MO650.0804 Types of Terrace Cross Sections, State Supplement

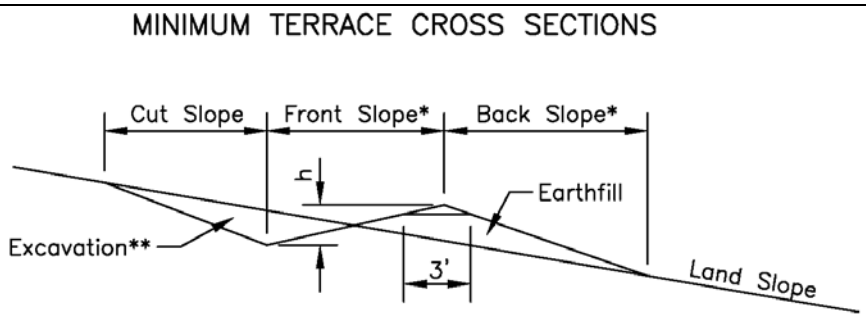


Figure MO-8-1. Broad Base Terrace

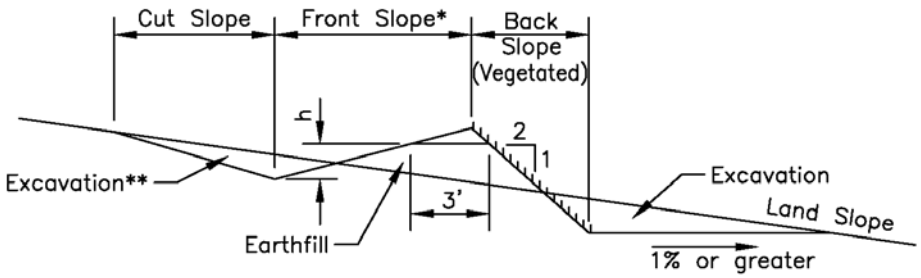


Figure MO-8-2. Steep Backslope Terrace

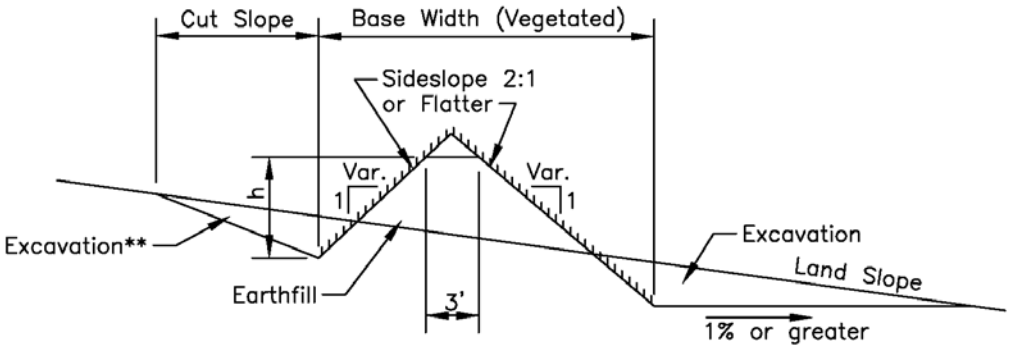


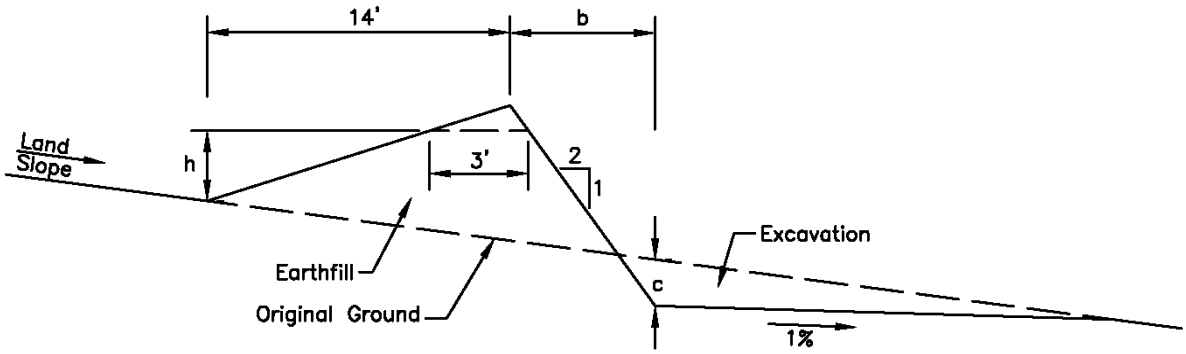
Figure MO-8-3. Narrow Base Terrace

Notes: h = Design height of terrace measured from channel bottom to 3-foot top width of ridge.

* The length of the farmable front slopes and backslopes for broad base and steep backslope terraces should be in increments of machinery width but not shorter than 14 feet nor steeper than 5:1.

** Excavation for steep backslope and narrow base terraces should be made from the downhill side of the terrace ridge. Only excavate on the uphill side of the terrace ridge as needed for surface drainage toward outlet.

Table MO-8-1. Guide Dimensions for Steep Backslope Terrace Cross-Section with 14 foot Frontslope



Landslope	h = 1.0 Ft.		h = 2.0 Ft.		h = 3.0 Ft.	
%	c	b	c	b	c	b
2	0.5	4	0.6	6	0.8	8
4	0.9	5	1.2	8	1.5	11
6	1.3	7	1.7	10	2.1	13
8	1.6	9	2.1	12	2.6	16
10	2.0	11	2.5	15	3.0	19
12	2.4	13	3.0	17	3.6	21
14	2.8	16	3.4	20	4.0	24
16	3.2	18	3.8	23	4.4	27

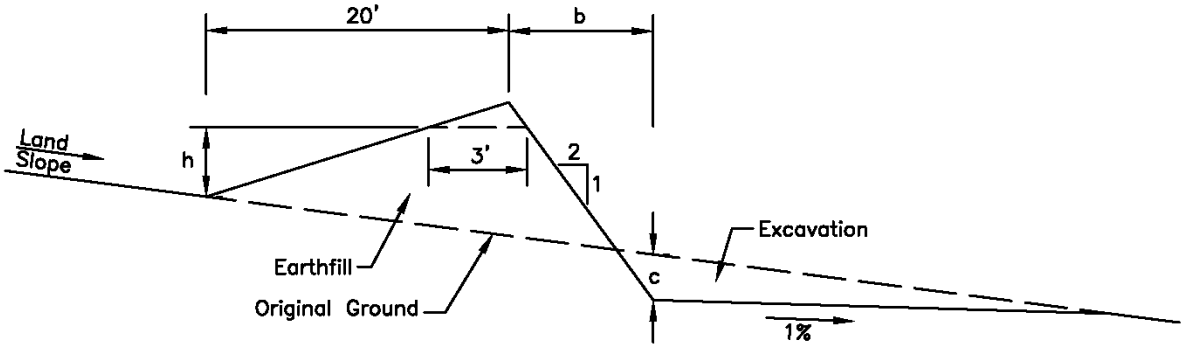
h = Design height of terrace (in feet) measured from channel bottom to the 3-foot top width of ridge.

c = Depth of cut (in feet) measured from natural ground at the toe of the backslope.

b = Width of backslope (in feet).

Note: The above values are based on the dimensions and slopes shown on the sketch and a "balanced" cut and fill at each station. If the entire ridge is constructed with borrowed fill (no excavation at downstream toe), the backslope width is equal to b-2c using the values of "b" and "c" shown in the table above.

Table MO-8-2. Guide Dimensions for Steep Backslope Terrace Cross-Section with 20 foot Frontslope



Landslope	h = 1.0 Ft.		h = 2.0 Ft.		h = 3.0 Ft.		h = 4.0 Ft.	
%	c	b	c	b	c	b	c	b
2	0.6	4	0.7	7	0.9	9	1.1	12
4	1.1	6	1.4	9	1.7	12	2.1	15
6	1.6	9	2.0	12	2.4	15	2.8	18
8	2.1	11	2.6	15	3.1	18	3.5	22
10	2.6	14	3.1	18	3.6	22	4.2	26
12	3.1	17	3.7	21	4.3	25	4.8	29
14	3.7	20	4.3	24	4.9	28	5.4	33

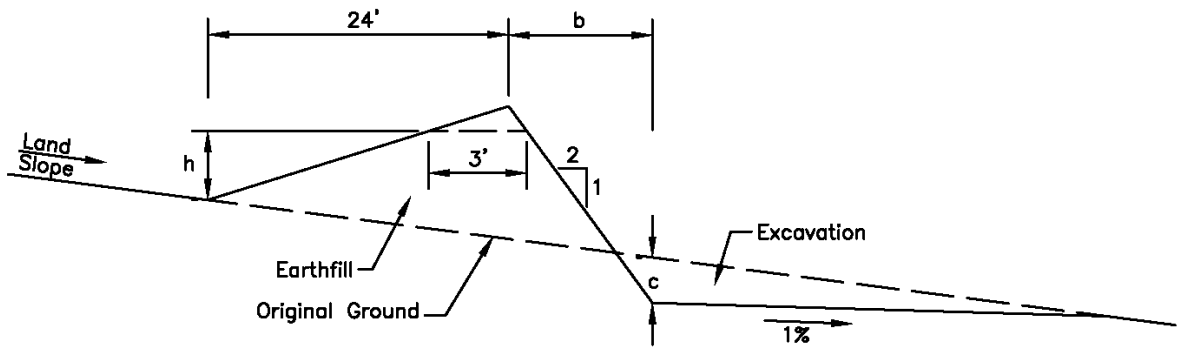
h = Design height of terrace (in feet) measured from channel bottom to the 3-foot top width of ridge.

c = Depth of cut (in feet) measured from natural ground at the toe of the backslope.

b = Width of backslope (in feet).

Note: The above values are based on the dimensions and slopes shown on the sketch and a "balanced" cut and fill at each station. If the entire ridge is constructed with borrowed fill (no excavation at downstream toe), the backslope width is equal to b-2c using the values of "b" and "c" shown in the table above.

Table MO-8-3. Guide Dimensions for Steep Backslope Terrace Cross-Section with 24 foot Frontslope



Landslope	h = 1.0 Ft.		h = 2.0 Ft.		h = 3.0 Ft.		h = 4.0 Ft.	
%	c	b	c	b	c	b	c	b
2	0.6	4	0.8	7	1.0	9	1.2	12
4	1.3	7	1.6	10	1.9	13	2.2	16
6	1.7	10	2.2	12	2.7	15	3.1	18
8	2.3	13	2.8	16	3.3	20	3.8	23
10	2.9	16	3.5	20	4.1	24	4.6	27
12	3.5	19	4.2	23	4.8	27	5.3	32
14	4.2	23	4.8	27	5.4	31	6.1	36

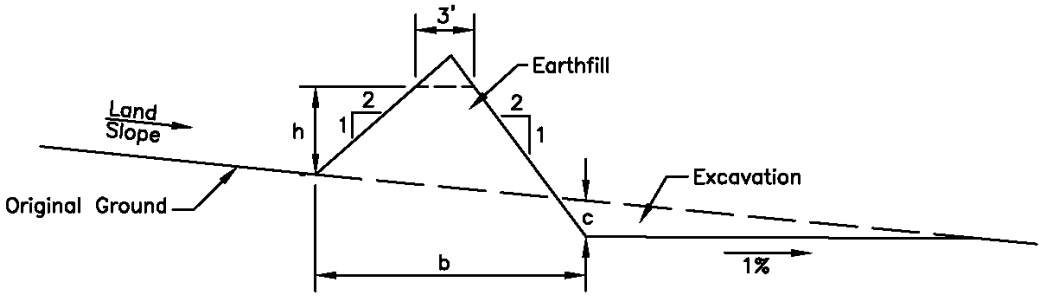
h = Design height of terrace (in feet) measured from channel bottom to the 3-foot top width of ridge.

c = Depth of cut (in feet) measured from natural ground at the toe of the backslope.

b = Width of backslope (in feet).

Note: The above values are based on the dimensions and slopes shown on the sketch and a "balanced" cut and fill at each station. If the entire ridge is constructed with borrowed fill (no excavation at downstream toe), the backslope width is equal to b-2c using the values of "b" and "c" shown in the table above.

Table MO-8-4. Guide Dimensions for Narrow Base Terrace Cross-Section



Landslope	h = 1.0 Ft.		h = 2.0 Ft.		h = 3.0 Ft.		h = 4.0 Ft.	
%	c	b	c	b	c	b	c	b
2	0.3	8	0.5	13	0.7	18	1.0	22
4	0.6	9	1.0	14	1.4	19	1.8	25
6	0.8	10	1.3	16	1.8	21	2.4	27
8	1.0	11	1.6	17	2.2	23	2.9	30
10	1.2	12	1.9	19	2.6	26	3.4	32
12	1.4	13	2.2	20	3.0	28	3.9	35
14	1.6	14	2.5	22	3.4	30	4.4	38
16	1.8	15	2.8	24	3.8	32	4.9	41

h = Design height of terrace (in feet) measured from natural ground at toe of front slope to 3-foot top width of ridge.

c = Depth of cut (in feet) measured from natural ground at the toe of the backslope.

b = Width of backslope (in feet).

Note: The above values are based on the dimensions and slopes shown on the sketch and a "balanced" cut and fill at each station. If the entire ridge is constructed with borrowed fill (no excavation at downstream toe), the backslope width is equal to b-2c using the values of "b" and "c" shown in the table above.

MO650.0806 Terrace Spacing, State Supplement

Table MO-8-5. Terrace Farmable Interval Adjusted for Specific Widths of Equipment [1/]

Odd or Even Number of Passes	Planter Rows (number) - Row Spacing (inch)							
	4 R - 30" 6 R - 20" **(10 ft)**	4 R - 38" **(12-2/3 ft)**	4 R - 40" **(13-1/3 ft)**	6 R - 30" 12 R - 15" **(15 ft)**	6 R - 38" **(19 ft)**	6 R - 40" 8 R - 30" 16 R - 15" **(20 ft)**	12 R - 30" 24 R - 15" **(30 ft)**	16 R - 30" 32 R - 15" **(40 ft)**
O	90	89	94	75	95	80	90	120
E	100	102	107	90	114	100	120	160
O	110	114	120	105	133	120	150	200
E	120	127	134	120	152	140	180	240
O	130	140	147	135	171	160	210	280
E	140	152	160	150	190	180	240	320
O	150	165	174	165	209	200	270	360
E	160	178	187	180	228	220	300	400
O	170	190	200	195	247	240	330	
E	180	203	214	210	266	260	360	
O	190	216	227	225	285	280	390	
E	200	228	240	240	304	300		
O	210	241	254	255	323	320		
E	220	254	267	270	342	340		
O	230	266	280	285	361	360		
E	240	279	294	300	380	380		
O	250	292	307	315	399	400		
E	260	304	320	330				
O	270	317	334	345				
E	280	330	347	360				
O	290	342	360	375				
E	300	355	374	390				
O	310	368	387	405				
E	320	380	400					
O	330	393						
E	340	406						
O	350							
E	360							
O	370							
E	380							
O	390							
E	400							

[1/] Terrace Spacing must be calculated from the Farmable Interval selected from this table and shall be within the allowable adjustments.

Broad Base Terraces – Farmable Interval equals Terrace Spacing. Adjust terrace front slope for the landuser's farm equipment.

Steep Backslope Terraces – Farmable Interval equals Terrace Spacing minus Backslope width. (See Tables MO-8-1 thru 3 for layout guide dimensions.) Adjust terrace front slope for the landuser's farm equipment.

Narrow Base Terraces – Farmable Interval equals Terrace Spacing minus Frontslope and Backslope widths. (See Table MO-8-4 for layout guide dimensions.)

MO650.0808 UGO Design, State Supplement

Estimating Sediment Storage for Terraces

Sediment storage needs may be estimated using the following table after the average annual soil loss in tons per acre has been determined for the terrace interval. Where large areas of the terrace interval will be disturbed during construction, additional sediment storage may be added to allow for the high first year accumulation.

Table MO-8-6. Estimating Storage Required for Sediment[1]

Soil Loss Tons per Acre per Year	Estimated 10-Year Sediment Accumulation in Acre-Feet per Acre of Drainage Area [2]
1	0.005
2	0.010
3	0.014
4	0.019
5	0.023
7	0.033
10	0.046
12	0.056
15	0.069
18	0.083

[1] Sediment storage should be included in the terrace design unless provisions have been made to maintain terrace capacity through maintenance.

[2] Based on sediment unit weight of 90 pounds per cubic foot (1.22 ton per cubic yard) and 90% sediment trap efficiency.

Table MO-8-7. Storage for Underground Outlet (acre-feet per acre of drainage area)

Outlet Discharge (CFS/AC)	10 Year Frequency, 24 Hour Rainfall (inch)[1]											
	5.0				5.4				5.8			
	Hydrologic Soil Group				Hydrologic Soil Group				Hydrologic Soil Group			
	V_r	B 2.37	C 2.89	D 3.08	V_r	B 2.69	C 3.24	D 3.44	V_r	B 3.02	C 3.6	D 3.8
0.05	48	0.150	0.193	0.209	48	0.176	0.223	0.240	48	0.204	0.255	0.273
0.06		0.142	0.183	0.199		0.167	0.212	0.229		0.194	0.242	0.260
0.08		0.132	0.169	0.184		0.155	0.196	0.211		0.179	0.224	0.240
0.1	24	0.124	0.159	0.173	24	0.146	0.184	0.199	24	0.169	0.211	0.226
0.12		0.118	0.152	0.165		0.139	0.175	0.189		0.160	0.201	0.215
0.14		0.113	0.146	0.158		0.133	0.168	0.182		0.154	0.192	0.206
0.16		0.109	0.140	0.152		0.128	0.162	0.175		0.148	0.186	0.199
0.18		0.106	0.136	0.147		0.124	0.157	0.170		0.144	0.180	0.193
0.2	12	0.103	0.132	0.143	12	0.121	0.153	0.165	12	0.140	0.175	0.187
0.22		0.100	0.129	0.140		0.117	0.149	0.161		0.136	0.170	0.182
0.24		0.098	0.126	0.136		0.115	0.145	0.157		0.133	0.166	0.178
0.26	9	0.096	0.123	0.133		0.112	0.142	0.153		0.130	0.163	0.174
0.28		0.094	0.121	0.131		0.110	0.139	0.150		0.127	0.159	0.171
0.3		0.092	0.118	0.128	9	0.108	0.137	0.148		0.125	0.156	0.168
0.32		0.090	0.116	0.126		0.106	0.134	0.145	12	0.123	0.154	0.165
0.34		0.089	0.114	0.124		0.104	0.132	0.143		0.121	0.151	0.162
0.36		0.087	0.113	0.122		0.103	0.130	0.140		0.119	0.149	0.159
0.38		0.086	0.111	0.120		0.101	0.128	0.138		0.117	0.147	0.157
0.4	6	0.085	0.109	0.119		0.100	0.126	0.137		0.116	0.145	0.155
0.42		0.084	0.108	0.117		0.099	0.125	0.135		0.114	0.143	0.153
0.44		0.083	0.107	0.116	6	0.097	0.123	0.133		0.113	0.141	0.151
0.46		0.082	0.105	0.114		0.096	0.122	0.131		0.111	0.139	0.149
0.48		0.081	0.104	0.113		0.095	0.120	0.130		0.110	0.138	0.147
0.5		0.080	0.103	0.112		0.094	0.119	0.128		0.109	0.136	0.146

1/ Interpolation may be used to obtain values between those shown on the Table.

Assumed Conditions:

Type II Storm Distribution; ACM II

RCN (contoured and terraced, poor) B Soils = 74, C Soils = 80, D Soils = 82

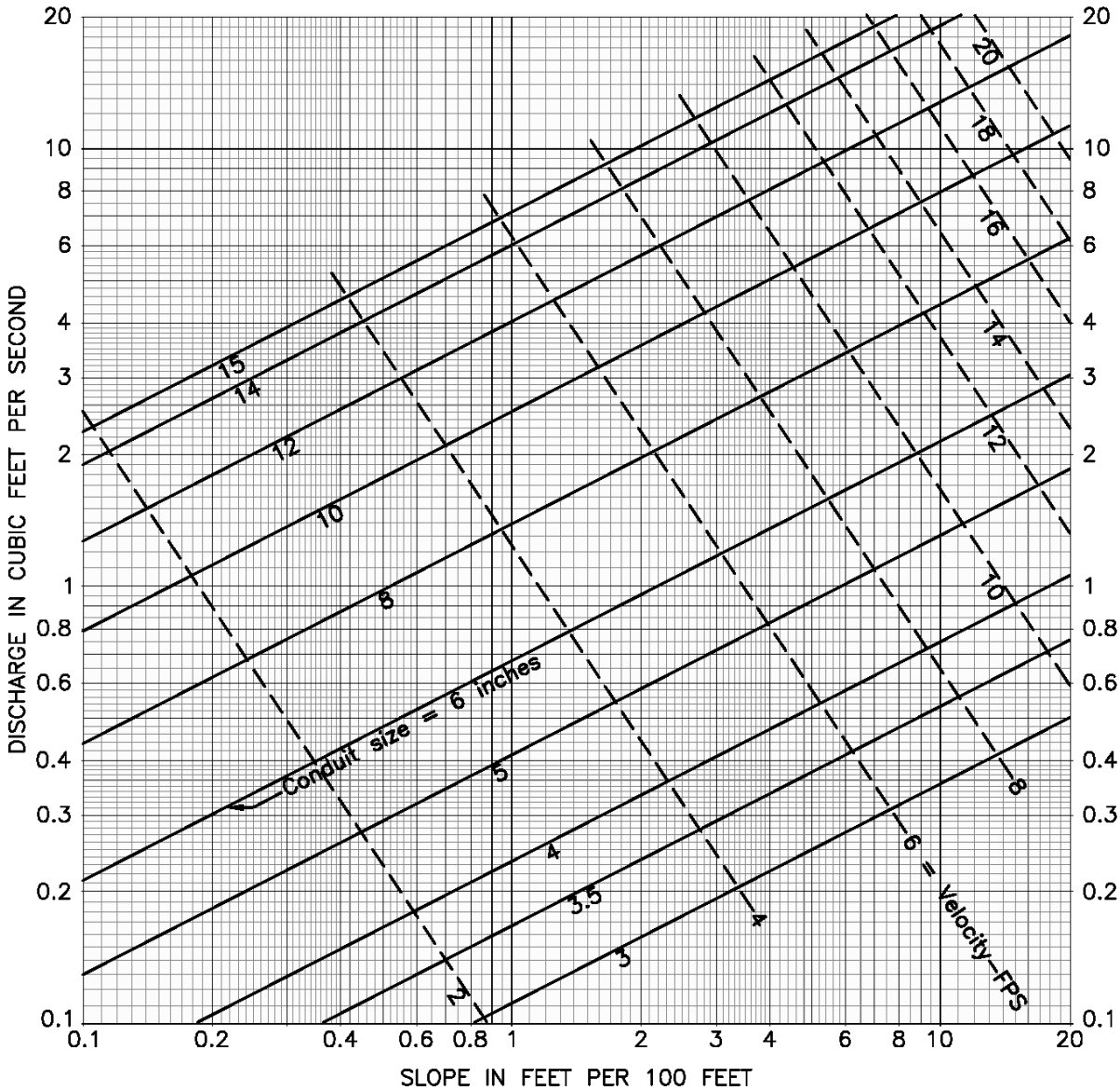
$V_s = 0.0221 \times V_r^{1.272} \div Q_A^{0.272}$ Where : V_s = Volume of storage in ac-ft/ac

V_r = Volume of runoff in inches

Q_A = Outlet discharge in cfs/ac

12 Horizontal lines represent flooding duration in hours

Figure MO-8-4. Average Discharge for Smooth Plastic Pipe Flowing Full (CFS)



Actual capacity of pipe should be checked by computing discharge when system includes more than one pipe size or type of pipe.

$Q = 0.0558\ d_i^{\ 8/3}\ s^{\ 1/2}$;

where Q = pipe discharge, di = inside diameter (inch), s = energy slope and n = 0.011

Diameter for the specific pipes to be used may be measured or taken from tables in ASTM specifications or from tables found in Engineering Field Handbook Chapter 15, Missouri Supplement.

Table MO-8-8. Discharge Capacity for Corrugated Plastic Tubing (CPT), Single Wall PE Flowing Full, Cubic Feet Per Second (CFS)

Energy Slope %	Conduit Diameter (inch)							
	3	4	5	6	8	10	12	15
0.2	0.04	0.08	0.14	0.22	0.47	0.75	1.2	2.2
0.4	0.05	0.11	0.19	0.31	0.67	1.1	1.7	3.1
0.6	0.06	0.13	0.24	0.38	0.82	1.3	2.1	3.8
0.8	0.07	0.15	0.27	0.44	0.94	1.5	2.4	4.4
1.0	0.08	0.17	0.30	0.49	1.1	1.7	2.7	4.9
1.2	0.09	0.19	0.33	0.54	1.2	1.8	3.0	5.4
1.4	0.10	0.20	0.36	0.58	1.2	2.0	3.2	5.8
1.6	0.10	0.21	0.38	0.62	1.3	2.1	3.5	6.3
1.8	0.11	0.23	0.41	0.66	1.4	2.3	3.7	6.6
			3.5				5	
2.0	0.11	0.24	0.43	0.69	1.5	2.4	3.9	7.0
2.2	0.12	0.25	0.45	0.73	1.6	2.5	4.0	7.3
2.4	0.12	0.26	0.47	0.76	1.6	2.6	4.2	7.7
2.6	0.13	0.27	0.49	0.79	1.7	2.7	4.4	8.0
2.8	0.13	0.28	0.50	0.82	1.8	2.8	4.6	8.3
3.0	0.14	0.29	0.52	0.85	1.8	2.9	4.7	8.6
3.2	0.14	0.30	0.54	0.87	1.9	3.0	4.9	8.8
3.4	0.15	0.31	0.56	0.90	1.9	3.1	5.0	9.1
3.6	0.15	0.32	0.57	0.93	2.0	3.2	5.2	9.4
3.8	0.15	0.33	0.59	0.95	2.0	3.3	5.3	9.6
	3.5			5			7	8
4.0	0.16	0.33	0.60	0.98	2.1	3.4	5.5	9.9
4.2	0.16	0.34	0.62	1.0	2.2	3.4	5.6	10.1
4.4	0.17	0.35	0.63	1.0	2.2	3.5	5.7	10.4
4.6	0.17	0.36	0.65	1.1	2.3	3.6	5.8	10.6
4.8	0.17	0.37	0.66	1.1	2.3	3.7	6.0	10.8
5.0	0.18	0.37	0.67	1.1	2.3	3.8	6.1	11.0
5.2	0.18	0.38	0.69	1.1	2.4	3.8	6.2	11.3
5.4	0.18	0.39	0.70	1.1	2.4	3.9	6.3	11.5
5.6	0.19	0.39	0.71	1.2	2.5	4.0	6.5	11.7
5.8	0.19	0.40	0.72	1.2	2.5	4.0	6.6	11.9
		5		7			8	
6.0	0.19	0.41	0.74	1.2	2.6	4.1	6.7	12.1
6.2	0.20	0.42	0.75	1.2	2.6	4.2	6.8	12.3
6.4	0.20	0.42	0.76	1.2	2.7	4.2	6.9	12.5
6.6	0.20	0.43	0.77	1.3	2.7	4.3	7.0	12.7
6.8	0.20	0.43	0.78	1.3	2.7	4.4	7.1	12.9
7.0	0.21	0.44	0.80	1.3	2.8	4.4	7.2	13.1
7.2	0.21	0.45	0.81	1.3	2.8	4.5	7.3	13.3
7.4	0.21	0.45	0.82	1.3	2.9	4.6	7.4	13.4
7.6	0.22	0.46	0.83	1.3	2.9	4.6	7.5	13.6
7.8	0.22	0.47	0.84	1.4	2.9	4.7	7.6	13.8
	5		7	8			10	
8.0	0.22	0.47	0.85	1.4	3.0	4.7	7.7	14.0
8.2	0.22	0.48	0.86	1.4	3.0	4.8	7.8	14.1
8.4	0.23	0.48	0.87	1.4	3.0	4.9	7.9	14.3
8.6	0.23	0.49	0.88	1.4	3.1	4.9	8.0	14.5
8.8	0.23	0.49	0.89	1.5	3.1	5.0	8.1	14.6
								12
9.0	0.23	0.50	0.90	1.5	3.1	5.0	8.2	14.8
9.2	0.24	0.50	0.91	1.5	3.2	5.1	8.3	15.0
9.4	0.24	0.51	0.92	1.5	3.2	5.1	8.4	15.1
9.6	0.24	0.52	0.93	1.5	3.3	5.2	8.4	15.3
9.8	0.24	0.52	0.94	1.5	3.3	5.2	8.5	15.5

Energy Slope %	Conduit Diameter (inch)							
	3	4	5	6	8	10	12	15
10.0	0.25	0.53	0.95	1.5	3.3	5.3	8.6	15.6
10.2	0.25	0.53	0.96	1.6	3.4	5.4	8.7	15.8
10.4	0.25	5 0.54	0.97	1.6	3.4	5.4	8.8	15.9
10.6	0.25	0.54	0.98	1.6	3.4	5.5	8.9	16.1
10.8	0.26	0.55	0.99	1.6	3.4	5.5	9.0	16.2
11.0	0.26	0.55	1.00	1.6	3.5	5.6	9.0	16.4
11.2	0.26	0.56	1.0	1.6	3.5	5.6	9.1	16.5
11.4	0.26	0.56	1.0	1.7	3.5	5.7	9.2	16.7
11.6	0.27	0.57	1.0	1.7	3.6	5.7	9.3	16.8
11.8	0.27	0.57	1.0	1.7	3.6	5.8	9.4	17.0
		7		8	10		12	
12.0	0.27	0.58	1.0	1.7	3.6	5.8	9.4	17.1
12.2	0.27	0.58	1.1	1.7	3.7	5.9	9.5	17.2
12.4	0.27	0.59	1.1	1.7	3.7	5.9	9.6	17.4
12.6	0.28	0.59	1.1	1.7	3.7	6.0	9.7	17.5
12.8	0.28	0.59	1.1	1.7	3.8	6.0	9.7	17.7
13.0	0.28	0.60	1.1	1.8	3.8	6.0	9.8	17.8
13.2	0.28	0.60	1.1	1.8	3.8	6.1	9.9	17.9
13.4	0.29	0.61	1.1	1.8	3.8	6.1	10.0	18.1
13.6	0.29	0.61	1.1	1.8	3.9	6.2	10.0	18.2
13.8	0.29	0.62	1.1	1.8	3.9	6.2	10.1	18.3
	7	8			10		12	
14.0	0.29	0.62	1.1	1.8	3.9	6.3	10.2	18.5
14.2	0.29	0.63	1.1	1.8	4.0	6.3	10.3	18.6
14.4	0.30	0.63	1.1	1.9	4.0	6.4	10.3	18.7
14.6	0.30	0.63	1.2	1.9	4.0	6.4	10.4	18.9
14.8	0.30	0.64	1.2	1.9	4.0	6.4	10.5	19.0
15.0	0.30	0.64	1.2	1.9	4.1	6.5	10.6	19.1
15.2	0.30	0.65	1.2	1.9	4.1	6.5	10.6	19.2
15.4	0.31	0.65	1.2	1.9	4.1	6.6	10.7	19.4
15.6	0.31	0.66	1.2	1.9	4.1	6.6	10.8	19.5
15.8	0.31	0.66	1.2	1.9	4.2	6.7	10.8	19.6
	7	8			10	12		
16.0	0.31	0.66	1.2	2.0	4.2	6.7	10.9	19.7
16.2	0.31	0.67	1.2	2.0	4.2	6.7	11.0	19.9
16.4	0.31	0.67	1.2	2.0	4.2	6.8	11.0	20.0
16.6	0.32	0.68	1.2	2.0	4.3	6.8	11.1	20.1
16.8	0.32	0.68	1.2	2.0	4.3	6.9	11.2	20.2
17.0	0.32	0.68	1.2	2.0	4.3	6.9	11.2	20.4
17.2	0.32	0.69	1.2	2.0	4.3	7.0	11.3	20.5
17.4	0.32	0.69	1.3	2.0	4.4	7.0	11.4	20.6
17.6	0.33	0.70	1.3	2.0	4.4	7.0	11.4	20.7
17.8	0.33	0.70	1.3	2.1	4.4	7.1	11.5	20.8
	7	8		10	12			
18.0	0.33	0.70	1.3	2.1	4.4	7.1	11.6	20.9
18.2	0.33	0.71	1.3	2.1	4.5	7.2	11.6	21.1
18.4	0.33	0.71	1.3	2.1	4.5	7.2	11.7	21.2
18.6	0.33	0.72	1.3	2.1	4.5	7.2	11.7	21.3
18.8	0.34	0.72	1.3	2.1	4.5	7.3	11.8	21.4
19.0	0.34	0.72	1.3	2.1	4.6	7.3	11.9	21.5
19.2	0.34	0.73	1.3	2.1	4.6	7.3	11.9	21.6
19.4	0.34	0.73	1.3	2.1	4.6	7.4	12.0	21.7
19.6	0.34	0.73	1.3	2.2	4.6	7.4	12.1	21.9
19.8	0.35	0.74	1.3	2.2	4.7	7.5	12.1	22.0

7 = Velocity, (fps)
n = 0.015 3 to 8 inch dia. CPT
n = 0.017 10 to 15 inch dia. CPT

$$Q = \frac{0.000614}{n} d_i^{8/3} s^{1/2}$$

n = Mannings Roughness coefficient
d_i = Inside diameter of conduit (inch)
s = Energy grade slope (ft/ft)

Table MO-8-9.

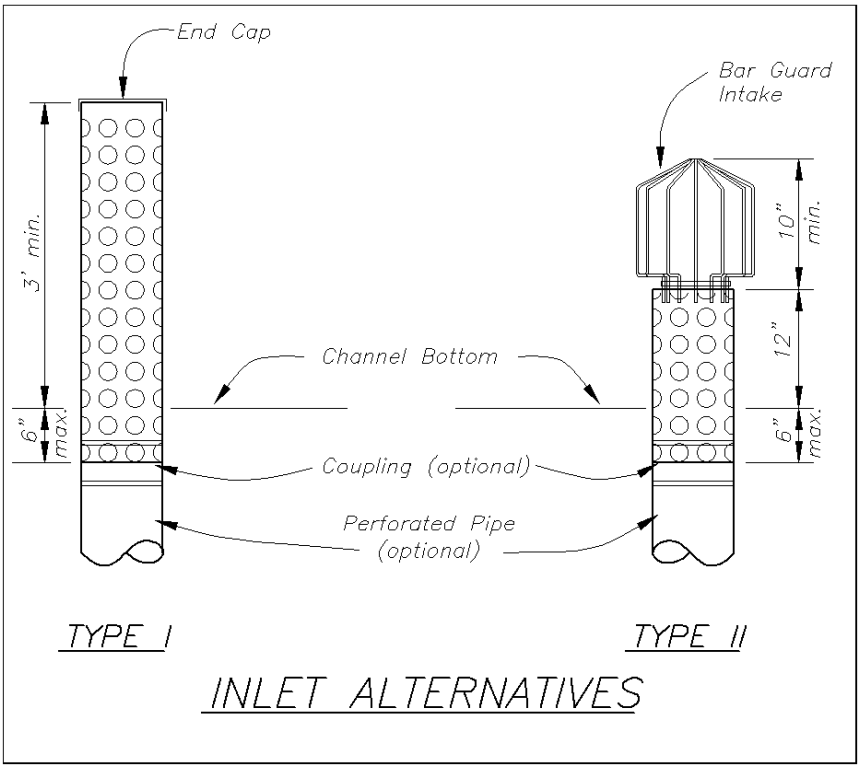
Maximum Permissible Velocities for Conduit Lines[1], in feet per second

Soil Texture	Perforated Corrugated Plastic Tubing	Non Perforated Corrugated Plastic Tubing	Dual Wall Polyethylene Pipe[2]	Polyvinyl Chloride Smooth Steel Corrugated Steel (Watertight Joints)
Sand & Sandy Loam	3.5	8.0	20.0	No Limit
Silt & Silt Loam	5.0	10.0	20.0	No Limit
Silty Clay Loam	6.0	12.0	20.0	No Limit
Clay & Clay Loam	7.0	12.0	20.0	No Limit
Coarse Sand or Gravel	9.0	12.0	20.0	No Limit

[1]Any change in alignment of the pipe, possible water hammer or cavitation conditions, will require analysis of resulting forces to determine restraint needed, if any.

[2]Dual Wall PE Pipe and Joints must meet ASTM Standards F 477, F 667, F 2306, and D 3212. All joints and fittings shall be watertight, capable of withstanding 10.8 psi of internal pressure.

Figure MO-8-5. UGO Inlet Alternatives Illustration.



Riser Inlet and Orifice Design Dimensions

Orifice Dimensions

1. Orifice diameters should be selected in quarter inch increments to allow for easier fabrication.

2. Orifice diameters less than 2.5 inches should be avoided.

3. The minimum ratio of nominal riser diameter to orifice diameter shall be 1.5, refer to Table MO-8-10 for maximum orifice diameters for common riser sizes.

Table MO-8-10. Maximum Orifice Diameter.

Nominal Riser Diameter (inch)	Maximum Orifice Diameter (inch)
5	3.25
6	4.0
8	5.25
10	6.5
12	8.0
15	10.0

Table MO-8-11. Inlet Discharge Capacities for Underground Outlets (CFS)

Type I Inlet Discharge Capacity for Underground Outlet (cfs)																	
Inlet Dia. (in)	No. of Holes per foot	Maximum Terrace Height at Riser Location (ft)															
		1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
5	25	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.9	0.9	1.0
6	30	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.1	1.2
8	40	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6
10	50	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.4	1.5	1.7	1.8	1.9	2.0
12	60	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.2	1.3	1.5	1.6	1.8	2.0	2.2	2.3	2.4
15	75	0.4	0.5	0.6	0.8	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.0

Type II Inlet Discharge Capacity for Underground Outlet (cfs)																	
Inlet Dia. (in)	No. of Holes per foot	Maximum Terrace Height at Riser Location (ft)															
		1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
5	25	0.1	0.1	0.2	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9
6	30	0.1	0.2	0.2	0.4	0.5	0.6	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2
8	40	0.2	0.2	0.3	0.5	0.8	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.7	1.8	1.9
10	50	0.2	0.3	0.4	0.6	1.1	1.4	1.6	1.7	1.9	2.0	2.2	2.3	2.4	2.5	2.6	2.7
12	60	0.3	0.4	0.5	0.8	1.3	1.9	2.1	2.4	2.6	2.8	2.9	3.1	3.3	3.4	3.5	3.7
15	75	0.4	0.5	0.6	1.0	1.6	2.5	3.1	3.5	3.8	4.0	4.3	4.5	4.8	5.0	5.2	5.4

The values above are based on the following assumptions:

1 Orifice flow through the holes (Type I) orifice flow through the holes and top (Type II)
2 Orifice C value = 0.6
3 Design hydraulic head = 0.7 x Maximum Terrace Height
4 Number of open holes = 50% plugging factor x number of holes per foot x minimum (Max. Terrace Height or Riser Perforation Length)
5 Perforation length of riser = 2.5 feet (Type I) and 1.0 feet (Type II)
6 All holes are 1 inch diameter
7 Average orifice head for all holes = Design hydraulic head - 0.5 perforation length below the design hydraulic head elevation
8 Top opening is 50% plugged

Design Procedure for Vertical Outlet of an Underground Outlet.

A. Conditions for use.

A vertical outlet can be used to discharge water to the ground surface where topography does not allow adequate conduit cover using a horizontal outlet or where it is practical to discharge over a vegetated filter strip.

B. Vertical Outlet Dimensions.

The vertical outlet diameter shall be a minimum of one conduit size larger than the incoming underground outlet. In the case of multiple conduit lines entering a single vertical outlet, the cross sectional end area of the vertical outlet shall be a minimum of 1.5 times the sum of the cross sectional end areas of the incoming conduits. In no case shall the vertical outlet be smaller than 6 inches. The use of nominal conduit diameters is acceptable for this calculation. The vertical outlet diameter shall be large enough to provide enough space along the circumference of the vertical outlet for fabricating tile subs (both incoming and outgoing lines) and allow for proper maintenance. The vertical outlet shall extend at least to the ground surface but no more than 6 inches above the surrounding ground surface. The minimum depth from the ground surface to the vertical outlet bottom shall be that which will provide the required depth of cover for the attached lines.

Table MO-8-12. Conduit Cross Section Dimensions

Conduit Cross Section Dimensions			
Diameter (inch)	**End Area (sq in)**	**End Area (sq ft)**	**Circumference (ft)**
4	12.6	0.087	1.05
5	19.6	0.136	1.31
6	28.3	0.196	1.57
8	50.3	0.349	2.09
10	78.5	0.545	2.62
12	113.1	0.785	3.14
15	176.7	1.227	3.93
18	254.5	1.767	4.71
24	452.4	3.142	6.28
32	804.2	5.585	8.38
36	1017.9	7.069	9.42

Example:

Two 6 inch diameter conduits enter a single vertical outlet.
End area of 6 inch conduit = 28.3 sq.in.
Minimum vertical outlet end area = 1.5 x (28.3 sq. in. + 28.3 sq. in.) = 84.9 sq. in.
Therefore, select a 12 inch diameter vertical outlet, which has an end area of 113.1 sq. in.

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Table MO-8-13. Maximum Terrace Channel Grade in Percent for Easily Eroded Soils[1/] [3/]

Terace Spacing (ft)	Terrace Length from Upper End (ft)[2/]											
	50	100	150	200	300	400	500	600	700	800	1000	1200
90	2.5	1.6	1.3	1.1	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4
100	2.3	1.5	1.2	1.0	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4
120	2.1	1.4	1.1	0.9	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4
160	1.8	1.2	0.9	0.8	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3
200	1.6	1.0	0.8	0.7	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3
240	1.4	0.9	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2
280	1.3	0.9	0.7	0.6	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2
300	1.3	0.8	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2
400	1.1	0.7	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2

[1/] The classification of the soil layer that will be exposed in the terrace channel bottom and sideslopes should be considered. Easily erodible soils generally have the following textures: silt, silt loam, sandy loam, loamy sand, sandy clay loam, and loam.

[2/] Channel grade in the lower reaches of the storage basin for underground outlets may exceed the table values.

[3/] Table values are based on the following data (utilize approved terrace design software to model the channel flow with actual site values to take credit for wider terrace channels):

Maximum velocity = 1.5 fps
10 yr-24 hr. rainfall = 5.4 inches
Average landslope = 8%
RCN = 75
“n” value = 0.035
V-shaped channel; Front slope ratio = 5:1 and cut slope ratio = 10:1
Minimum ridge height = 1.0 foot

Table MO-8-14. Maximum Terrace Channel Grade in Percent for Erodible and Erosion Resistant Soils[1/] [3/]

Terace Spacing (ft)	Terrace Length from Upper End (ft)[2/]											
	50	100	150	200	300	400	500	600	700	800	1000	1200
90	3.0	3.0	2.4	2.1	1.6	1.4	1.3	1.1	1.1	1.0	0.9	0.8
100	3.0	2.9	2.3	1.9	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8
120	3.0	2.6	2.0	1.7	1.4	1.2	1.0	1.0	0.9	0.8	0.7	0.7
160	3.0	2.2	1.7	1.5	1.2	1.0	0.9	0.8	0.7	0.7	0.6	0.6
200	3.0	1.9	1.5	1.3	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.5
240	2.7	1.7	1.4	1.1	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4
280	2.5	1.6	1.2	1.1	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4
300	2.4	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.5	0.5	0.4	0.4
400	2.1	1.3	1.0	0.9	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3

1/ The classification of the soil layer that will be exposed in the terrace channel bottom and sideslopes should be considered. Erodible and Erosion Resistant soils generally have the following textures: Clay, silty clay, silty clay loam, clay loam, and sandy clay. Erosion Resistant soils are allowed a maximum channel velocity of 2.5 fps, utilize approved terrace design software to design with the higher velocity limit.

2/ Channel grade in the lower reaches of the storage basin for underground outlets may exceed the table values.

3/ Table values are based on the following data (utilize approved terrace design software to model the channel flow with actual site values to take credit for wider terrace channels):

Maximum velocity = 2.0 fps
10 yr-24 hr. rainfall = 5.4 inches
Average landslope = 8%
RCN = 80
“n” value = 0.035
V-shaped channel; Front slope ratio = 5:1 and cut slope ratio = 10:1
Minimum ridge height = 1.0 foot

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Table MO-8-15. Minimum Height of Settled Ridge for Gradient Terraces[1/] [3/] [4/]

Distance From Upper End of Terrace (feet)		Terrace Spacing					
		90 to 120 feet		121 to 240 feet		241 to 400 feet	
		Channel Grade		*Channel Grade*		*Channel Grade*	
From	*To*	Less Than 0.4%	0.4% and Greater	Less Than 0.4%	0.4% and Greater	Less Than 0.4%	0.4% and Greater
0	200	1.0	1.0	1.2	1.0	1.4	1.1
201	400	1.2	1.0	1.5	1.2 [2/]	1.8 [2/]	1.4 [2/]
401	600	1.4	1.1	1.7 [2/]	1.3 [2/]	2.0 [2/]	1.6 [2/]
601	800	1.5	1.1	1.9 [2/]	1.4 [2/]	2.2 [2/]	1.7 [2/]
801	1000	1.6	1.2	2.0 [2/]	1.5 [2/]	2.4 [2/]	1.8 [2/]
1001	1200	1.6	1.3	2.1 [2/]	1.6 [2/]		
1201	1400	1.7 [2/]	1.3 [2/]	2.2 [2/]	1.7 [2/]		
1401	1600	1.8 [2/]	1.4 [2/]				

[1/] Measured from the 3 foot bottom width of channel to the 3 foot top of ridge. Ridge height will not be reduced for channel grades greater than those in table.

Channel grade used to select ridge height must not exceed the maximum allowable channel grade as shown in Tables MO-8-13 and MO-8-14.

[2/] Terraces with this combination of grade, spacing and length may be above maximum allowable grade if soils are easily erodible with a cultivated channel.

[3/] Table values are based on the following data:

10 year-24 hour rainfall = 5.4 inches

Average land slope = 8%

RCN = 80

n-value = 0.060

V-shaped channel; Front slope ratio = 5:1 and cut slope ratio = 10:1

Minimum ridge height = 1.0 foot

[4/] Gradient terraces may be designed using the NRCS Engineering Field Tools Terrace Design Tool program in lieu of using the values listed in this table.

MO650.0811 Terrace Construction Methods, State Supplement

Topsoiling Criteria for Terrace Construction

Terraces are used to reduce erosion, manage water, and prevent loss of topsoil. During construction of terraces, it is desirable to salvage topsoil and re-spread it over the disturbed areas to maintain the soil's texture and productivity.

The following soils lists establish criteria for topsoiling terraces. Only those soils where terraces are normally constructed in Missouri are included (Major Land Resource Areas 107, 108, 109, 112, 113 and 115). These soils are more likely in need of topsoiling; however, an onsite evaluation of specific field conditions is required to determine if an adequate depth of topsoil is present to require topsoiling (i.e., topsoiling of severely eroded areas cannot be accomplished if the topsoil has already been lost).

Table MO-8-16a. Soils Requiring Topsoiling
The soils listed below have at least 25% more clay in the subsoil immediately below the surface layer, more than 40% clay in the subsoil, and are greater than 5% slope. Topsoiling on these soils is required during construction of terraces.*

Adair	Gosport	Lamoni	Sylvania
Armstrong	Keswick	Leonard	Weller
Belinda	Ladoga	Leslie	Winnegan
Clarinda	Lagonda	Mystic	

*Topsoiling will not be used unless 6 inches of topsoil is present before terrace construction begins. If topsoil depths are great enough that at least 6 inches will remain after terrace construction, then salvage and re-spreading of topsoil is not necessary. Topsoiling normally will be applied throughout the entire terrace length. Not all terraces in a field may need topsoiling.

Table MO-8-16b. Soils Recommended for Topsoiling
The soils listed below have at least 20% more clay in the subsoil immediately below the surface layer. Topsoiling on these soils during terrace construction is optional.**

Armster	Goss	Kilwinning	Smileyville
Brazilton	Greenton	Lindley	Sturges
Caleb	Grundy	Macksburg	Woodson
Calwoods	Herrick	Maplegrove	
Chilhowie	Holstein	McGirk	
Gorin	Kenoma	Mexico	

**Topsoiling will not be used unless 6 inches of topsoil is present before terrace construction begins. If topsoil depths are great enough that at least 6 inches will remain after terrace construction, then salvage and re-spreading of topsoil is not necessary. Topsoiling normally will be applied throughout the entire terrace length. Not all terraces in a field may need topsoiling.