA SUPERFICIE DEL SUELO. TODAS LAS MANTAS DEBERAN ASEGURARSE A LA SUPERFICIE DEL SUELO POR MEDIO DE GRAPAS O ESTACAS EN LUGARESAPROPIADOS TAL Y COMO SE INDICA EN EL PATRON GUIA DE ENGRAPADO. CUANDO ESTE USANDO EL DOT SYSTEM™, LAS GRAPAS O ESTACAS DEBEN COLOCARSE A TRAVES DE CADA UNO DE LOS PUNTOS CON COLOR CORRESPONDIENTES AL PATRON DE ENGRAPADO APROPIADO.
4. COLOQUE LAS MANTAS CONSECUTIVAS BORDE SOBRE BORDE (TIPO ESCALONADO) CON UN TRASLAPE DE 4" – 6" (10 CM – 15 CM). USE UNA LINEA DOBLE DE GRAPAS ESCALONADAS, SEPARADAS POR 4" (10 CM) Y CADA 4" (10 CM) SOBRE EL CENTRO PARA ASEGURAR LAS MANTAS.
5. EN EL TOPE DE LAS DOS PENDIENTES LATERALES DEL CANAL, SE DEBE SUJETAR TODO EL LARGO DE LA ORILLA DE LAS MANTAS CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE CADA 12" (30 CM) UNA DE LA OTRA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD POR 6" (15 CM) DE ANCHO. RELLENE Y COMPACTE LA ZANJA DESPUES DEL ENGRAPE.
6. LAS MANTAS ADYACENTES DEBEN TRASLAPARSE APROXIMADAMENTE DE 2" – 5" (5 CM– 12.5 CM) (DEPENDIENDO DEL TIPO DE. MANTA) Y ENGRAPPARSE.
7. EN APLICACIONES PARA CANALES DE FLUJO ALTO, SE RECOMIENDA DEJAR UNA RANURA PARA EL CHEQUEO DE LAS GRAPAS A INTERVALOS DE 30 A 40 PIES (9 M – 12 M). USE UNA LINEA DOBLE DE PRAPAS ESCALONADAS, SEPARADAS POR 4" (10 CM) Y CADA 4" (10 CM) SOBRE EL CENTRO A TRAVES DE TODO EL ANCHO DEL CANAL.
8. LOS BORDES FINALES DE LAS MANTAS DEBEN SUJETARSE CON UNA LINEA DE GRAPAS O ESTACAS APROXIMADAMENTE CADA 12" (30 CM) UNA DE LA OTRA EN UNA ZANJA DE 6" (15 CM) DE PROFUNDIDAD POR 6" (15 CM) DE ANCHO. RELLENE Y COMPACTE DESPUES DEL ENGRAPADO.

NOTA:
* EN CONDICIONES DE SUELTO, PUEDE QUE SE NECESITEN GRAPAS O ESTACAS DE MAS DE 6" (15 CM) DE LARGO PARA ASEGURAR LAS MANTAS CORRECTAMENTE.

REV. 4/07

(2) The installation procedure requires the holes be drilled with rotary drilling equipment capable of providing 3 inch {75 mm} to six inch {150 mm} diameter holes up to 600 feet {180 m} in length to the designated lines and grades through soil and rock formations.

The drilling equipment shall allow the installation operation to be accomplished by inserting the plastic drain inside the drill hole the full length of the drill hole.

The installation operation of the drain pipe shall be done in such a manner that the drain pipe will be cemented together where necessary to form a continuous tube and will not be telescoped or damaged to the extent that its drainage efficiency will be impaired when completed.

The entrance end of the pipe shall be plugged with a rounded or pointed extension. The space between the drilled hole and the pipe shall be tightly plugged with earth for a length of at least 2 feet {600 mm} at the outlet end of the hole.

Water used for drilling and water developed during drilling operations shall be disposed of by the Contractor in such a manner that no damage will result to the work.

Unslotted PVC pipe approximately 10 feet {3 m} in length, shall be provided at the mouth of the drain to collector structure.

(d) SLOPE RETAINING STRUCTURES.

1. Retaining walls (cast-in-place or precast), if required, shall be constructed, measured, and paid for as provided in the appropriate Section of the Specifications.

2. Rock buttress, if required, shall be constructed, etc., in accordance with the following requirements:

General.

The construction, in general, consists of the excavation of a trench, preparation of a bedding to receive a rock buttress and the construction of a rock buttress to the line, grades, and slopes detailed on the plans.

Excavation of Trench.

The excavation necessary to prepare the trench to the line, grades, slopes, and section shown on the plans or directed shall be classified and paid for under the Item of Unclassified Excavation or as provided on the plans.

Preparation of Trench Bed.

The preparation of the trench bed shall be as detailed on the plans. Special bedding, if required, will be noted on the plans. Materials used in the special bedding shall conform to the specified sections of the Standard Specifications and will be paid for under the appropriate pay item for the materials used.

Rock Buttress.

The rock buttress material, unless otherwise noted on the plans, shall be hard durable stone obtained by normal quarrying operations, and will be limited to sandstone, limestone, dolomite, or granite free of dirt and debris meeting the approval of the Engineer. The rock buttress shall be placed, in the prepared trench to the slopes indicated on the plans or directed, in approximately 2 foot {600 mm} thick layers. Material used shall be approximate in size to that of a Class 2 to Class 3 Riprap. Boulders larger than 2 foot {600 mm} may be used provided they are spaced so as to permit filling and densification of the intervening space in the 2 foot {600 mm} layers. The rock shall be selected in a manner that will provide a choking material for filling voids. Densification of the rock backfill will be required; however, no density test will be required on the rock backfill.

Furnishing of the rock for the construction of the buttress shall be the responsibility of the Contractor. If permission is given to use any material outside regular excavation limits within the right of way, it will be paid for only once under the appropriate pay item provided by this Section.

(e) CONSTRUCTION REQUIREMENTS FOR GEOTEXTILES.

Exposure of geotextiles to the elements between lay down and cover shall be a maximum of 14 days to minimize damage potential.

The geotextile shall be placed and anchored on a smooth graded surface approved by the Engineer. The geotextile shall be placed in such a manner that placement of the overlying materials will not excessively stretch or tear the fabric. Anchoring of the terminal ends of the geotextiles shall be accomplished through the use of key trenches or aprons at the crest and toe of the back slope of the buttress or as specified on the plans.

Successive geotextile sheets shall be overlapped in such a manner that the upslope sheet is placed over the downslope sheet or upstream over downstream. In underwater applications, the

geotextile and required thickness of backfill material shall be placed the same day. The backfill placement shall begin at the toe and proceed up the slope.

Riprap and heavy stone filling shall not be dropped onto the geotextile from the height of more than 1 foot {300 mm}. Smaller sizes of stone filling shall not be dropped onto the geotextile from a height exceeding 3 feet {1 m}. Any geotextile damaged during placement shall be replaced as directed by the Engineer at no additional cost to the State.

The geotextile shall be joined by either sewing or overlapping as outlined in Article 608.05 of these specifications. All seams shall be subject to the approval of the Engineer. Overlapped seams shall have a minimum overlap of 12 inches {300 mm} except where placed under water where the overlap shall be a minimum of 3 feet {1 m}.

A geotextile patch placed over a damaged area shall be extended 3 feet {1 m} beyond the perimeter of the tear or damage.

(f) RESTORATION OF SLIDE SLOPE.

Restoration of slide slope (front or back) shall consist of preparing the area to receive the replacement material by the shaping and compaction of the area as prescribed in Subarticle 210.03(d) for embankments. The material in place shall be compacted as noted in the plan details or directed by the Engineer.

The backfill material may be the material previously removed, ordinary borrow, or special backfill material of the type designated in the plans or proposal. Said backfill shall be placed in layers and compacted as prescribed in Section 210 or noted by plan details.

Erosion control items provided in the plans shall be used to re-establish the ground cover damaged or destroyed by the landslide or the restoration work.

219.04 Method of Measurement.

(a) GENERAL ITEM.

Construction items not specifically provided in this Section will be classified, measured, and paid for under the respective pay items for such work provided in the contract.

(b) ROCK BUTTRESS FOR LANDSLIDE CORRECTION.

The Item of Rock Buttress for Landslide Correction, when provided in the plans or proposal, will be the weight {mass} of rock used in construction of the buttress, measured on approved scales.

Measurement of any special bedding, if required, will be as specified for the respective pay item used for bedding.

(c) SPECIAL UNDERDRAIN.

The Item of Special Underdrain, when provided in the contract, will be measured in linear feet {meters} of each special type detailed in the plans, along the center of each line or lateral, center to center of junctions and/or fittings.

(d) SPECIAL FILTER BLANKET.

The Item of Special Filter Blanket, when provided in the contract, will be measured in square yards {square meters} to the nearest 0.1 square yard {0.1 m^2}, complete in place, for the material placed and accepted.

(e) HORIZONTAL DRAINS.

Horizontal drains will be measured by the linear foot {meter} of drain pipe installed in the holes drilled, including the extension necessary to discharge into the collector structure.

(f) SPECIAL BACKFILL FOR SLIDE CORRECTION.

1. When the item of special backfill for slide correction per ton {metric ton} is provided in the contract, the material ordered and accepted will be measured in tons {metric tons} on approved scales.

2. When the item of special backfill for slide correction per cubic yard in place {cubic meter} is provided in the contract, the accepted volume of backfill will be measured in cubic yards {cubic meters} complete in place by the cross section and average end area method. Cross sections shall be taken of the material in its original position, whether from a borrow pit, stockpile, or other approved source, before placing of the backfill and re-cross sectioned after placing the backfill. The volume computed between these cross sections shall be the volume of backfill.

Unless shown otherwise on the plans, the required overlap shall be as shown for a CBR value of 1 - 2.

The geotextile may be held in place prior to subbase placement by pins, staples, or piles of fill or rock. Geotextiles may be folded or cut to conform to any curvature of the area. A fold or overlap shall be in the direction of construction and held in place as prescribed above.

608.05 Seams.

Both factory and field sewn or sealed seams shall conform to the strength requirements of Table 1 as outlined in AASHTO M 288 for Separation Applications. All seams shall be subject to the approval of the Engineer.

608.06 Subbase Placement.

The subbase shall be placed by end dumping onto the geotextile from the edge of the geotextile, or over previously placed subbase aggregate. On subgrades having a CBR of 1, the subbase aggregate shall be spread simultaneously with dumping to minimize the potential of a localized subgrade failure. Direct traffic on the geotextile, along with any sudden stops, starts, or turns on the subbase material by construction equipment, shall be avoided where possible. Using whatever means, the subbase material shall be spread from the back dumped pile. Except in the case of low volume roads (ADT < 200), a minimum thickness of 6 inches {150 mm} shall be maintained. In the case of low volume roads, this thickness shall be 4 inches {100 mm}. A smooth drum roller shall be used to achieve the specified density. Any ruts occurring during construction shall be filled with additional subbase material and compacted to the specified density. The use of vibratory compaction will not be allowed as it may cause damage to the geotextile.

608.07 Damage Repair.

Damaged geotextiles, as identified by the Engineer, shall be repaired immediately. The damaged area, plus an additional 3 feet {1 m} around the area, shall be cleared of all fill material. This area shall be covered with a geotextile patch extending 3 feet {1 m} beyond the perimeter of the damage. The removed subbase material shall be replaced and compacted to the specified density.

608.08 Method of Measurement.

The geotextile will be measured by the square yard {square meter} from the payment lines shown on the plans, or from the payment lines established in writing by the Engineer. This excludes seam overlaps.

Excavation, backfill, bedding, and cover material are separate pay items.

608.09 Basis of Payment.

(a) GENERAL.

The accepted quantities of geotextiles will be paid for at the contract unit price per square yard {square meter} in place.

(b) PAYMENT WILL BE MADE UNDER ITEM NO.:

608-A Separation Geotextile - per square yard {square meter}

SECTION 609
AGGREGATE SLOPE PROTECTION

609.01 Description.

This Section shall cover the work of furnishing and constructing a slope protection layer of graded aggregate on slopes as shown on the plans or directed in accordance with these Specifications. This Section shall also cover the work, if shown on the plans, of furnishing and installing a geotextile filter blanket on slopes which are to receive the aforementioned aggregate protection layer.

609.02 Materials.

Materials furnished for use shall conform to the appropriate requirements of Division 800, Materials, and the following:

(a) GEOTEXTILE FILTER.

1. GENERAL.

The geotextile shall meet the requirements of AASHTO M 288 for Permanent Erosion Control Geotextile, Class 2, and Section 810 of these specifications. In addition, the fabric shall have a minimum coefficient of friction of the wet fabric on wet aggregate of 0.4 as determined by the Department's Central Lab. The geotextile shall be selected from List II-3, of the Department's manual titled "Materials, Sources, and Devices With Special Acceptance Requirements". Information concerning this list is given in Subarticle 106.01(f) and ALDOT-355.

2. SECURING PINS.

Securing pins for anchoring the filter shall be 3/16 of an inch {5 mm} steel bars, pointed at one end and fabricated with a head to retain a steel washer having an outside diameter of not less than 1.5 inches {38 mm}. The length of the pin shall not be less than 18 inches {450 mm}.

(b) AGGREGATE.

The aggregate shall be crushed stone meeting the requirements given in Section 801. The aggregate gradation shall be:

AGGREGATE GRADATION FOR AGGREGATE SLOPE PROTECTION Percent Passing by Weight {Mass}		
Sieve Size	Minimum	Maximum
7" {175 mm}	100	-
6" {150 mm}	90	100
4" {100 mm}	20	55
3" {75 mm}	0	15
2" {50 mm}	0	5

609.03 Construction Requirements.

(a) PREPARATION OF SURFACE.

The slope to be treated shall be prepared by removing vegetation, topsoil, and dressing the slope to reasonable line and grade. The surface shall then be compacted, if necessary, by the use of mechanical tampers to the satisfaction of the Engineer before placement of the geotextile filter and aggregate blanket. The dressing and preparation of the slope shall be considered incidental to the placement of the Aggregate Protection Blanket and no direct payment for such will be made.

Where grading has been completed under another contract and regrading is necessary to obtain the desired uniform slope, such regrading shall be considered incidental to the placement of the aggregate protection blanket and no direct payment for such will be made.

(b) PLACEMENT OF GEOTEXTILE FILTER.

The geotextile filter, if required, shall be placed in the manner and at the locations shown on the plans or as directed by the Engineer. Exposure of the geotextile to the elements between lay down and cover shall be a maximum of 14 days to minimize damage potential. At the time of installation, filter shall be rejected if it has defects, rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. The filter shall be placed with the long dimension horizontal with the natural ground line, unless otherwise directed by the Engineer, and shall be laid smooth and free of tension, stress, folds, wrinkles or creases. The strips shall be placed to provide a minimum width of 3 feet {1 m} of overlap for each joint. Overlap joints and seams shall be measured as a single layer of cloth. Securing pins with washers shall be inserted through both strips of overlapped cloth at not greater than the following intervals along a line through the midpoint of the overlap.

Pin Spacing	Slope
2 feet {0.6 m}	Steeper than 1:3
3 feet {1.0 m}	1:3 to 1:4
5 feet {1.6 m}	Flatter than 1:4

The filter shall be turned down and buried approximately 12 inches {300 mm} at all exterior limits.

Additional pins, regardless of location, shall be installed as necessary to prevent any slippage of the geotextile filter. Each securing pin shall be pushed through the filter until the washer bears against the filter and secures it firmly to the foundation. The filter shall be protected at all times during construction from contamination by surface runoff and any filter so contaminated shall be removed and replaced with uncontaminated filter. Any damage to the filter during its installation or

during placement of riprap shall be replaced by the Contractor. The work shall be scheduled so that 30 days does not expire between placement of the filter and the covering of the filter with the graded aggregate. Aggregate shall not be dropped on the filter from a height greater than 1 foot {300 mm}. Greater drop heights will be permitted if the Contractor provides a cushioning layer of sand on top of the filter before dumping of stone. The combination of drop height for stone and sand cushion layer thickness to be approved shall be demonstrated to not puncture or damage the filter. No measurement or separate payment shall be made for a sand cushion layer placed for the purpose of allowing an increased drop height of stones. Any damage to the geotextile filter during placement of aggregate shall be corrected prior to proceeding with the work.

(c) PLACEMENT OF AGGREGATE.

The method of placement of the aggregate shall be at the option of the Contractor provided it produces uniform coverage and depth without damaging the geotextile filter, if present.

Any damage to the filter shall be cause for ordering the aggregate cleaned from the damaged area and the repair of the filter by an additional layer of filter covering the damaged area overlapping at least 3 feet {1 m} onto undamaged filter and securing the patch with adequate securing pins.

If uniformity of coverage is not obtained by the method of placement, such shall be corrected in a manner satisfactory to the Engineer.

No compaction of the aggregate blanket is required.

609.04 Method of Measurement.

Accepted aggregate slope protection and geotextile filter for aggregate slope protection, if applicable, will each be measured in square yards {square meters}, complete in place, computed from actual measurements taken along the top surface of the treated area to the nearest 0.1 square yard {0.1 m^2}.

609.05 Basis of Payment.

(a) UNIT PRICE COVERAGE.

The accepted Aggregate Slope Protection and geotextile filter for aggregate slope protection, measured as noted above, will each be paid for at the contract unit price bid per square yard {square meter}. Said unit price bid shall be full compensation for the item complete in place and includes the furnishing of all materials, the preparation of the slope (excavation, backfill, compacting slope, disposal of surplus material), placement of materials and for all equipment, tools, labor, and incidentals necessary to complete the work.

(b) PAYMENT WILL BE MADE UNDER ITEM NO.:

609-A Aggregate Slope Protection - per square yard {square meter}

609-B Geotextile Filter for Aggregate Slope Protection - per square yard {square meter}

SECTION 610
RIPRAP

610.01 Description.

This Section shall cover the work of furnishing and constructing the several classes or types of Riprap, each of which shall consist of a protective course of stone or other approved materials on embankment slopes, in channels and ditches, wave protection for causeways and shoreline roadway embankments, bridge piers and abutments, or other work as shown on the plans or directed, with or without a geotextile filter, all in accordance with these specifications and in conformity with the lines, and grades noted in the plan details.

610.02 Materials.

If a geotextile filter is required, it shall meet the requirements of AASHTO M 288 for Permanent Erosion Control Geotextile, Class 1, and Section 810 of these specifications. All other materials shall conform to the requirements of Division 800, Materials. Specific reference is made to Section 814, Riprap Materials. The geotextile shall be selected from List II-3, of the Department's manual titled "Materials, Sources, and Devices With Special Acceptance Requirements". Information concerning this list is given in Subarticle 106.01(f) and ALDOT-355.

610.03 Construction Requirements.

(a) GENERAL.

All slopes to be treated with riprap shall be trimmed to the lines and grades indicated by the plans or directed; loose material shall be compacted by methods approved by the Engineer or removed.

Slopes which require a geotextile blanket under the riprap shall, in addition to the above, be prepared as noted in Subarticle (b) below.

Placement of any riprap on a filter blanket shall be by such means that will not damage or destroy the blanket. Any damage to the blanket shall be repaired without additional compensation.

Unless otherwise authorized or directed by the Engineer, riprap protection for bridge ends shall be placed immediately following the grading operations. The bridge Contractor shall protect any slope protection material in place during the bridge construction and shall be responsible for any damage due to negligence on the part of his operations.

If directed by the Engineer or shown by plan details, all outer edges and the top of riprap where the riprap terminates shall be formed so that the surface of the riprap will be embedded and even with the surface of the ground and/or slope.

All riprap construction shall begin at the bottom of the slope and progress upward.

(b) FILTER BLANKET.

1. GENERAL.

Unless otherwise specified by the plans or ordered in writing, the Contractor may select one of the filter blanket materials provided in Article 814.03 for construction of the filter blanket except that a geotextile blanket will not be allowed for soils with 85% by weight {mass} passing the #200 {75 µm} sieve.

If an aggregate blanket is used, the blanket shall be constructed using the designated material to a minimum thickness of 6 inches {150 mm}, unless otherwise shown by the plans, all in accordance with the provisions noted in this Subarticle and the plan details.

If a geotextile filter is used, it shall conform with Article 610.02 of this Section.

2. FOUNDATION PREPARATION.

Areas on which filter blankets are to be placed shall be uniformly trimmed and dressed to conform to cross sections shown by the plans within an allowable tolerance of plus or minus 3 inches {75 mm} from the theoretical slope lines and grades.

3. PLACEMENT.

a. Aggregate Blankets (Gravel or Crushed Stone).

Filter blanket material shall be spread uniformly on the prepared base, in a satisfactory manner, to a thickness of not less than 1/2 of an inch {10 mm} from that specified and to neat lines as indicated on the plans. Placing or spreading of material by methods which will tend to segregate particle sizes within the filter layer will not be permitted. Any damage to the surfaces of the filter blanket foundation during the placing of the filter blanket shall be repaired before proceeding with the work. Compaction of the filter material will not be required, but shall be finished to present a reasonably even surface free from mounds, depressions, or windrows.

b. Geotextile Filter.

Exposure of geotextiles to the elements between lay down and cover shall be a maximum of 14 days to minimize damage potential.

The geotextile shall be placed and anchored on a smooth graded surface approved by the Engineer. The geotextile shall be placed in such a manner that placement of the overlying materials will not excessively stretch or tear the filter. Anchoring of the terminal ends of the geotextile shall be accomplished through the use of key trenches or aprons at the crest and toe of the slope. In certain applications, 18 inch {450 mm} long anchoring pins, placed on 2 to 6 foot {1 to 2 m} centers, depending on the slope of the covered area, should be used to expedite construction.

Successive geotextile sheets shall be overlapped in such a manner that the upstream sheet is placed over the downstream sheet and/or upslope over downslope. In underwater applications, the geotextile and required thickness of backfill material shall be placed the same day. The backfill placement shall begin at the toe and proceed up the slope.

Riprap and heavy stone filling shall not be dropped onto the geotextile from the height of more than 1 foot {300 mm}. Slope protection and smaller sizes of stone filling shall not be dropped onto the geotextile from a height exceeding 3 feet {1 m}. Any geotextile damaged during placement shall be replaced as directed by the Engineer at the Contractor's expense.

The geotextile shall be joined by either sewing or overlapping. All seams shall be subject to the approval of the Engineer.

Overlapped seams shall have a minimum overlap of 12 inches {300 mm} except where placed underwater where the overlap shall be a minimum of 3 feet {1 m}.

A geotextile patch shall be placed over the damaged area and extend 3 feet {1 m} beyond the perimeter of the tear or damage.

(c) STONE RIPRAP.

1. GENERAL.

Unless otherwise shown by the plan details or directed, stone riprap shall not be placed on slopes steeper than the natural angle of repose of the riprap material.

Placement of stones may, unless otherwise noted in this Subarticle, be placed by methods and equipment approved by the Engineer suitable for the purpose of placing the riprap in accordance with the requirements for the class riprap involved without damaging any existing facility or construction feature.

2. CLASS 1.

Class 1 riprap is essentially designed for hand placement and use with minimal water currents. Stones shall be laid with close broken joints and resting on the embankment slope. The stones shall be of such shape and shall be so laid as to produce a single layer of stone of the thickness shown on the plans, measured perpendicular to the slope. The bottom course shall be laid in a trench excavated to such depth below the toe of the slope that all parts of the bottom course will be 3 feet {1 m} below the toe. Trenching will not be required where the toe of the slope is below water level. The back of the trench shall be on the same slope as the fill. The laying of the courses shall progress upward, the larger stones being placed in the lower courses. The individual pieces of stone in each horizontal course shall be laid so that they will break joints with the stones in the course below the tops sloped to drain away from embankment. Open joints shall be filled with spalls, or small stones in such manner that all stones are tightly wedged or keyed. The finished surface shall present a reasonably uniform appearance and shall not vary more than 6 inches {150 mm} from the average surface. The finished surface at the ends of the riprap shall be flush with the adjacent earth fill surface.

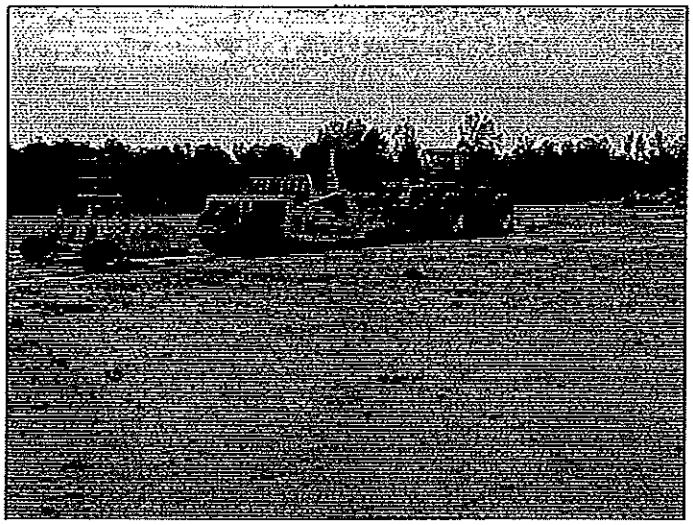
3. CLASS 2 AND 3.

Class 2 and 3 riprap is designed for use in areas with minimal to medium water currents and wave action. The stones shall be placed in such a manner as to produce a reasonably well graded mass of rock with the minimum practical percentage of voids. The riprap shall be constructed to the lines, grades and thickness shown by the plans or directed within a tolerance of plus 15 inches {375 mm} or minus 3 inches {75 mm} from the designated finish surface of the riprap, except that either extreme of such tolerance shall be reached as a uniform rate over an area greater than 200 square feet {19 m^2}. Riprap shall be placed in its full course thickness in one operation and in such a manner as to avoid displacing the filter blanket material, where filter blanket is required. The larger stones shall be well distributed and the entire mass of stones in their final position shall conform to a reasonable uniform gradation. The finished riprap shall be free from objectionable pockets of small stones and clusters of larger stones. Placing riprap by dumping into chutes or by other methods likely to cause segregation of sizes will not be permitted. The desired distribution of the various sizes of stones throughout the mass shall be obtained by selective loading of the material at the source, by controlled dumping of successive loads during final placing, or by other methods of placement which will produce the specified results. Rearranging of individual stones by mechanical equipment, or by hand, will be required to the extent necessary to obtain a reasonably well graded distribution of stone as specified above.

4. CLASS 4 AND 5.

Class 4 and 5 riprap is designed for use in medium to high water currents and wave actions for the protection of bridge piers and abutments, and protection of channel slopes. Stones may be placed without strict gradation controls provided sufficient small sizes are included to choke the larger stones. Dumping of the stones will be allowed; however, mechanical equipment to dress the material to a reasonable uniform slope will be required. Stones deposited contrary to directions will be considered wasted and will not be paid for.

Land Grading (LG)



Practice Description

Land grading is reshaping of the ground surface to provide suitable topography for buildings, facilities and other land uses, to control surface runoff, and to minimize soil erosion and sedimentation both during and after construction. This practice applies to sites where the existing topography must be modified to prepare for another land use, or where adapting proposed development to the existing landscape can reduce the erosion potential of the site and the cost of installing erosion and sediment control measures. In some instances other practices such as diversions can be used to reduce the length of continuous slopes and reduce erosion potential.

Planning Considerations

A detailed plan should be developed by a qualified design professional for all land grading activities at the project site. The plan should show all areas to be disturbed, the areas of cut, areas of fill, and the finished elevation for all graded areas.

The grading plan should be designed to protect existing vegetation where possible, especially around natural drainageways. Grading activities should be scheduled to minimize the area disturbed at any one time during the construction process. The plan should include provisions for stabilizing disturbed areas immediately after final grading is completed. Provisions should also be made to

protect existing underground utilities. Finally, topsoil should be removed and stockpiled for use in revegetating the site.

The grading plan should also include necessary practices for controlling sediment and erosion at the site. These practices could include stable outlets and slope breaks.

Design Criteria

Site Preparation

A detailed survey of the construction site should be performed by a qualified surveyor prior to grading plan development. This survey should include existing topographic information at the site including existing elevations, existing drainage patterns, locations of existing overhead and underground utilities, and construction limit boundaries.

The grading plan should require that the existing topsoil at sites to be graded be removed as the first step in the grading process. The plan should include a location on the construction site where topsoil will be stockpiled. Stockpiled topsoil should be protected by temporary vegetation (see Temporary Vegetation practice) or other appropriate temporary cover, such as plastic, until it is used to cover disturbed areas in advance of permanent vegetation of the site.

The grading plan should include a schedule of disturbance activities that minimizes the area disturbed at any point in time using sequencing and staging concepts. In areas where clearing of existing vegetation is planned, the area should be cleared and grubbed by removing trees, vegetation, roots and other debris such as trash. In areas to be filled all loose or weak soil and oversized rocks should be removed from the area. The foundation of the area to be filled should consist of soil or rock material of adequate strength to support the proposed fill material and the structures to be built at the site. The exact depth of material to be removed should be determined by a qualified geotechnical professional according to accepted engineering standards.

Grading

A plan for placement of fill should be developed by a qualified geotechnical professional. The plan should specify the source of fill materials, which should be obtained on site if possible. Materials used for fill, when placed according to the plans and specifications, should provide sufficient strength to support structures planned for construction at the location.

Loose fill material should be placed in layers not exceeding 9" in thickness. The materials should be compacted to a moisture content and to a dry density that will produce the design bearing strength required for structures planned at the site. A qualified geotechnical engineer should provide fill placement specifications using standard accepted engineering practices.

Slope lengths at the site should be minimized using diversions as slope breaks to reduce erosion potential (see Diversion practice). The following table gives guidance on the horizontal spacing of slope breaks:

Table LG-1 Guidelines for Spacing Slope Breaks [1]

Slope	Spacing (Ft)
33-50%	20
25-33%	40
15-25%	60
10-15%	80
6-10%	120
3-6%	200
<3%	300

[1] Adjustments in spacing may be made to account for soil and site conditions and professional experience of the site designer.

In areas where seepage and ground water are present subsurface drains should be installed to improve slope stability or soil bearing capacity (see Subsurface Drain practice).

Steep slopes should be avoided if possible. Slopes that are to be vegetated should be 2 horizontal to 1 vertical or flatter. If the slope is to be maintained by tractor or other equipment the slope should be 3 horizontal to 1 vertical or flatter. Slopes should be designed to blend with surrounding topography as much as possible.

Erosion Control

The grading plan should include provisions for stabilization of graded areas immediately after final grading is completed. On areas that will have no additional disturbance, permanent vegetation should be applied immediately to the site (see Permanent Seeding practice) if grading is finished during the planting season. If grading is finished outside of the recommended planting dates a temporary cover should be installed using a Temporary Seeding or other appropriate cover and the Permanent Seeding planned for the next planting period. On areas where work is to be interrupted or delayed for 14 working days or longer, such as topsoil stockpiles, the area should be stabilized using mulch or temporary seeding (see Mulching or Temporary Seeding practice). Other stabilization measures such as erosion control blankets should be used in extreme conditions, such as steep slopes and channels.

Where practical, runoff from undisturbed off-site areas should be diverted around the construction site to prevent erosion on the disturbed areas (see Diversion practice).

Sediment Control

Required sediment control practices should be installed before the land disturbance activities in the drainage area of the sediment control practices. Until disturbed areas can be stabilized, appropriate sediment control measures will be maintained to minimize sediment delivery off-site. Measures should include as a minimum:

- Sediment Barriers – Placed along toes of slopes and drainageways (see Sediment Barrier practice).
- Sediment Basins – Divert sediment laden runoff to basins as needed to minimize off-site sedimentation (see Sediment Basin practice).
- Inlet Protection – Where sediment-laden runoff is diverted to on-site stormwater drain inlets, the inlets should be protected with an appropriate sediment control practice.
- Stabilized Outlets – All runoff from the site should be conveyed in stabilized channels (see Grassed Swale, Lined Swale, or Channel Stabilization practice).

Topsoiling (TSG)

Practice Description

Topsoiling is the removal of a desirable soil surface, referred to as topsoil, at a site prior to construction and using it on areas to be vegetated. Topsoiling a site usually improves the quality of the plant growth medium at the site and increases the likelihood of successful plant establishment and performance. This practice applies to sites that are to be disturbed by excavation, compaction or filling, and to other areas where the subsoil is unsuitable for plant growth.

Planning Considerations

Topsoil is the surface layer of the soil profile, generally characterized as darker than the subsoil due to enrichment with organic matter. It is the major zone of root development and biological activity. Microorganisms that enhance plant growth thrive in this layer. Topsoil can usually be differentiated from subsoil by texture as well as color. Clay content usually increases in the subsoil.

The depth of topsoil may be quite variable. On severely eroded sites it may be non-existent.

Advantages of topsoil include its high organic-matter content and friable consistency (soil aggregates can be crushed with only moderate pressure), and its available water-holding capacity and nutrient content. Most often it is superior to subsoil in these characteristics. The texture and friability of topsoil are usually much more conducive to seedling emergence and root growth.

In addition to being a better growth medium, topsoil is often less erodible than subsoil because it has less clay and more organic matter and the coarse texture of topsoil increases infiltration capacity and reduces runoff.

Although topsoil provides an excellent growth medium, there are disadvantages to its use. Stripping, stockpiling, and reapplying topsoil, or importing topsoil, may not always be cost-effective. Topsoiling can delay seeding or sodding operations, increasing the exposure time of denuded areas. Most topsoil contains weed seeds and weeds may compete with desirable species.

In site planning, the option of topsoiling should be compared with that of preparing a seedbed in subsoil. The clay content of subsoils does provide high moisture availability and deter leaching of nutrients. When properly limed and fertilized, subsoils may provide a good growth medium especially if there is adequate rainfall or irrigation water to allow root development in otherwise high density material.

Topsoiling is strongly recommended where ornamental plants or high-maintenance turf will be grown. Topsoiling is a recommended procedure when establishing vegetation on shallow soils, soils containing potentially toxic materials, and soils of critically low pH (high acid) levels.

If topsoiling is to be done, the following items should be considered:

- An adequate volume of topsoil should exist on the site. Topsoil will be spread at a lightly compacted depth of 4" or greater.
- The topsoil stockpile should be located so that it meets specifications and does not interfere with work on the site, block drainage or release appreciable amounts of sediment.
- Allow sufficient time in scheduling for topsoil to be spread and bonded prior to seeding, sodding, or planting.
- Care must be taken not to apply topsoil to subsoil if the two soils have contrasting textures. Clayey topsoil over sandy subsoil is a particularly poor combination, as water creeps along the junction between the soil layers and causes the topsoil to slough.
- If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation.

Design Criteria

Materials

Field evaluation of the site should be made to determine if there is sufficient surface soil of good quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, and clay loam). It shall be relatively free of debris, trash, stumps, rocks, roots and noxious weeds, and shall give evidence of being able to support healthy vegetation. It shall contain no substance that is potentially toxic to plant growth.

Topsoil should meet the following criteria:

- pH range should be from 6.0-7.0. If pH is less than 6.0, lime should be added in accordance with soil test results or in accordance with the recommendations of the vegetative establishment practice being used.
- Soluble salts shall not exceed 500 ppm.
- If additional off-site topsoil is needed, it should meet the standards stated above.
- The depth of material meeting the above qualifications should be at least 4". Soil factors such as rock fragments, slope, depth to water table, and layer thickness affect the ease of excavation and spreading of topsoil.

Generally, the upper part of the soil, which is richest in organic matter, is most desirable; however, material excavated from deeper layers may be worth storing if it meets the other criteria listed above.

Stripping

Strip only those areas that will be affected by construction or development. A normal stripping depth is 4-6" but deeper depths may be satisfactory if the soil is suitable and undercutting is allowable in locations such as buildings, water impoundment structures, roadways, etc. Appropriate sediment control measures such as sediment barriers, sediment basins, inlet protection, etc., should be in place before the topsoil is stripped. Stripping should not be done on areas intended to support conventional on-site effluent disposal lines (field lines).

Stockpiling

The stockpile location should be out of drainageways and traffic routes. Stockpiles should not be placed on steep slopes where undue erosion will take place. Measures should be taken to prevent erosion of the stockpiles. These would include:

- Mulching the stockpile when it is left inactive for 14 days or longer.
- Planting temporary vegetation when the stockpile is to be inactive over 30 days.
- Covering the stockpile with plastic whenever the piles are small or any soil loss would damage existing buildings or facilities.
- Planting permanent vegetation when the stockpile use will be inactive over 12 months.
- In cases where the stockpile is small and will be removed in less than 14 days, it may be more practical to use a sediment barrier than an erosion control practice.

Site Preparation

Areas to be covered with topsoil shall be excavated, graded, filled and shaped to the proper lines, grades and elevations before topsoil placement is started.

The subgrades should be checked for pH and limed if it is less than 6.0. Liming shall be done in accordance with soil tests and in relation to the seeding mixture to be planted. Incorporate lime to a depth of at least 2" by disking.

Applying Topsoil

The subsoil should be disked or scarified to a depth of 2" to enhance bonding of the subsoil and topsoil, immediately before placement of topsoil. Topsoil should be uniformly spread to a minimum compacted depth of 4". Required volumes of topsoil may be determined using Table TSG-1.

Table TSG-1 Volume of Soil Needed for Topsoiling

Depth to Spread (inches)	Cubic Yards Per 1,000 Sq. Ft.	Cubic Yards Per Acre
1	3.1	134
2	6.2	268
3	9.3	403
4	12.4	537
5	15.5	672
6	18.6	806

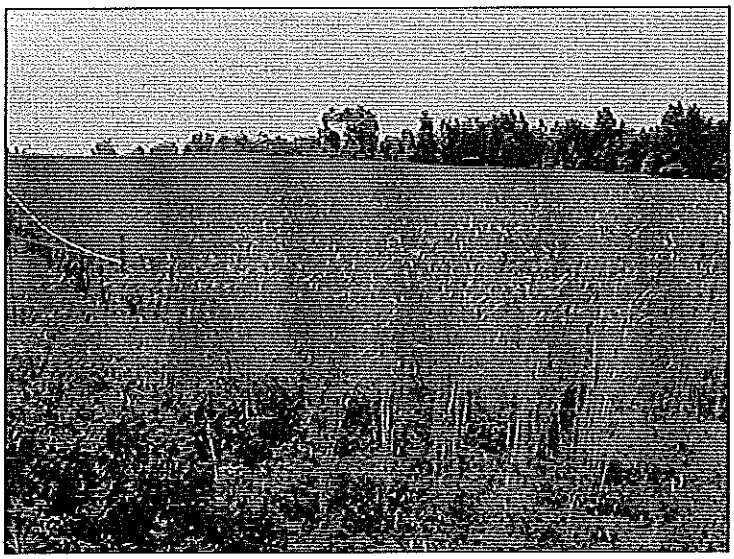
When applying topsoil, maintain needed erosion control practices such as diversions, grassed swales, lined swales, etc. Topsoil should not be spread when it or the subgrade is frozen or muddy.

Precautions should be taken to prevent layering of the topsoil over the subsoil. Mixing and bonding of the two soils should be enhanced.

Settling of the topsoil is necessary to bond the soils together, but excessive compaction should be prevented. Light compaction is necessary to increase soil strength, reduce erosion and enhance vegetation establishment. Excessive compaction should be prohibited as it increases runoff and inhibits seed germination and root development.

Surface irregularities that would impede drainage, increase erosion or otherwise damage the site should be removed in final grading.

Temporary Seeding (TS)



Practice Description

Temporary seeding is the establishment of fast-growing annual vegetation from seed on disturbed areas. Temporary vegetation provides economical erosion control for up to a year and reduces the amount of sediment moving off the site.

This practice applies where short-lived vegetation can be established before final grading or in a season not suitable for planting the desired permanent species. It helps prevent costly maintenance operations on other practices such as sediment basins and sediment barriers. In addition, it reduces problems of mud and dust production from bare soil surfaces during construction. Temporary or permanent seeding is necessary to protect earthen structures such as dikes, diversions, grass-lined channels and the banks and dams of sediment basins.

Planning Considerations

Temporary vegetative cover can provide significant short-term erosion and sediment reduction before establishing perennial vegetation.

Temporary vegetation will reduce the amount of maintenance associated with sediment basins.

Temporary vegetation is used to provide cover for no more than 1 year. Permanent vegetation should be established at the proper planting time for permanent vegetative cover.

Certain plants species used for temporary vegetation will produce large quantities of residue which can provide mulch for establishment of the permanent vegetation.

Proper seedbed preparation and selection of appropriate species are important with this practice. Failure to follow establishment guidelines and recommendations carefully may result in an inadequate or short-lived stand of vegetation that will not control erosion.

The selection of plants for temporary vegetation must be site specific. Factors that should be considered are type of soils, climate, establishment rate, and management requirements of the vegetation. Other factors that may be important are wear, mowing tolerance, and salt tolerance of vegetation.

Seeding properly carried out within the optimum dates has a higher probability of success. It is also possible to have satisfactory establishment when seeding outside these dates. However, as plantings are deviated from the optimum dates, the probability of failure increases rapidly. Seeding dates should be taken into account in scheduling land-disturbing activities.

Site quality impacts both short-term and long-term plant success. Sites that have compacted soils should be modified whenever practical to improve the potential for plant growth.

The operation of equipment is restricted on slopes steeper than 3:1, severely limiting the quality of the seedbed that can be prepared. Provisions for establishment of vegetation on steep slopes can be made during final grading. In construction of fill slopes, for example, the last 4-6" might not be compacted. A loose, rough seedbed with irregularities that hold seeds and fertilizer is essential for hydroseeding. Cut slopes should be roughened (see practice Land Grading).

Good mulching practices are critical to protect against erosion on steep slopes. When using straw, anchor with netting or asphalt. On slopes steeper than 2:1, jute, excelsior, or synthetic matting may be required to protect the slope.

The use of irrigation (temporary or permanent) will greatly improve the success of vegetation establishment.

Design Criteria

Plant Selection

Select plants that can be expected to meet planting objectives. To simplify plant selection, use Table TS-1, Commonly Used Plants for Temporary Cover and Figure TS-1, Geographical Areas for Species Adaptation and Seeding Dates. Seeding mixtures commonly specified by the Alabama Department of Transportation are an appropriate alternative for plantings on rights-of-ways. Additional information related to plantings in Alabama is found in Chapter 2 in the section Non-woody Vegetation for Erosion and Sediment Control.

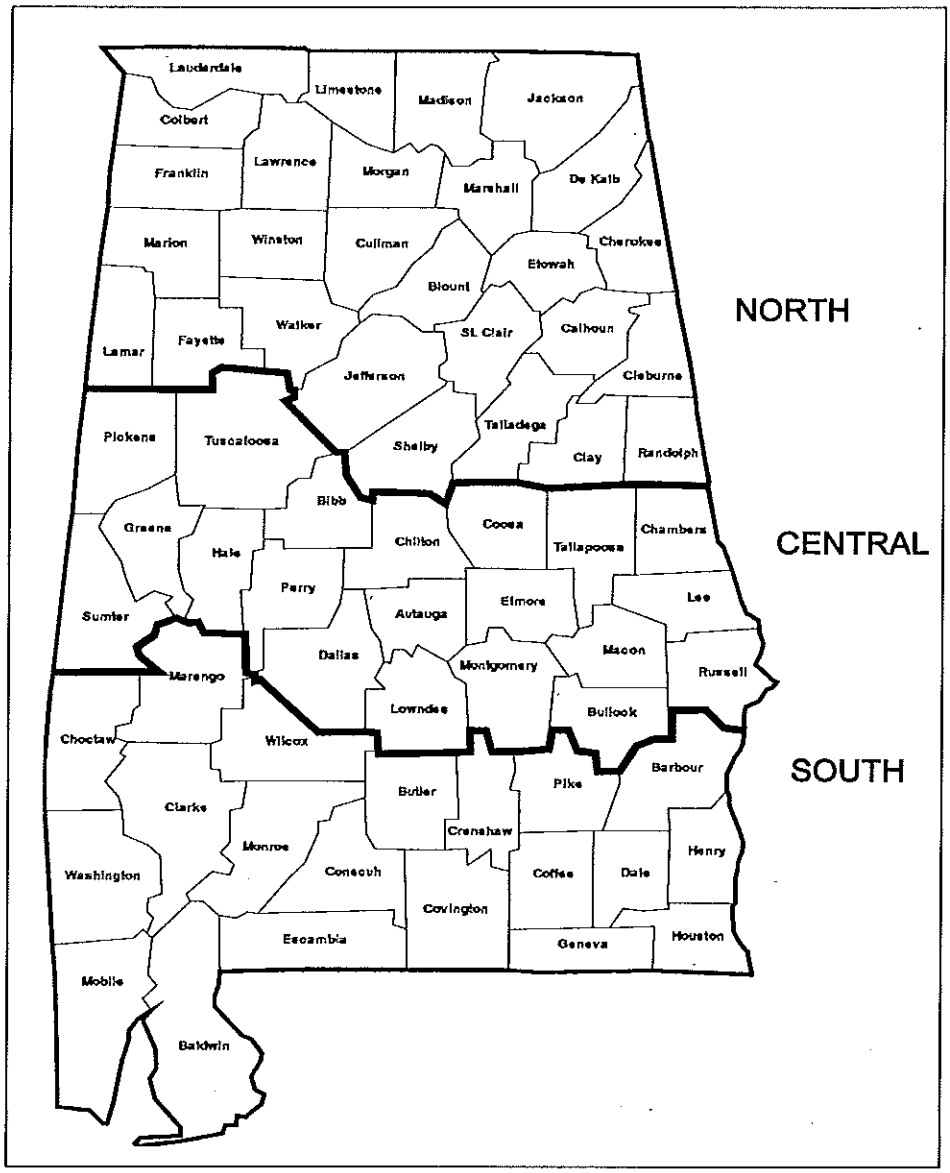


Figure TS-1 Geographical Areas for Species Adaptation and Seeding Dates

Table TS-I Commonly Used Plants for Temporary Cover

Species	Seeding Rate/AC PLS	North	Central	South
			Seeding Dates	
Millet, Browntop or German	40 lbs	May1-Aug 1	Apr1- Aug 15	Apr 1-Aug 15
Rye	3 bu	Sep I-Nov 15	Sep 15-Nov 15	Sep 15-Nov 15
Ryegrass	30 lbs	Aug I-Sep 15	Sep I-Oct 15	Sep 1-Oct 15
Sorghum-Sudan Hybrids	40 lbs	May I-Aug 1	Apr 15-Aug 1	Apr I-Aug 15
Sudangrass	40 lbs	May I-Aug I	Apr 15-Aug	Apr I-Aug 15
Wheat	3 bu	Sep I-Nov 1	Sep 15-Nov 15	Sep 15-Nov 15
Common Bermudagrass	10 lbs	Apr 1-July 1	Mar 15-July 15	Mar 1-July 15
Crimson Clover	10lbs	Sept 1-Nov 1	Sept 1-Nov 1	Sept 1-Nov 1

Site Preparation and Soil Amendments

Complete grading and shaping before applying soil amendments if needed to provide a surface on which equipment can safely and efficiently be used to apply soil amendments and accomplish seedbed preparation and seeding.

Lime

Apply lime according to soil test recommendations. If a soil test is not available, use 1 ton of agricultural limestone or equivalent per acre on coarse textured soils and 2 tons per acre on fine textured soils. Do not apply lime to alkaline soils or to areas which have been limed during the preceding 2 years. Other liming materials that may be selected should be provided in amounts that provide equal value to the criteria listed for agricultural lime or be used in combination with agricultural limestone or Selma chalk to provide equivalent values to agricultural limestone.

Fertilizer

Apply fertilizer according to soil test results. If a soil test is not available, apply 8-24-24 fertilizer.

When vegetation has emerged to a stand and is growing, 30 to 40 lbs/acre (approximately 0.8 lbs/1000 ft^2) of additional nitrogen fertilizer should be applied.

Note: Fertilizer can be blended to meet exact fertilizer recommendations. Take soil test recommendations to local fertilizer dealer for bulk fertilizer blends. This may be more economical than bagged fertilizer.

Application of Soil Amendments

Incorporate lime and fertilizer into the top 6" of soil during seedbed preparation.

Seedbed Preparation

Good seedbed preparation is essential to successful plant establishment. A good seedbed is well pulverized, loose, and smooth. If soils become compacted during grading, loosen them to a depth of 6" to 8" using a ripper or chisel plow.

If rainfall has caused the surface to become sealed or crusted, loosen it just prior to seeding by disking, raking, harrowing, or other suitable methods. When hydroseeding methods are used, the surface should be left with a more irregular surface of clods.

Planting Methods

Seeding

Evenly apply seed using a cyclone seeder (broadcast), drill seeder, cultipacker seeder, or hydroseeder. Broadcast seeding and hydroseeding are appropriate for steep slopes where equipment cannot operate safely. Small grains should be planted no more than 1" deep, and grasses and legumes no more than ½" deep. Seed that are broadcast must be covered by raking or chain dragging, and then lightly firmed with a roller or cultipacker.

Hydroseeding

Surface roughening is particularly important when hydroseeding, as a roughened slope will provide some natural coverage for lime, fertilizer, and seed. The surface should not be compacted or smooth. Fine seedbed preparation is not necessary for hydroseeding operations; large clods, stones, and irregularities provide cavities in which seeds can lodge.

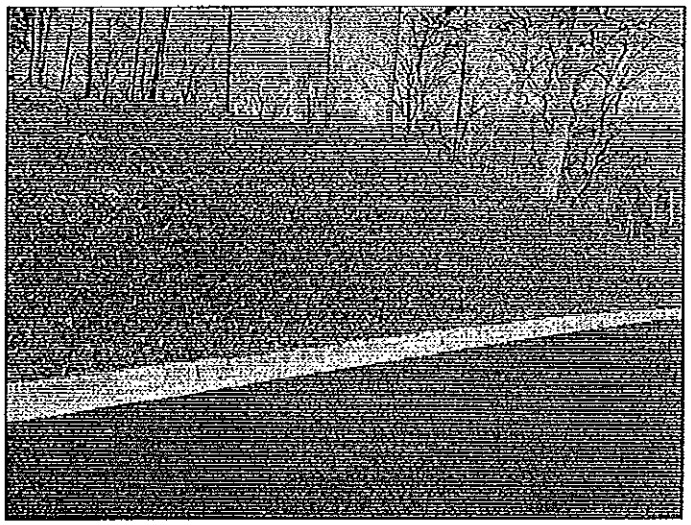
Mix seed, inoculant if required, and a seed carrier with water and apply as slurry uniformly over the area to be treated. The seed carrier should be a cellulose fiber, natural wood fiber or other approved fiber mulch material which is dyed an appropriate color to facilitate uniform application of seed. Use the correct legume inoculant at 4 times the recommended rate when adding inoculant to hydroseeder slurry. The mixture should be applied within one hour after mixing to reduce damage to seed.

Fertilizer should not be mixed with the seed-inoculant mixture because fertilizer salts may damage seed and reduce germination and seedling vigor. Fertilizer may be applied with a hydro seeder as a separate operation after seedlings are established.

Mulching

The use of an appropriate mulch provides instant cover and helps ensure establishment of vegetative cover under normal conditions and is essential to seeding success under harsh site conditions (see the Mulching practice for guidance). Harsh site conditions include the following: slopes steeper than 3:1 and adverse soils (soils that are shallow to rock, rocky, or high in clay or sand). Areas with concentrated flow should be treated differently and require a hydromulch formulated for channels or an appropriate erosion control blanket.

Permanent Seeding (PS)



Practice Description

Permanent seeding is the establishment of perennial vegetation on disturbed areas from seed. Permanent vegetation provides economical long-term erosion control and helps prevent sediment from leaving the site. This practice is used when vegetation is desired and appropriate to permanently stabilize the soil.

Planning Considerations

The advantages of seeding over other means of establishing plants include the smaller initial cost, lower labor input, and greater flexibility of method.

Disadvantages of seeding include potential for erosion during the establishment stage, seasonal limitations on suitable seeding dates, and weather-related problems such as droughts.

The probability of successful plant establishment can be maximized through good planning. The selection of plants for permanent vegetation must be site specific. Factors that should be considered are type of soils, climate, establishment rate, and management requirements of the vegetation. Other factors that may be important are wear, mowing tolerance, and salt tolerance of vegetation.

Plant selection for permanent vegetation should be based on plant characteristics, site and soil conditions, time of year of planting, method of planting, and the intended use of the vegetated area. Climate factors can vary widely in Alabama. Important plant attributes are discussed in Vegetation Establishment for Erosion and Sediment Control in Chapter 2.

Plant selection may include companion plants to provide quick cover on difficult sites, late seedings, or where the desired permanent cover may be slow to establish. Annuals are usually used for companion plants and should be selected carefully to prevent using a species that provide so much competition that it prevents the establishment of the desired species.

Seeding properly carried out within the optimum dates has a higher probability of success. It is also possible to have satisfactory establishment when seeding outside these dates. However, as plantings are deviated from the optimum dates, the probability of failure increases rapidly. Seeding dates should be taken into account in scheduling land-disturbing activities.

Site quality impacts both short-term and long-term plant success. Sites that have compacted soils, soils that are shallow to rock or have textures that are too clayey or too sandy should be modified whenever practical to improve the potential for plant growth and long-term cover success.

The operation of equipment is restricted on slopes steeper than 3:1, severely limiting the quality of the seedbed that can be prepared. Provisions for establishment of vegetation on steep slopes can be made during final grading. In construction of fill slopes, for example, the last 4-6" might not be compacted. A loose, rough seedbed with irregularities that hold seeds and lime and fertilizer is essential for hydroseeding. Cut slopes should be roughened (see Land Grading practice).

Proper mulching is critical to protect against erosion on steep slopes. When using straw, anchor with netting or asphalt. On slopes steeper than 2:1, jute, excelsior, or synthetic matting may be required.

The use of irrigation (temporary or permanent) will greatly improve the success of vegetation establishment.

Design Criteria

Plant Selection

Select plants that can be expected to meet planting objectives. To simplify plant selection, use Figure PS-1 Geographical Areas for Species Adaptation and Seeding Dates and Table PS-1, Commonly Used Plants for Permanent Cover. Mixtures commonly specified by the Alabama Department of Transportation are an appropriate alternative for plantings on rights-of-ways. Additional information related to plantings in Alabama is found in Chapter 2 under the section Vegetation for Erosion and Sediment Control.

The plants used for temporary vegetation may be used for companion plants provided the seeding rate is reduced by one half. See the Temporary Seeding practice for additional information on establishing temporary vegetation. **Ryegrass or other highly competitive plants should not be used as a companion plant.**

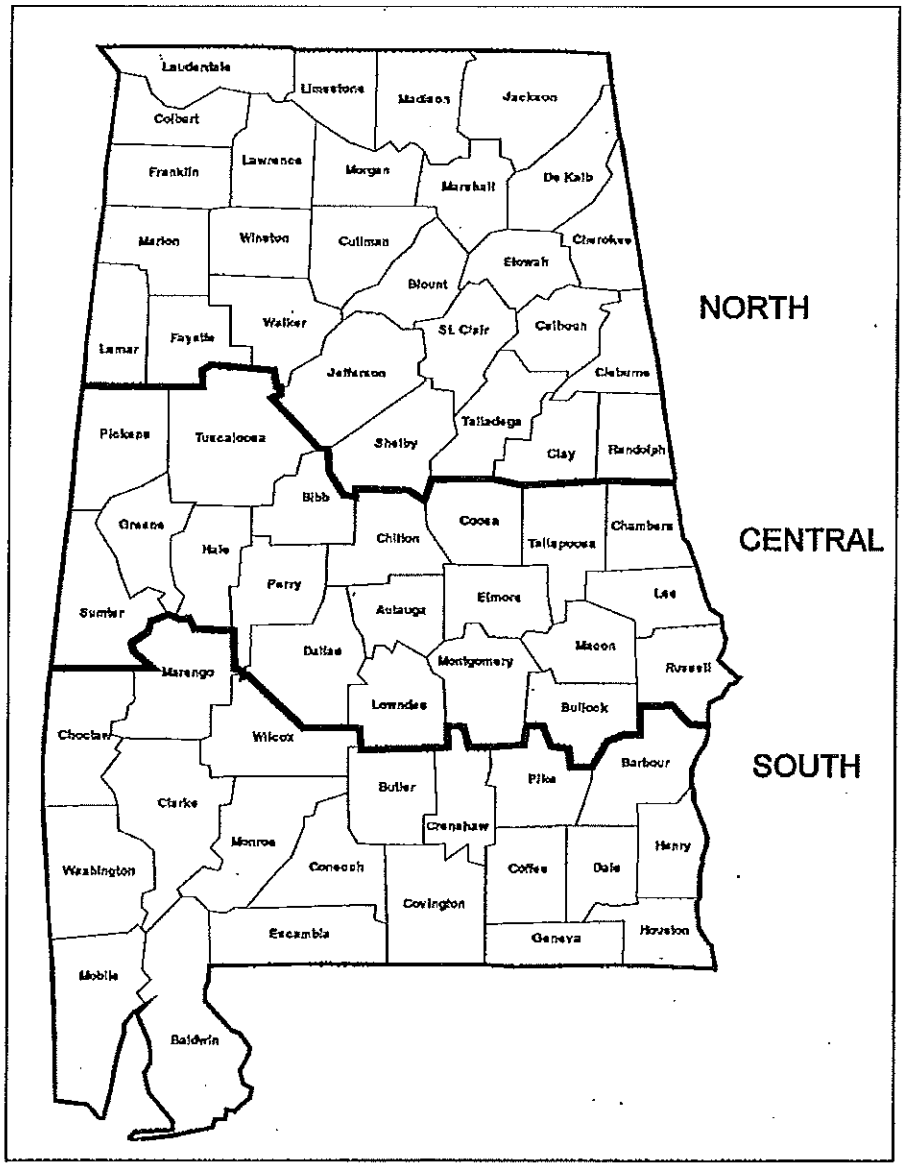


Figure PS-1 Geographical Areas for Species Adaptation and Seeding Dates

Table PS-1 Commonly Used Plants for Permanent Cover with Seeding Rates and Dates

Species	Seeding Rates/Ac PLS	North	Central	South
			Seeding Dates	
Bahiagrass, Pensacola	40 lbs	–	Mar 1-July 1	Feb 1-Nov 1
Bermudagrass, Common	10 lbs	Apr 1-July 1	Mar 15-July 15	Mar 1-July 15
Bahiagrass, Pensacola Bermudagrass, Common	30 lbs 5 lbs	--	Mar 1-July 1	Mar 1-July 15
Bermudagrass, Hybrid (Lawn Types)	Solid Sod	Anytime	Anytime	Anytime
Bermudagrass, Hybrid (Lawn Types)	Sprigs 1/sq ft	Mar 1-Aug 1	Mar 1-Aug 1	Feb 15-Sep 1
Fescue, Tall	40-50 lbs	Sep 1-Nov 1	Sep 1-Nov 1	--
Sericea	40-60 lbs	Mar 15-July 15	Mar 1-July 15	Feb 15-July 15
Sericea & Common Bermudagrass	40-60 lbs 10 lbs	Mar 15-July 15	Mar 1-July 15	Feb 15-July 15
Switchgrass, Alamo	4 Lbs	Apr 1-Jun 15	Mar 15-Jun 15	Mar 15-Jun15

PLS means pure live seed and is used to adjust seeding rates. For example, to plant 10 lbs PLS of a species with germination of 80% and 10% inert material, 10 lbs PLS = 10 lbs/ % live seed = 10/ 0.70 = 14.3 lbs.

Seedbed Requirements

Establishment of vegetation should not be attempted on sites that are unsuitable due to compaction or inappropriate soil texture, poor drainage, concentrated overland flow, or steepness of slope until measures have been completed to correct these problems. To maintain a good stand of vegetation, the soil must meet certain minimum requirements as a growth medium. A good growth medium should have these attributes:

- Sufficient pore space to permit root penetration.
- Enough fine-grained soil material (silt and clay) to maintain adequate moisture and nutrient supply.
- Sufficient depth of soil to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans should be 12" or more, except on slopes steeper than 2:1 where topsoiling is not feasible.
- A favorable pH range for plant growth, usually 6.0-6.5.

- Sufficient nutrients (nitrogen, phosphorus and potassium) for initial plant establishment.

- Freedom from large roots, branches, stones, or large clods. Clods and stones may be left on slopes steeper than 3:1 if they are to be hydroseeded.

If any of the above attributes are not met: i.e., if the existing soil is too dense, coarse, shallow or acidic to foster vegetation -- chiseling, topsoil, or special amendments should be used to improve soil conditions. The soil conditioners described below may be beneficial or topsoil may be applied (for guidance on topsoiling see Topsoiling practice). These amendments should only be necessary where soils have limitations that make them poor for plant growth or for turf establishment.

- Peat-appropriate types are sphagnum moss peat, reed-sedge peat, or peat humus, all from fresh-water sources. Peat should be shredded and conditioned in storage piles for at least 6 months after excavation.

- Sand-should be clean and free of toxic materials.

- Vermiculite-use horticultural grade.

- Rotted manure-use stable or cattle manure not containing undue amounts of straw or other bedding materials.

- Thoroughly rotted sawdust-should be free of stones and debris. Add 6 lbs of nitrogen to each cubic yard.

Soil Amendments

Liming Materials

Lime (Agricultural limestone) should have a neutralizing value of not less than 90 percent calcium carbonate equivalent and 90 percent will pass through a 10 mesh sieve and 50 percent will pass through a 60 mesh sieve.

Selma chalk should have a neutralizing value of not less than 80 percent calcium carbonate equivalent and 90 percent will pass through a 10 mesh sieve.

Other liming materials that may be selected should be provided in amounts that provide equal value to the criteria listed for agricultural lime or be used in combination with agricultural limestone or Selma chalk to provide equivalent values to agricultural limestone.

Plant Nutrients

Commercial grade fertilizers that comply with current Alabama Fertilizer Laws should be used to supply nutrients required to establish vegetation.

Rates of Soil Amendments

Lime and fertilizer needs should be determined by soil tests. Soil testing is performed by the Auburn University Soil Testing Laboratory and provides recommendations based on field tests on Alabama soils. The local county

Cooperative Extension Service can provide information on obtaining soil tests. Commercial laboratories that make recommendations based on soil analysis may be used.

When soil tests are not available, use the following rates for application of soil amendments.

Lime (Agricultural Limestone or Equivalent – see Liming Materials)
Sandy soils: Use 1 ton/acre (exception on sandy soils – if the cover will be tall fescue and clover) use 2 tons/acre.
Clayey soils: 2 tons/acre.
(Do not apply lime to alkaline soils).

Fertilizer
Grasses alone: Use 400 lbs/acre of 8-24-24 or the equivalent. Apply 30 lbs of additional nitrogen when grass has emerged and begun growth (approximately 0.8lbs/1000 ft^2).
Grass-legume mixtures: Use 800 to 1200 lbs/acre of 5-10-10 or the equivalent.
Legumes Alone: Use 800 to 1200 lbs/acre of 0-10-10 or the equivalent.

Note: Fertilizer can be blended to meet exact fertilizer recommendations. Take soil test recommendations to local fertilizer dealer for bulk fertilizer blends. This may be more economical than bagged fertilizer.

Application of Soil Amendments

Apply lime and fertilizer evenly and incorporate into the top 6" of soil by disking, chiseling or other suitable means during seedbed preparation. Operate machinery on the contour.

Seedbed Preparation

If needed, grade and shape to provide a surface on which equipment can safely and efficiently be used for seedbed preparation and seeding.

Install necessary sediment control practices before seedbed preparation and complete grading according to the approved plan.

Prepare a friable seedbed with tillage to a depth of at least 6". Break up large clods, alleviate compaction, and smooth and firm the soil into a uniform surface. Fill in or level depressions that can collect water.

Planting Methods

Seeding

Use certified seed for permanent seeding whenever possible. Certified seed is inspected by the Alabama Crop Improvement Association to meet high quality standards and will be tagged with a "Certified Seed" tag. (Note: all seed sold in Alabama is required by law to be tagged to identify seed purity, germination, and presence of weed seeds. Seed must meet state standards for content of noxious weeds.)

Seeding dates are determined using Figure PS-1 and Table PS-1.

Inoculate legume seed with the Rhizobium bacteria appropriate to the species of legume. Details of legume inoculation are located in Chapter 2 in the part on Vegetation for Erosion and Sediment Control under Inoculation of Legumes.

Plant seed uniformly with a cyclone seeder, a drill seeder, a cultipacker seeder, or by hand on a fresh, firm, friable seedbed. If the seedbed has been sealed by rainfall, it should be disked so the seed will be sown into a freshly prepared seedbed.

When using broadcast-seeding methods, subdivide the area into workable sections and determine the amount of seed needed for each section. Apply one-half the seed while moving back and forth across the area, making a uniform pattern; then apply the second half in the same way, but moving at right angles to the first pass.

Cover broadcast seed by raking or chain dragging; then firm the surface with a roller or cultipacker to provide good seed contact. Small grains should be planted no more than 1" deep and grasses and legume seed no more than ½" deep.

Hydroseeding

Surface roughening is particularly important when hydroseeding, as a roughened slope will provide some natural coverage for lime, fertilizer, and seed. The surface should not be compacted or smooth. Fine seedbed preparation is not necessary for hydroseeding operations; large clods, stones, and irregularities provide cavities in which seeds can lodge.

Mix seed, inoculant if required, and a seed carrier with water and apply as a slurry uniformly over the area to be treated. The seed carrier should be a cellulose fiber, natural wood fiber or other approved fiber mulch material which is dyed an appropriate color to facilitate uniform application of seed. Use the correct legume inoculant at 4 times the recommended rate when adding inoculant to a hydroseeder slurry. The mixture should be applied within one hour after mixing to reduce damage to seed.

Fertilizer should not be mixed with the seed-inoculant mixture because fertilizer salts may damage seed and reduce germination and seedling vigor.

Fertilizer may be applied with a hydroseeder as a separate operation after seedlings are established.

Lime is not normally applied with a hydraulic seeder because it is abrasive but if necessary it can be added to the seed slurry and applied at seeding or it may be applied with the fertilizer mixture. Also lime can be blown onto steeper slopes in dry form.

Sprigging

Hybrid bermudagrass cannot be grown from seed and must be planted vegetatively. Vegetative methods of establishing common and hybrid bermudagrass, centipedegrass and zoysia include sodding, plugging and sprigging (see Sodding practice).

When sprigs are planted with a sprigging machine, furrows should be 4-6" deep and 2 feet apart. Place sprigs no farther than 2 feet apart in the row and so that at least one rooting node is in the furrow.

When broadcasting is used for sprig planting, broadcast sprigs at the specified rate (Table PS-1). Press into the top ½" to 2" of soil with a cultipacker or with a disk set nearly straight so that the sprigs are not brought back to the surface. A mulch tacking machine may be used to press sprigs into the soil.

Mulching

The use of mulch provides instant cover and helps ensure establishment of vegetation under normal conditions and is essential to seeding success under harsh site conditions (see Mulching practice). Harsh site conditions include: slopes steeper than 3:1 and adverse soils (shallow, rocky, or high in clay or sand). Areas with concentrated flow should be treated differently and require sod, a hydromulch formulated for channels or an appropriate erosion control blanket.

Irrigation

Moisture is essential for seed germination and vegetation establishment. Supplemental irrigation can be very helpful in assuring adequate stands in dry seasons or to speed development of full cover. It is a requirement for establishment of vegetation from sod and sprigs and should be used elsewhere when feasible. However, irrigation is rarely critical for low-maintenance vegetation planted at the appropriate time of the year.

Water application rates must be carefully controlled to prevent runoff. Inadequate or excessive amounts of water can be more harmful than no supplemental water.

Maintenance

Generally, a stand of vegetation cannot be determined to be fully established until soil cover has been maintained for 1 full year from planting. Inspect vegetated areas for failure and make necessary repairs and vegetate as soon as possible.

If a stand has inadequate cover, reevaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand after seedbed

preparation or over-seed the stand. Consider a temporary seeding if the time of year is not appropriate for establishment of permanent vegetation (see Temporary Seeding practice).

If vegetation fails to grow, soil must be tested to determine if acidity or nutrient imbalance is responsible.

To attain complete establishment, fertilization is usually required in the second growing season. Turf grasses require annual maintenance fertilization. Use soil tests if possible or follow the guidelines given for the specific seeding mixtures.

Protect vegetation during its establishing period from traffic that will be harmful. If appropriate, use either temporary fences or barriers to protect areas that may be damaged by excessive traffic.

ZONE 1 - AREAS SUBJECT TO FREQUENT MOWING REQUIRED POUNDS PER ACRE {KILOGRAMS PER HECTARE} OF PURE LIVE SEED				
Date of Planting	Jan. 1 to Feb. 29	Mar. 1 to May 15	May 16 to August 15	Aug. 16 to Dec. 31
Annual Ryegrass	25 {28}			25 {28}
Hulled Bermudagrass		15 {17}	20 {22}	
Unhulled Bermudagrass		10 {11}		
Annual Lespedeza (Kobe)			30 {34}	
White Dutch Clover		5 {6}		
Notes	*			*
Required Permanent Plant	Bermudagrass			
* Requires seeding in stubble during the following month of March for the establishment of permanent plants.				

ZONE 1 - AREAS NOT SUBJECT TO FREQUENT MOWING REQUIRED POUNDS PER ACRE {KILOGRAMS PER HECTARE} OF PURE LIVE SEED				
Date of Planting	Jan. 1 to Feb. 29	Mar. 1 to August 15	Aug. 16 to Nov. 15	Nov. 16 to Dec. 31
Annual Ryegrass	15 {17}			15 {17}
Hulled Bermudagrass		15 {17}		
Unhulled Bermudagrass	30 {34}	10 {11}	15 {17}	30 {34}
Tall Fescue	30 {34}	30 {34}	30 {34}	30 {34}
Weeping Lovegrass		2 {2}		
Hulled Sericea Lespedeza		30 {34}	30 {34}	
Unhulled Sericea Lespedeza	30 {34}			30 {34}
Reseeding Crimson Clover			25 {28}	
Required Permanent Plant	Mixed			

ZONE 2 - AREAS SUBJECT TO FREQUENT MOWING REQUIRED POUNDS PER ACRE {KILOGRAMS PER HECTARE} OF PURE LIVE SEED				
Date of Planting	Jan. 1 to Feb. 15	Feb. 16 to Apr. 15	Apr. 16 to Aug. 15	Aug. 16 to Dec. 31
Annual Ryegrass	25 {28}			25 {28}
Hulled Bermudagrass		15 {17}	20 {22}	
Unhulled Bermudagrass		10 {11}		
Annual Lespedeza (Kobe)			30 {34}	
White Dutch Clover		5 {6}		
Notes	*			*
Required Permanent Plant	Bermudagrass			
* Requires seeding in stubble during the following month of March for the establishment of permanent plants.				