Peter

DESIGN MANUAL

MAMMOTH LAKES STORM DRAINAGE AND EROSION CONTROL

PREPARED FOR

MONO COUNTY PUBLIC WORKS DEPARTMENT

JULY 1984

BROWN AND CALDWELL
AND
TRIAD ENGINEERING

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INTRODUCTION

This design manual establishes procedures for planning and design of storm drainage and flood control systems and erosion control facilities. Procedures defined herein have been developed specifically for application in the community of Mammoth Lakes and to comply with applicable county regulations. Requirements for project review and procedures for issuance of applicable grading and building permits are specified in the Mono County Code and other county ordinances. The Public Works Department of the County of Mono should be consulted for reference to applicable county regulations and ordinances.

PART I

STORM DRAINAGE AND FLOOD CONTROL

CHAPTER 1

RUNOFF CALCULATION PROCEDURES

This chapter describes the calculation procedures to be used for determining design flows for flood control and storm drainage systems and erosion control facilities. Two separate calculation procedures are applicable to the Mammoth Lakes area. Descriptions of the two procedures, their applicability, and sample calculations using the procedures are presented below. The method to be used for calculating runoff hydrographs for the design of storage facilities is also presented.

EXCEEDENCE INTERVALS FOR DESIGN

Table 1-1 gives the appropriate exceedence intervals (return periods) for use in the design of storm drainage and erosion control facilities. In all cases, the storm drainage system shall be sized to carry 100-year peak flows without damage to persons or property. Individual facilities in the system may have lower exceedence intervals, but should be designed to overflow to another portion of the storm drainage system when their capacity is exceeded.

For example, the appropriate exceedence interval for the design of a 24-inch storm drain in a street from Table 1-1 is 20 years. During a larger storm, the storm drain would overflow to the street. The capacity of the street, curb and gutter,and storm drain should be adequate to carry the 100-year peak flow without flooding adjacent property. The exceedence intervals given in Table 1-1 shall be used in Procedures A and B for runoff calculations described below.

PROCEDURE A

Runoff Procedure A applies to the design of all improvements in Area A as shown on Figure 1-1. In addition, it applies to undeveloped areas of 1,600 acres or less and all developed areas within Area B. The procedure is a form of the rational method. A step-by-step description of Procedure A is presented below, and a sample calculation for a drainage subarea follows the description.

Table 1-1. Exceedence Intervals for Design

Type of facility	Exceedence interval, years
Diversion dikes on slopes	50
Runoff interceptor ditches on slope terrace	20
Temporary straw bale sediment barriers	5
Temporary filter berms and filter inlets	5
Temporary siltation berms[a]	5
Temporary flexible downdrains	10
Chutes and flumes	100
Storm drainage inlets	20
Curb and gutter	10
Storm drains in streets	
Less than 48 inches in diameter	20
Greater than or equal to 48 inches in diameter	50
Open channels and storm drains not in streets	
Less than 50 cfs capacity	50
Greater than 50 cfs capacity	100
Roadside drainage ditches	20
Slotted drains	20
Culverts	100
Infiltration facilities in parking lots[b]	20
Dry wells[b]	20
Permanent sediment retention or flow detention basins[c]	10, 50, 100
Temporary sediment retention basins[c]	5, 10, 20

[a]The 24-hour precipitation volume shall be used to compute storage volume required.

[b]The facilities shall provide for retention of the one-hour precipitation volume for this exceedence interval.

[c]Submit calculations to County Public Works Director for review for all three exceedence intervals. (See text in this chapter for procedure to calculate runoff hydrograph.)

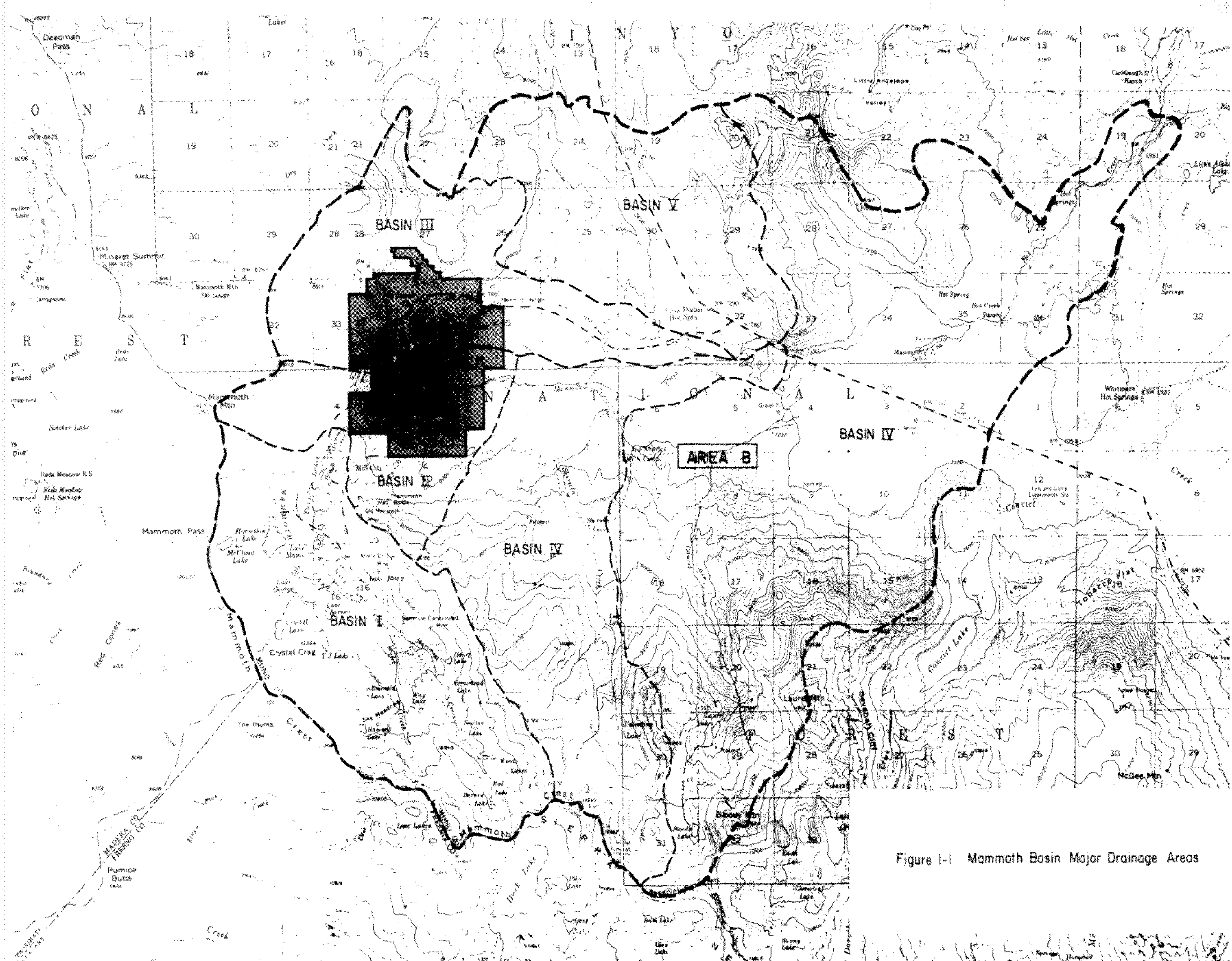


Figure I-1 Mammoth Basin Major Drainage Areas

Procedure Outline

Follow these steps to calculate the peak runoff using Procedure A. The Watershed Time of Concentration Form and a Storm Drainage Flow Calculation Form, as shown at the end of Chapter 1, should be completed using the results of these steps. Blank forms are available from the Mono County Department of Public Works.

1. Determine the appropriate exceedence interval from Table 1-1.

2. Lay out the natural drainage patterns and the proposed drainage system on a topographic map of the tributary area. A scale of 1 inch = 20 feet and contour intervals of 1 foot should be used for the mapping.

3. Determine the tributary acreage (A) from topographic mapping.

4. Measure the overland flow distance (Lo) from the most remote point in the drainage basin to the point where runoff from that point enters a defined open channel, gutter, or pipe.

5. Determine the overland flow slope (So) by dividing the change in overland flow elevation (between the most remote point in the basin and the place where the runoff enters a defined channel, pipe, or gutter) by the overland flow distance, Lo.

6. Determine the overland flow component of the time of concentration (tco) from Figure 1-2 for both winter and summer storms.

7. Determine the length of channel (Lc) between the point where flow enters a defined channel or pipe and the lowest point in the basin.

8. Determine the channel slope by dividing the change in elevation in the channel by Lc.

9. Determine the channel component of the time of concentration (tcc) from Figure 1-3.

10. Find the total time of concentration, tc = tcc + tco. Note that Steps 3 through 9 may need to be checked for more than one point to determine the drainage path which has the longest tc. If the resulting total time of concentration, tc, is less than 0.25 hour, 0.25 hour should be used as the tc in the following steps.

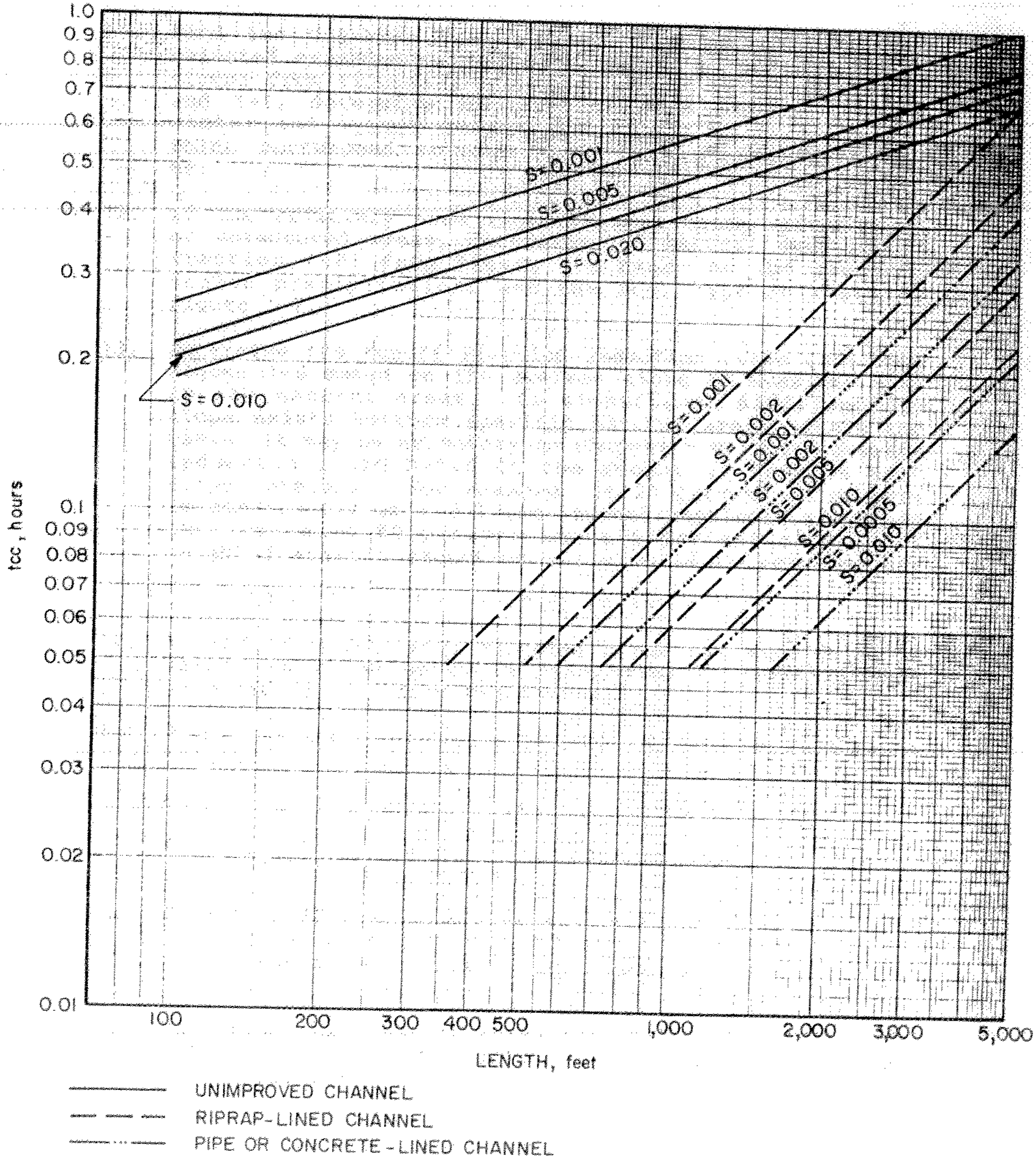


Figure 1-3 Channel Flow tc Component, tcc

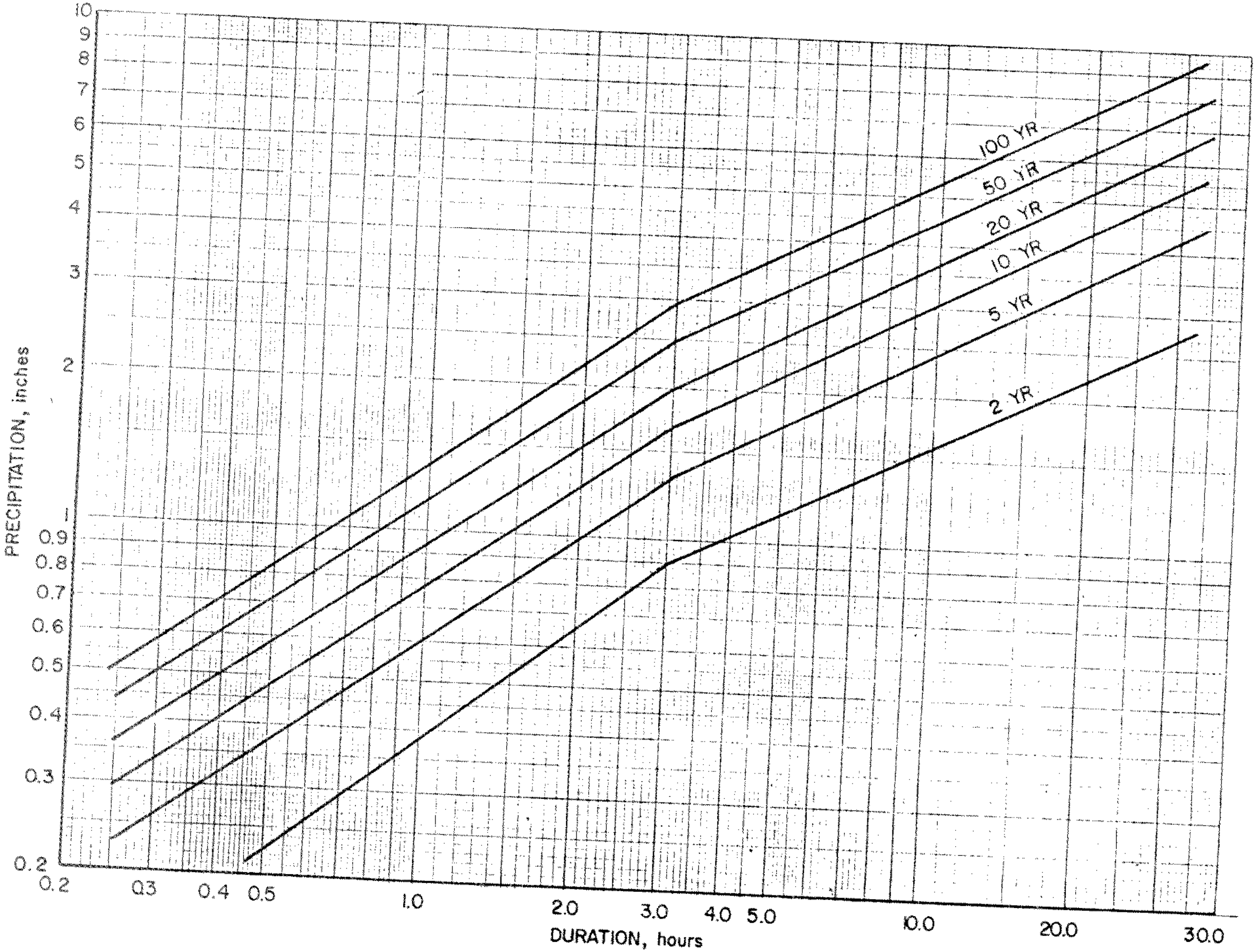


Figure 1-4 Winter Precipitation Design Curve

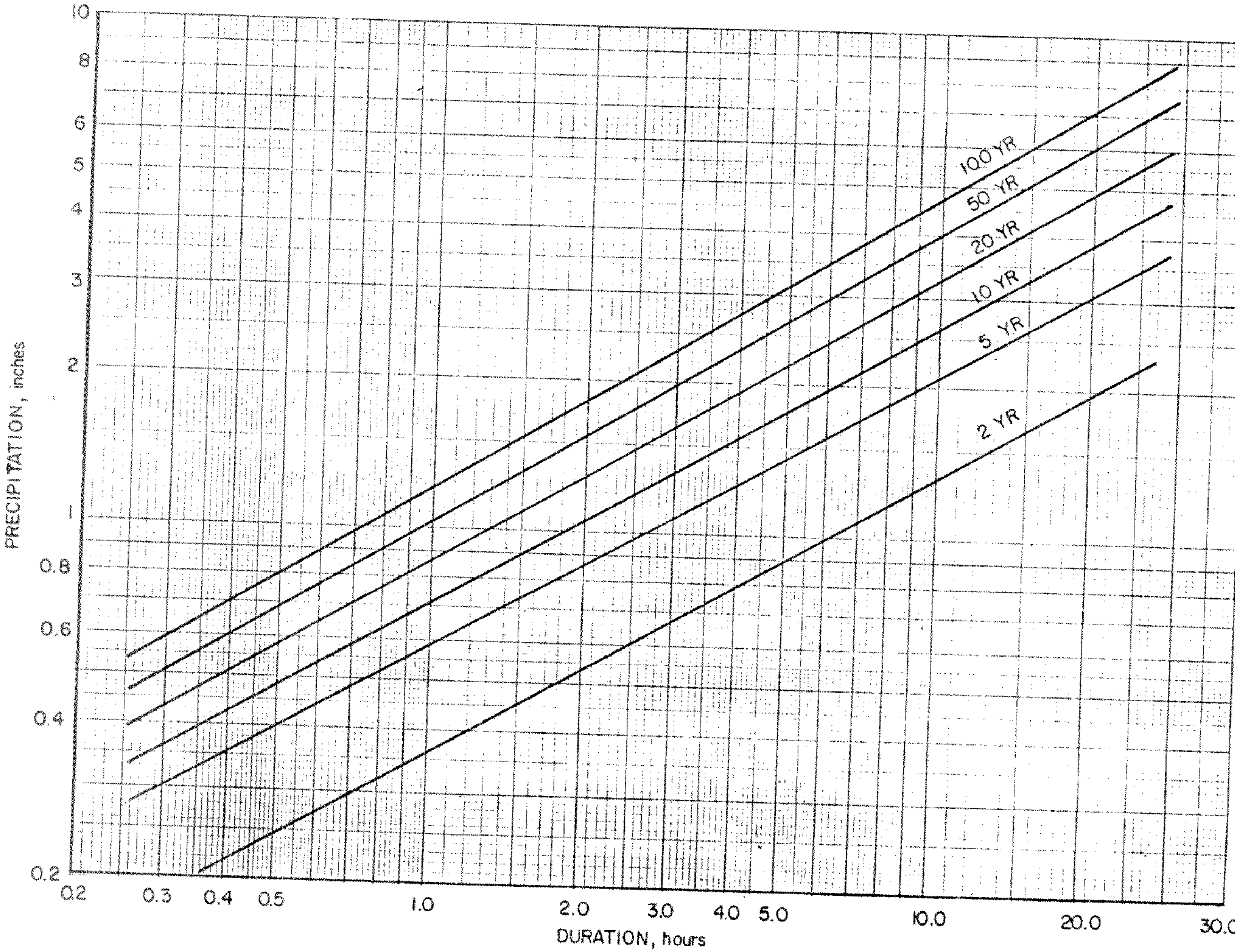


Figure I-5 Summer Precipitation Design Curve

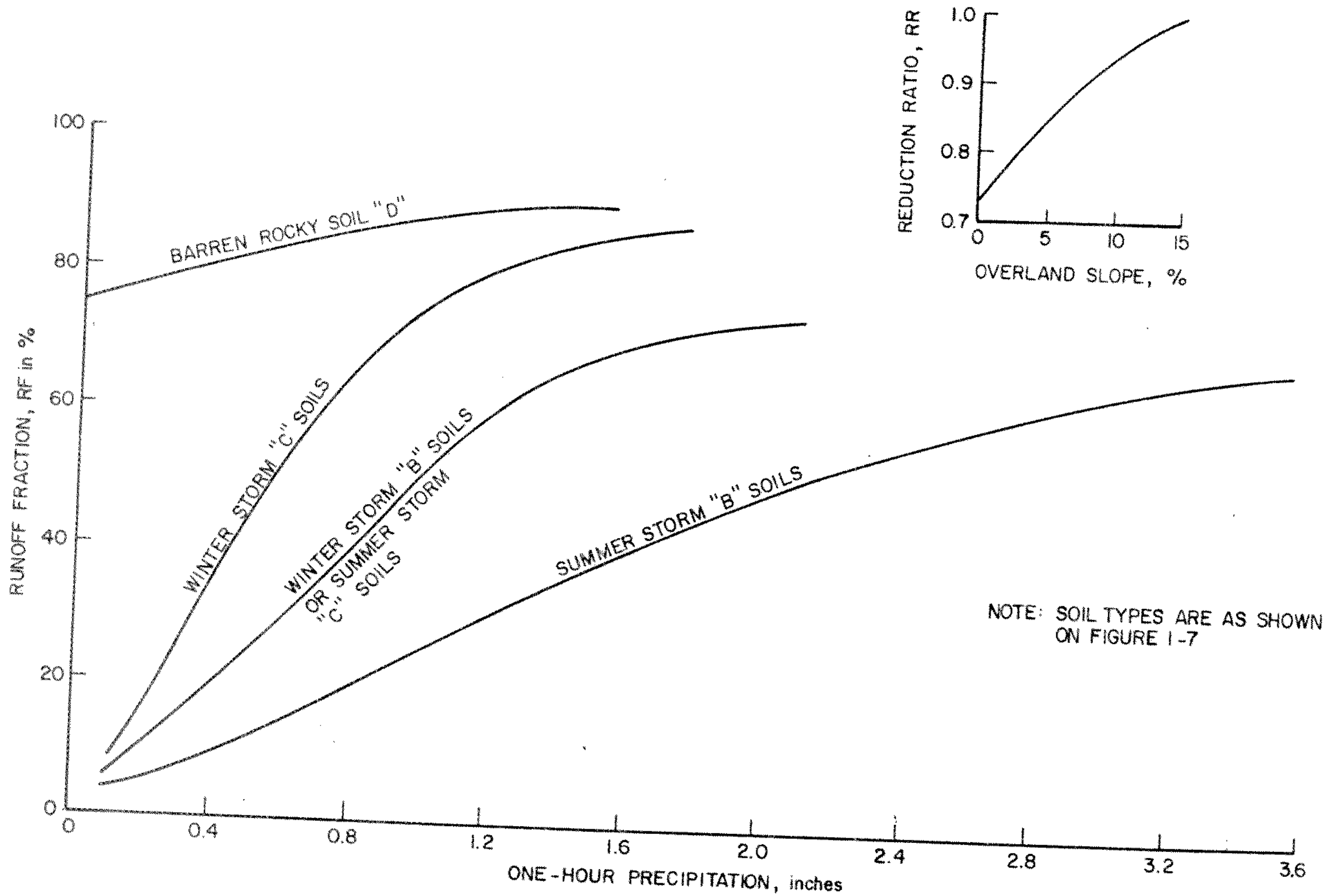


Figure I-6 Natural Area Runoff Factor, RF, and Reduction Ratio, RR

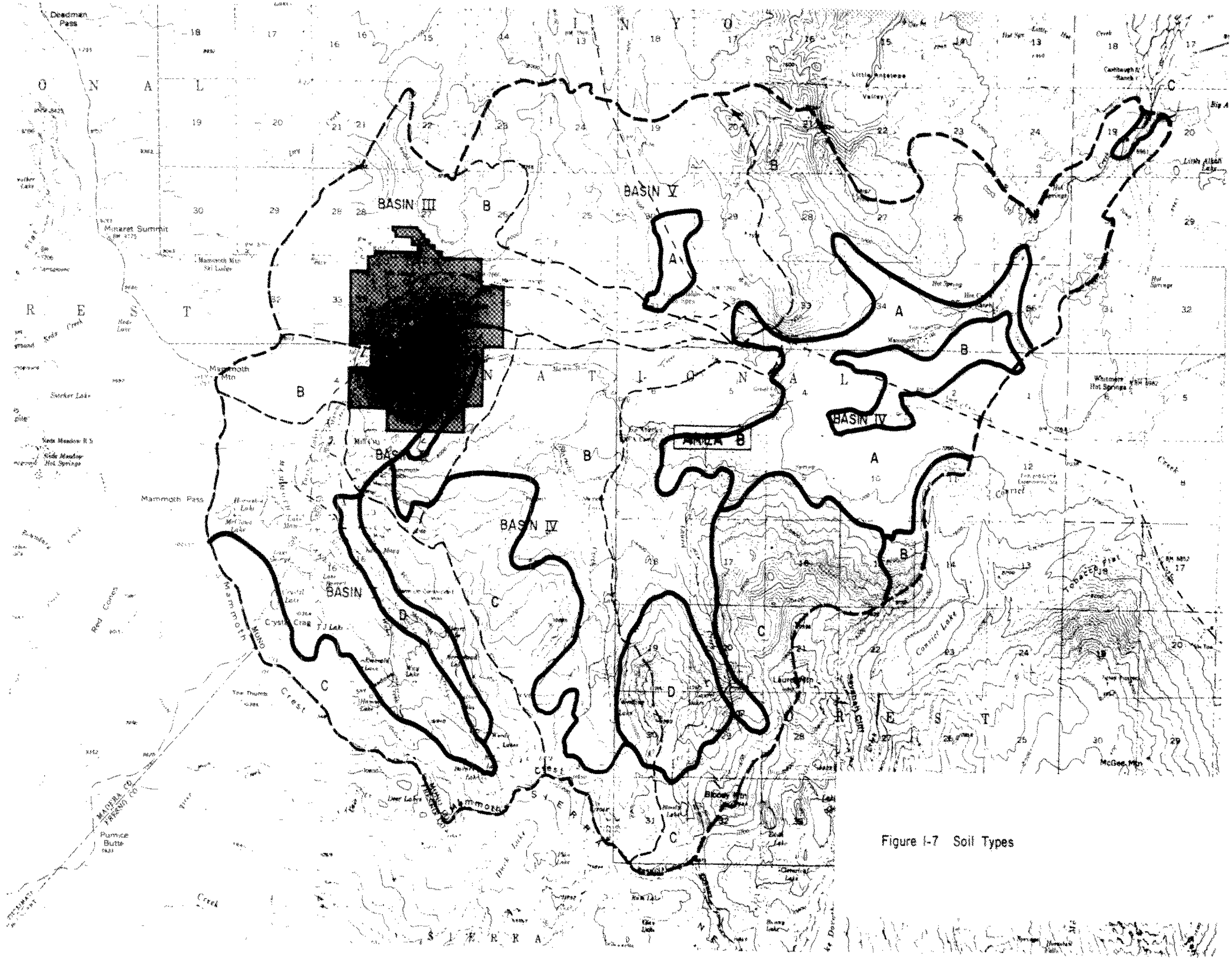


Figure I-7 Soil Types

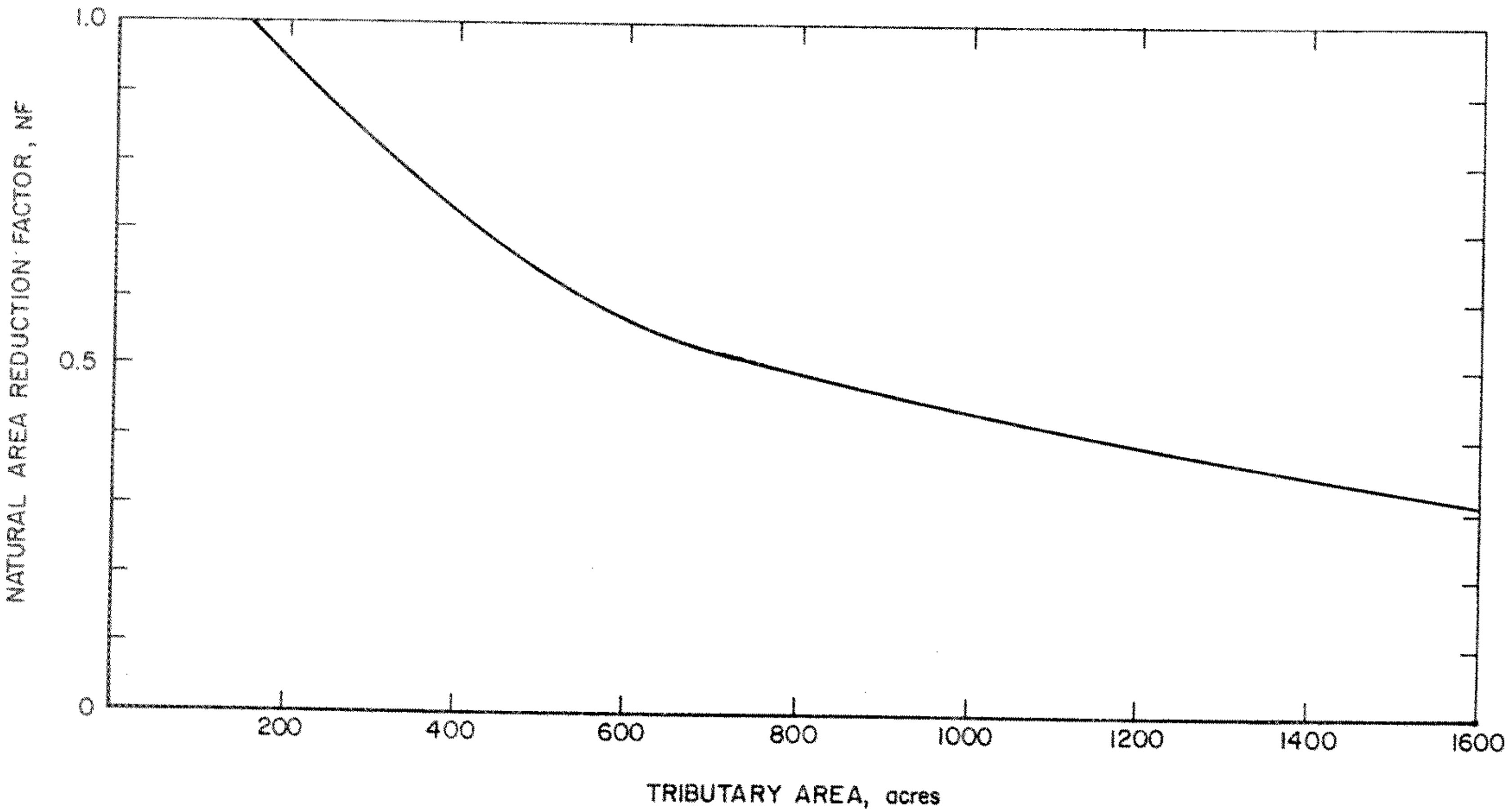


Figure I-8 Natural Area Size Factor, NF

Table 1-2. "C" Factors for Use in Procedure A

Type of area or surface	Coefficient, C
Roofs	0.90
Paving, asphaltic or concrete	0.90
Aggregate driveways and walks	0.80
Corporation yards, unpaved	0.75
Landscaped, open, or undeveloped areas	Cn

17. Calculate the peak runoff for winter and summer storms using the equation:

    $Q = (1.008)\ (A)\ (C)\ (P)$

    Where: Q = peak runoff, cfs
    A = total basin tributary area, acres
    C = weighted coefficient of runoff for winter or summer storm
    P = precipitation intensity for winter or summer storm, inches/hour

18. Choose the largest of the calculated peak flows (winter or summer storm) as the design Q.

Sample Calculation

The following example illustrates the use of Procedure A to calculate peak runoff rates.

1. Assumed Basin Characteristics:

   a. A = 230 acres
   b. Lo = 2,500 feet
   c. So = 0.05 foot/foot
   d. Lc = 250 feet, unimproved
   e. Sc = 0.02 foot/foot
   f. 10 percent paved; 2 percent roofs; 88 percent natural
   g. "B" soils

2. Procedure:

   a. Calculate tco: Lo/So = 50,000

      From Figure 1-2:

      Winter tco = 1.34 hours (unpaved, unplowed)
      Summer tco = 0.72 hour (unpaved)

b. Calculate tcc:

From Figure 1-3: tcc = 0.26 hour

c. Find time of concentrations:

Winter tc = 1.60 hours
Summer tc = 0.98 hour

d. Find one hour precipitation and precipitation intensities for the time of concentration from Figures 1-4 and 1-5 for the appropriate exceedence interval. Assume design is for storm drain in street--use 20-year exceedence interval.

Winter: P (1 hour) = 0.9 inch;
P (1.6 hours) = 0.8 inch/hour

Summer: P (1 hour) = 0.9 inch;
P (0.98 hour) = 0.9 inch/hour

e. Find Cn from Figures 1-6, 1-7, and 1-8:

<u>Winter</u>

RF = 0.45
RR = 0.85
NF = 0.90
Cn = (0.45)(0.85)(0.90) = 0.34

<u>Summer</u>

RF = 0.22
RR = 0.85
NR = 0.90
Cn = (0.22)(0.85)(0.90) = 0.17

f. Find weighted average runoff coefficient, C

Surface	Fraction of total area	Coefficient Winter	Coefficient Summer
Paved	0.10	0.9	0.9
Roofs	0.02	0.9	0.9
Natural	0.88	0.34	0.17

$\bar{C}$ Winter = (0.1) (0.9) + (0.02) (0.9) + (0.88) (0.34)
= 0.41

$\bar{C}$ Summer = (0.1) (0.9) + (0.02) (0.9) + (0.88) (0.17)
= 0.26

g. Find peak flow:

Q Winter = (1.008) (0.41)(0.8)(230) = 76.0 cfs
Q Summer = (1.008) (0.26)(0.9)(230) = 54.3 cfs
Q Design = 76.0 cfs

Design of Drainage Facilities

Where a storm drainage system is composed of a number of elements which have different design exceedence intervals, several flow calculations will have to be performed. For example, a typical drainage system might include a standard street cross-section, curb and gutter, inlets with grates, and storm drainage pipe. From Table 1-1, the requirements for design exceedence interval are as follows:

Entire system	100 years
Curb and gutter	10 years
Drain inlets	20 years
Storm drain pipe	20 or 50 years depending on size

In some cases, the hydraulic capacity of the street section may not be adequate to convey the difference between the 20- or 50-year event for which the pipe is designed and the 100-year event for which the system must be designed. In these cases, the pipe size should be increased to provide the required total capacity. The spacing of inlets to the pipe should also be decreased to convey the increased capacity to the pipe.

Although Procedure A can be applied to drainages which have both developed and undeveloped areas, care should be taken to avoid using times of concentration based on flow in undeveloped areas for calculating peak runoff from a developed area when the two areas are relatively distinct. For example, consider a watershed which is approximately 60 percent developed and 40 percent natural. The time of concentration in the natural area would probably be considerably longer than that for the developed area. Use of this longer time of concentration will give lower design precipitation intensities than would be used if the developed area were considered separately. In this case, the calculated flow could be lower than the peak flow that would be calculated if the two areas were segregated into individual drainages and the peak flows combined. This would result in undersized facilities for the developed area. Where doubt exists as to whether to separate areas into individual drainages, the peak flow should be calculated both ways and the larger of the two results used.

Flows from one or more drainages should be combined using the following steps:

1. Calculate the time of concentration for the uppermost watershed and the corresponding design flow.

2. At the first junction of two watersheds moving downstream, determine which one has the longer time of concentration. Add the design flow from this watershed to the flow calculated for the second watershed using the longer time of concentration. This gives the design flow at the first junction.

3. At the next junction downstream, determine the time of concentration by adding the travel time in the channel or pipe between the two junctions to the time of concentration used for design from Step 2. Calculate the flow by adding the original design flow from the uppermost watershed to new flows calculated for each of the other watersheds tributary to the junction using the time of concentration at the junction.

4. Continue downstream, calculating the time of concentration at each junction by adding the travel time in the channel from the last junction. Use the time of concentration at the point for which the design flow is being calculated to determine the contribution from each tributary watershed, except the uppermost watershed. Add the original design flow for the uppermost watershed (calculated based on its own time of concentration) to the flow from the other watersheds (calculated based on the time of concentration at the junction).

PROCEDURE B

This procedure applies to the calculation of design runoff flows from relatively large, undeveloped basins within Area B, as shown on Figure 1-1. Basins must be undeveloped and greater than 1,600 acres in size for Procedure B to apply. The procedure is based on a flow-frequency analysis rather than an analysis of short-term precipitation intensities. Procedure B contains two basic parts--one analysis which applies to rain floods and one which applies to snowmelt flows. The peak design flow should be selected as the larger of the two results. This section describes Procedure B and presents a sample design flow calculation.

Procedure Outline

The following steps are used to calculate the peak design flow:

1. Determine the appropriate design exceedence interval from Table 1-1.

2. Calculate the mean daily rain flood design flow from:

   $Q = CKA^{0.85} p^2$

   Where:

   - "C" is a constant related to exceedence interval as shown on Figure 1-9.
   - "K" = $\frac{12{,}000 - \text{Mean Basin Elevation}}{4{,}000}$
   - "A" = Basin area in square miles
   - "p" = Mean annual precipitation in inches, as shown on Figure 1-10.

3. Calculate the peak rain flood flows as follows:

   - For the Lake Mary Basin (Basin I on Figure 1-1), Q peak = 1.15 x Mean Daily Flow
   - For all other basins, Q = 1.7 x Mean Daily Flow

4. Calculate the peak snowmelt flows as follows:

   a. Determine the approximate maximum elevation of the basin. One to two percent of the basin area can be above the selected approximate maximum for basins with very steep upper portions. In any case, the maximum value selected should be no higher than 11,200 feet.

   b. Use the top curve on Figure 1-11 to find the highest elevation of melt corresponding to the selected exceedence interval.

   c. Use the second curve on Figure 1-11 to find the width of the melt band for the selected exceedence interval. In conjuction with the highest elevation of melt from Item b, this sets the lowest elevation of melt.

   d. If the lowest elevation of melt is below the lowest point in the basin, raise the highest elevation of melt until the full melt band falls within the basin.

   e. Determine the area of the basin (in square miles) that lies within the melt band.

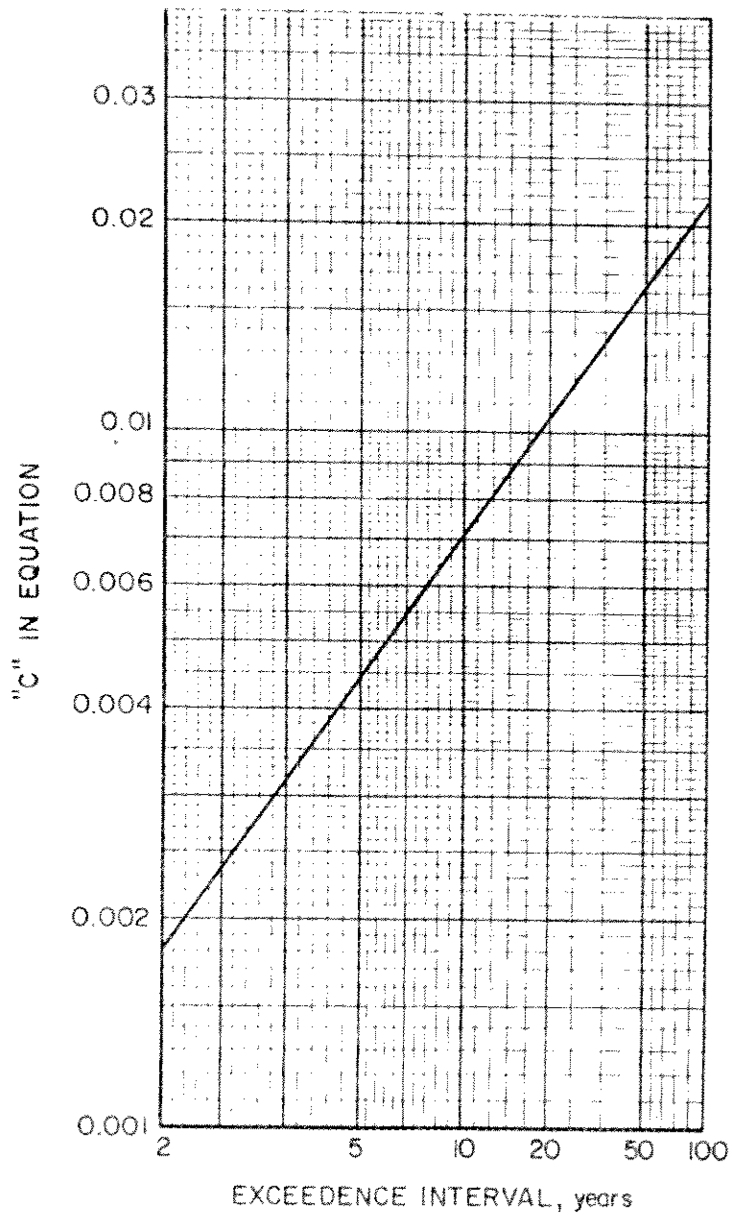
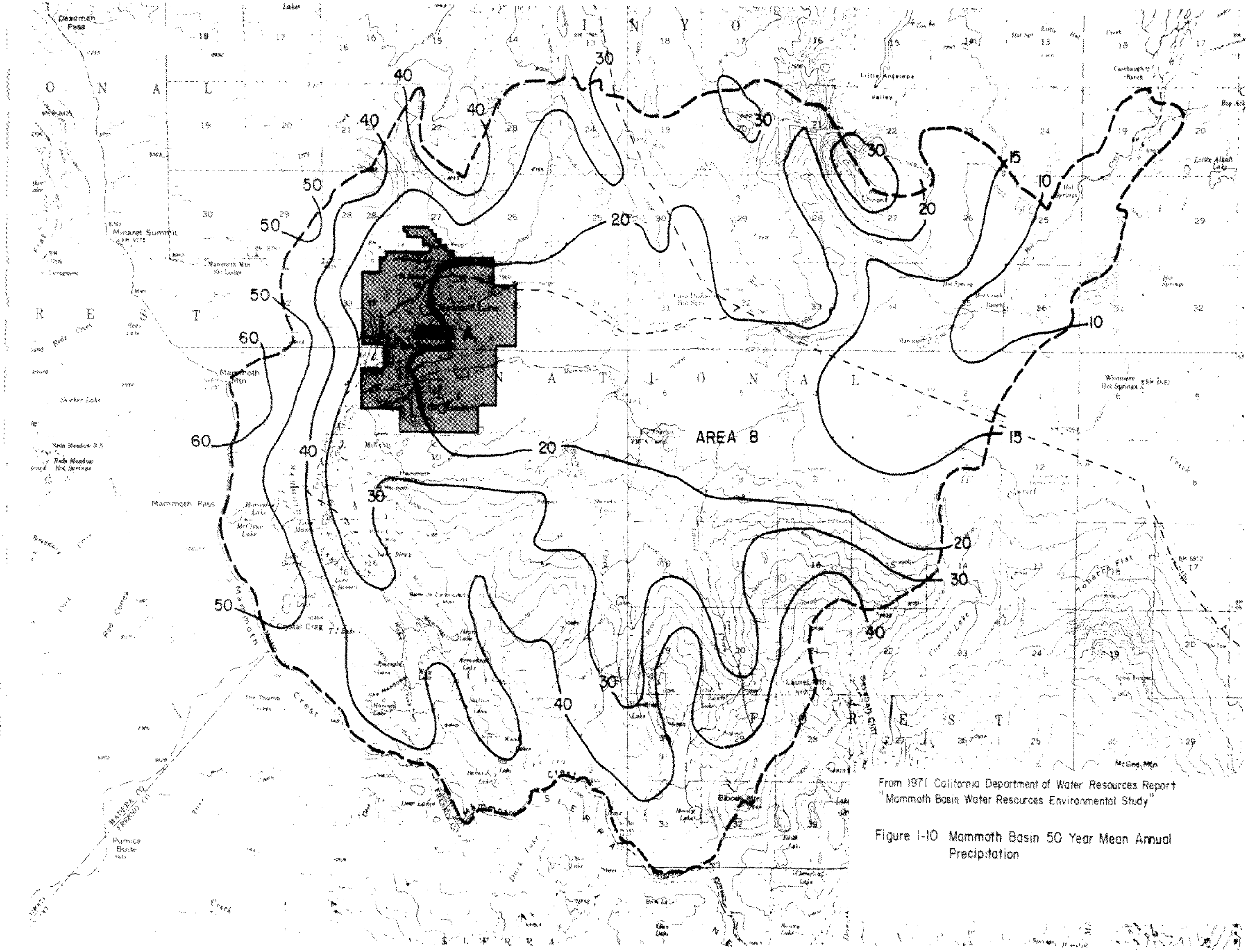


Figure 1-9 Coefficient "C" for Rainflood Frequency Equation



From 1971 California Department of Water Resources Report "Mammoth Basin Water Resources Environmental Study"

Figure I-10 Mammoth Basin 50 Year Mean Annual Precipitation

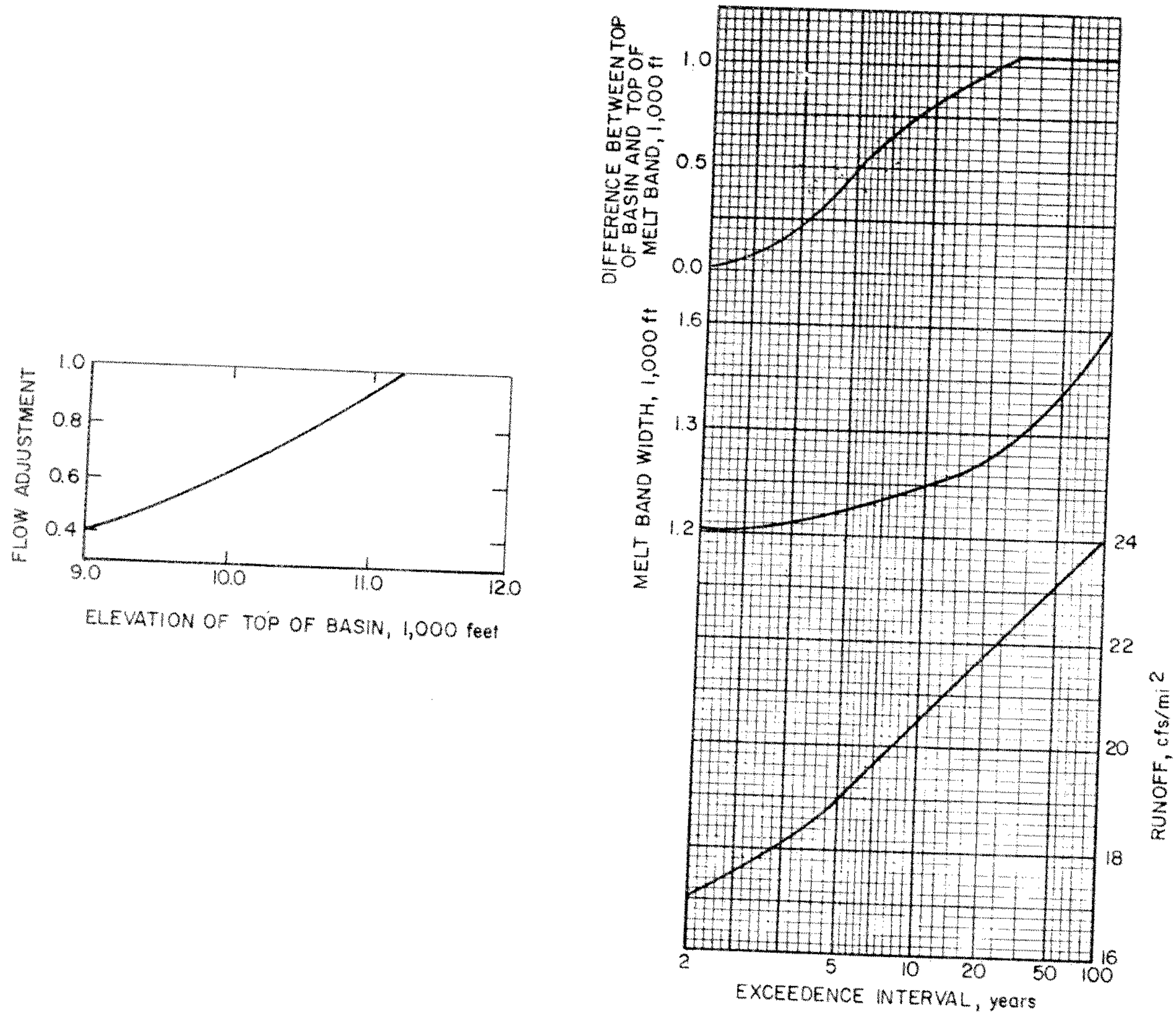


Figure I-11 Snowmelt Runoff Graphs

3. Snowmelt Analysis:

   a. Top of melt band from Figure 1-11. 10,400-1,100 = 9,300 feet

   b. Determine bottom of melt band from Item a and Figure 1-11.

      - 9,300 - 1,420 = 7,880 feet. 7,880 is less than minimum elevation of basin. Therefore, raise top of melt band to 8,200 + 1,420 = 9,620 feet. Bottom of melt band = 8,200 feet.

   c. Determine area of basin within melt band. For this example, assume 4.2 square miles in melt band.

   d. Find the runoff rate per unit area of melt band from Figure 1-11.

      Unit Runoff Rate = 23.1 cfs/square mile

   e. Find flow adjustment factor from Figure 1-11.

      Flow adjustment = 0.68

   f. Find design mean daily flow rate.

      Q = (23.1 cfs/square mile) x (4.2 square miles) x (0.68)

      = 66.0 cfs

   g. Find peak flow.

      Q peak = (66.0) x (1.7) = 112.2 cfs

4. Select the larger of the two results from the rain flood and snowmelt analyses as the peak design flow.

   Q design = 112.2 cfs

DEVELOPMENT OF HYDROGRAPHS FOR DESIGN OF STORAGE FACILITIES

This section describes the procedure to be used to calculate runoff hydrographs where required for the design of runoff storage facilities. The procedure is primarily applicable to the design of flow detention facilities, and is based on the unit hydrograph method used by the U.S. Soil Conservation Service.

Development of a Unit Hydrograph

The following steps are used to develop a unit hydrograph for the tributary basin.

1. Determine the area (A), time of concentration (t_c), and weighted C values for the basin as described for Procedure A.

2. Compute the unit rainfall excess time interval, D, from

   $D = 0.133\ t_c$, where t_c = time of concentration

3. Compute the time to peak, T_p, from

   $T_p = D/2 + 0.6\ t_c$

4. Compute the peak flow, q_p, for a volume of runoff equal to one inch from

   $q_p = 484\ T_p \times A$

   where A = area in square miles
   T_p = time to peak in hours
   q_p = peak flow in cfs

5. Compute the coordinates of the unit hydrograph from the t/T_p and q/q_p ratios given in Table 1-3.

6. Tabulate the ordinates of the unit hydrograph in intervals of D from a plot of the coordinates formed in Step 5.

7. Check the volume of the unit hydrograph by summing the ordinates and multiplying by D. Compare this to the volume computed from:

   $V = 645.33 \times A$

   where V = computed volume in cfs-hours
   A = area in square miles

   If the two volumes do not check, adjust the coordinates of the unit hydrograph uniformly to obtain a reasonable balance.

Calculation of a Runoff Hydrograph

The following steps are used to convert the unit hydrograph into a storm runoff hydrograph. The procedure must be applied independently to summer and winter conditions.

Table 1-3. Ratios for Dimensionless Unit Hydrograph

Time ratios (t/T_p)	Discharge ratios (q/q_p)
0	.000
.1	.030
.2	.100
.3	.190
.4	.310
.5	.470
.6	.660
.7	.820
.8	.930
.9	.990
1.0	1.000
1.1	.990
1.2	.930
1.3	.860
1.4	.780
1.5	.680
1.6	.560
1.7	.460
1.8	.390
1.9	.330
2.0	.280
2.2	.207
2.4	.147
2.6	.107
2.8	.077
3.0	.055
3.2	.040
3.4	.029
3.6	.021
3.8	.015
4.0	.011
4.5	.005
5.0	.000

1. Determine the 1-, 3-, 6-, 12-, and 24-hour precipitation volumes for winter and summer rainfall at the selected exceedence interval from Figures 1-4 and 1-5.

2. Plot rainfall graphs for the design storms using the volumes from Step 1. The graphs should be constructed by plotting the 1-hour volume at the center of the graph and working outward so that the volumes under the graphs correspond to the rainfall volumes obtained in Step 1.

   For example, Figure 1-12 shows a graph constructed for the following data:

Precipitation duration, hours	Volume, inches
1	1.5
3	3.0
6	3.9
12	4.5
24	5.1

3. Convert the plot from Step 2 into a tabulation of incremental precipitation volumes for time intervals of D.

4. Compute a loss volume, V, from the 1-hour precipitation volume and the weighted "C" factor computed in Procedure A. Note that this must be done for winter and summer conditions. The loss volume is calculated from,

   $$V = (1-c)\ PD$$

   where V = loss volume, inches
   C = weighted C from Procedure A
   P = 1-hour precipitation volume from Figure 1-4.
   D = time interval, hours

5. Subtract V from each of the incremental precipitation volumes from Step 3 to find the incremental excess precipitation volumes.

6. Use the tabulation of the unit hydrograph in intervals of D and the tabulation from Step 5 to compute a runoff hydrograph. If the intervals of D are represented by Di, and the corresponding incremental precipitation volumes, unit hydrograph ordinates, and runoff hydrograph ordinates are represented by Ri, Hi, and RHi, the following equation can be used to compute the runoff hydrograph ordinates:

$$RHi = (R_1 \times Hi) + (R_2 \times Hi-1) + (R_3 \times Hi-2\ ) \ldots + (\ Ri \times H_1)$$

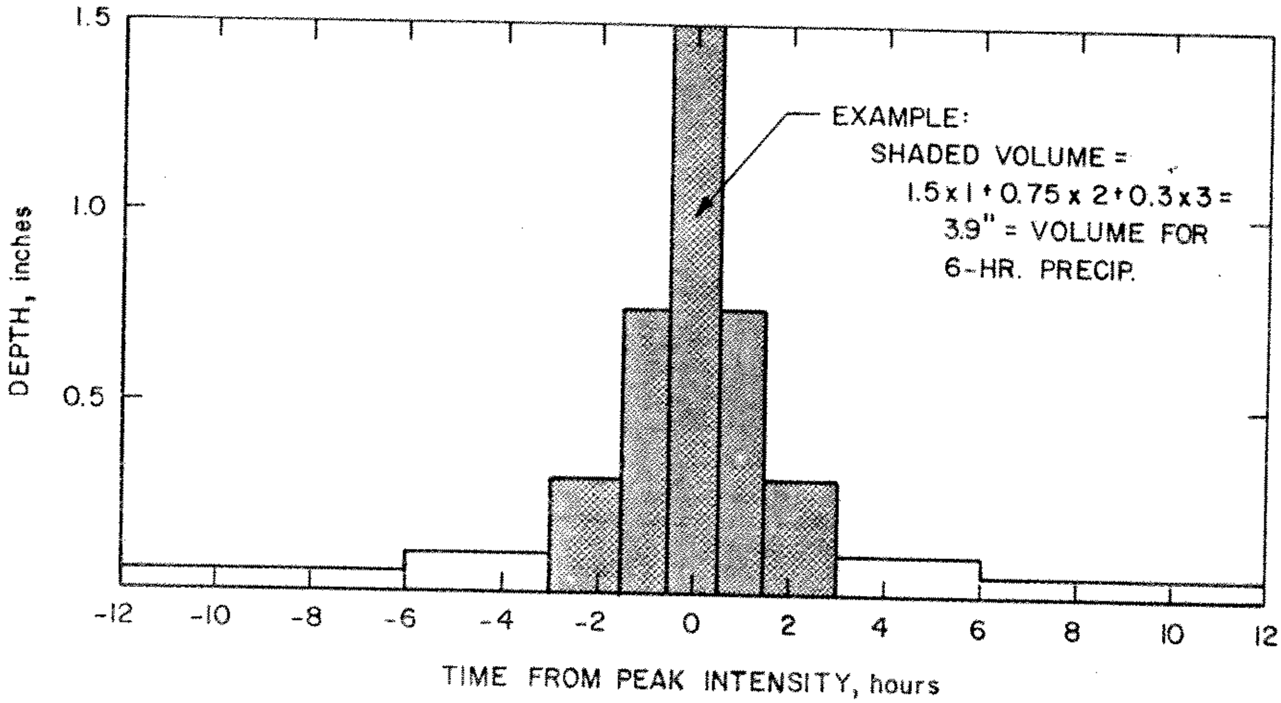


Figure 1-12 Rainfall Design Storm Graph

The computed runoff hydrograph ordinates should be plotted against time (t = i x D) to obtain a runoff hydrograph. Required volumes for storage facilities can be found by computing the area under the curve for a particular maximum flow rate.

FORM A

Watershed Time of Concentration Form

Watershed	Area, acres	Exceedence interval, years	Overland Flow							Channel Flow											Total tc, hours
			Unpaved Area			Paved Area				Gutter			Channel			Pipe				
			Lo, feet	So, feet/feet	t_{co}, hours	Lo, feet	So, feet/feet	t_{co}, hours	Total t_{co}, hours	L_c, feet	S_c, feet/feet	t_{cc}, hours	L_c, feet	S_c, feet/feet	t_{cc}, hours	L_c, feet	S_c, feet/feet	t_{cc}, hours	Total t_{cc}, hours	

FORM B

Storm Drainage Peak Flow Calculation Form

Watershed	Area, acres	Exceedence intervals, years	t_c, hours	Design Precipitation		Runoff Coefficient													Q = 1.008 x CiA
						Natural					Roofs		Paved		Other				
				1 hour	i, inch per hour	RF	RR	NF	C_n	Percent natural	C_{roof}	Percent roof	C_{paved}	Percent paved	C_{other}	Percent other	C		

CHAPTER 2

STORM DRAINAGE SYSTEM

This section describes criteria for design of facilities to collect and convey stormwater in a storm drainage system. It includes criteria for the design of storm drains, inlets, and roadway drainage.

APPLICABILITY

The guidelines and standard details below apply to all development projects, road construction work, and storm drainage improvement projects. Curbs, gutters, and inlets are required for all new construction of roads. Culverts shall be provided at all locations where natural drainages or open channels cross roadways. All drainage conduits, channels, and appurtenances shall be located within dedicated and recorded public easements or rights-of-way with working space for all construction and maintenance operations. Improvements shall be designed to conform with the Mammoth Lakes Storm Drainage Master Plan. Runoff calculations used for design shall be as specified in Chapter 1 of this design manual.

STREET RUNOFF COLLECTION

Guidelines for design of drainage improvements for streets are given below. The guidelines cover typical roadway sections and slopes, curb and gutter, storm drains, and inlets. The following general criteria apply:

1. All facilities described herein shall be designed by a registered civil engineer.

2. Paved roadways shall be designed to drain to curb and gutter.

3. If curb is not provided at the top of the slope, roadways shall be constructed to drain away from fill slopes.

4. Backfill or sidewalks placed behind the curb shall be designed to conform to the guidelines for a sloped bottom bench (Chapter 5) wherever a roadway is bounded by slopes.

5. Gutter capacity shall be determined at a depth equal to 0.5 times the curb height. Gutters shall be sized to carry the 10-year return period storm, as calculated using the procedures given in Chapter 1.

6. Minimum grades of new streets and gutters shall be 0.50 percent.

7. Except for intersections and superelevated curves, cross slopes on new streets shall be 2.0 percent.

8. Maximum grade on new streets shall be 9 percent. Slopes up to 15 percent may be approved by the Director of Public Works if County snow removal is not required.

9. The grade of the pavement surface across an intersection shall not be more than 4 percent, nor less than 1 percent.

10. The gradient of any street entering an intersection shall not be more than 4 percent within a distance of 30 feet from the beginning of an intersection.

11. Roadways shall be designed according to the Road Improvement Standards, County of Mono.

Figure 2-1 shows a typical roadway section for use in relatively flat terrain. Figure 2-2 shows an alternative section for use in areas where the roadway will be bounded by slopes. Figure 2-3 shows a typical concrete curb detail. Figure 2-4 shows a nomograph for use in calculating the flow capacity of streets with curb and gutter.

Storm Drainage Inlets

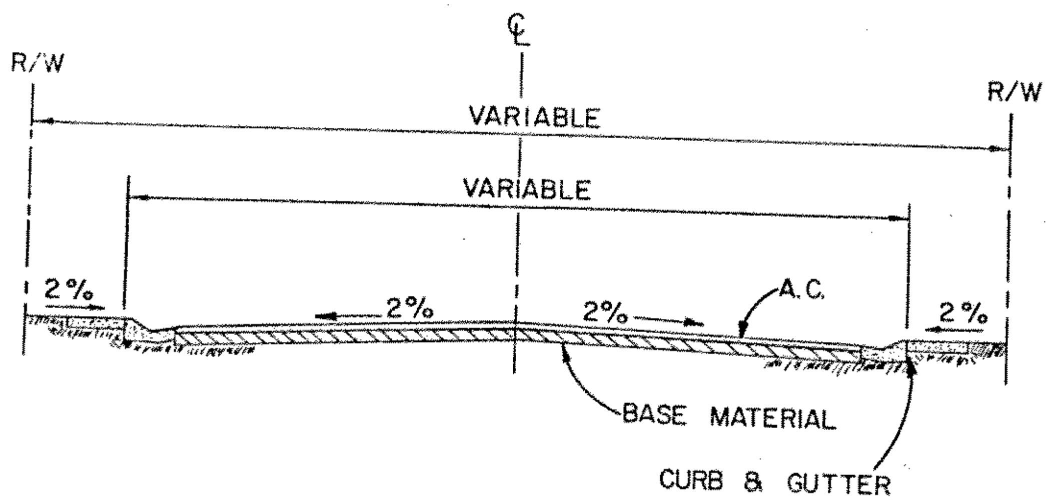
The following criteria apply to the design of storm drainage inlets:

1. Inlets may be curb-opening, grate, or combination-type inlets.

2. Where used in conjunction with curb and gutter, inlets shall be located in gutter depressions no less than 0.10 foot and no more than 0.25 foot deep.

3. In sag vertical curves, one curb opening or combination-type inlet shall be used on each side of the low point. An additional inlet shall be placed at the low point.

4. Where significant amounts of debris will be present, inlets shall be constructed in series, with the upstream inlet being either a curb-opening or combination-type

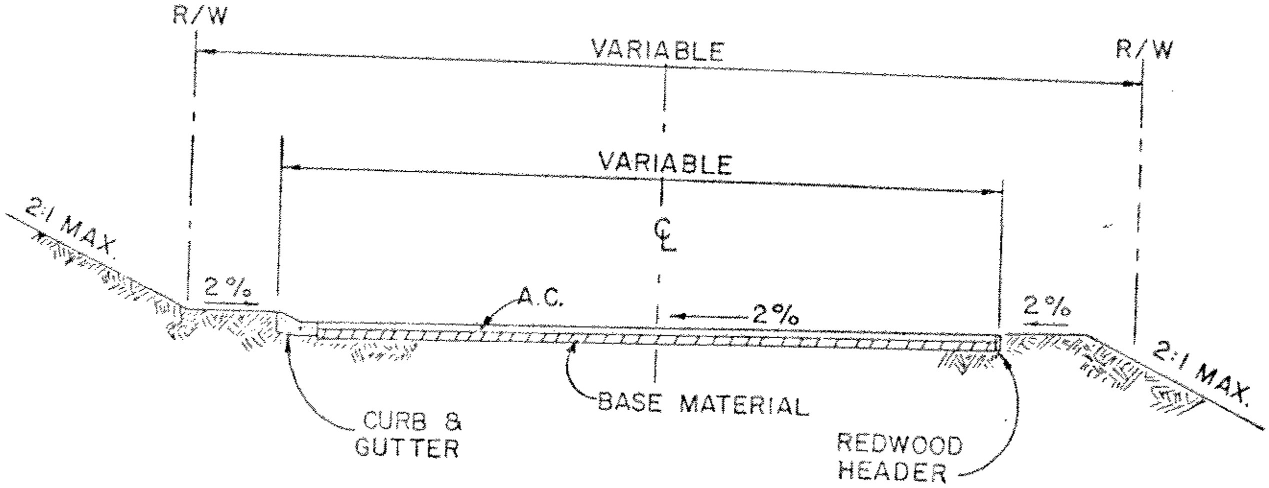


NOTE:

1. THE DEGREE OF SIDE SLOPE FOR CUT OR FILL BEYOND THE RIGHT-OF-WAY SHALL NOT EXCEED 2:1

2. SEE MONO COUNTY ROAD IMPROVEMENT STANDARDS FOR RIGHT-OF-WAY AND PAVEMENT WIDTHS AND FOR DESIGN OF ROADWAY SECTION.

Figure 2-1 Paved Roadway, Flat Terrain

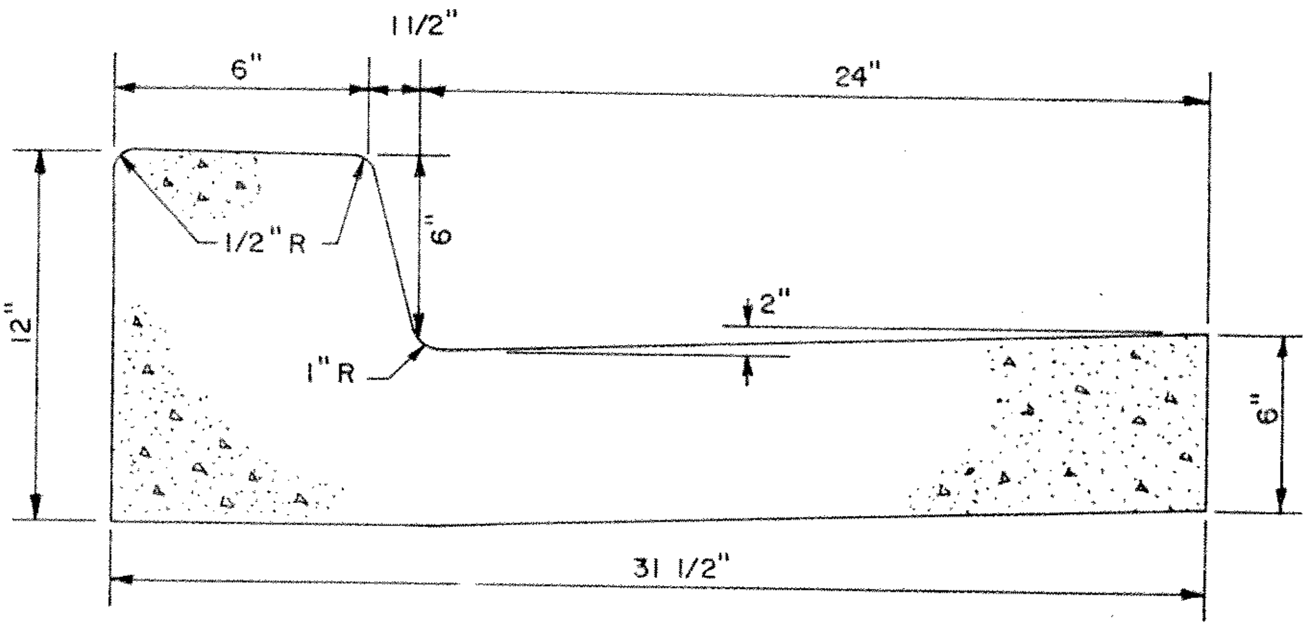


NOTE: 1. THIS SECTION SHOULD BE USED IN LIEU OF FLAT TERRAIN SECTION WHERE AVERAGE GROUND CROSS SLOPES EXCEED 15% OR WHERE ROADWAY IS BOUNDED BY LARGE FILL SLOPES OR CUT SLOPES.

2. SEE MONO COUNTY ROAD IMPROVEMENT STANDARDS FOR RIGHT-OF-WAY AND PAVEMENT WIDTHS AND FOR DESIGN OF ROADWAY SECTION.

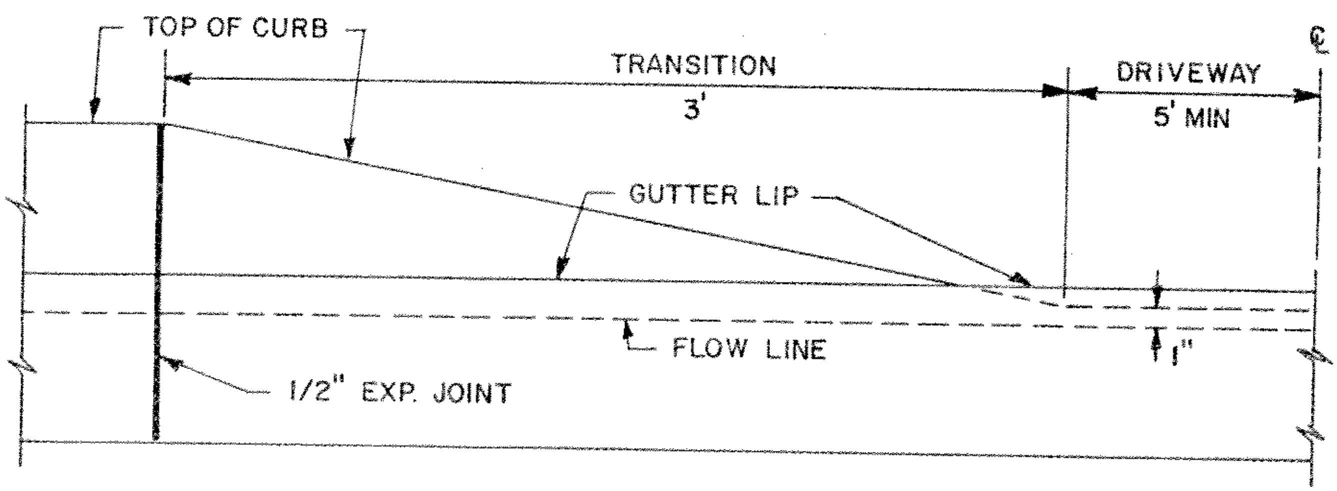
Figure 2-2 Paved Roadway, Sidehill Alternative

CURB AND GUTTER



SECTION
NOT TO SCALE

DRIVEWAY CURB CUT



ELEVATION
NOT TO SCALE

Figure 2-3 Curb and Gutters

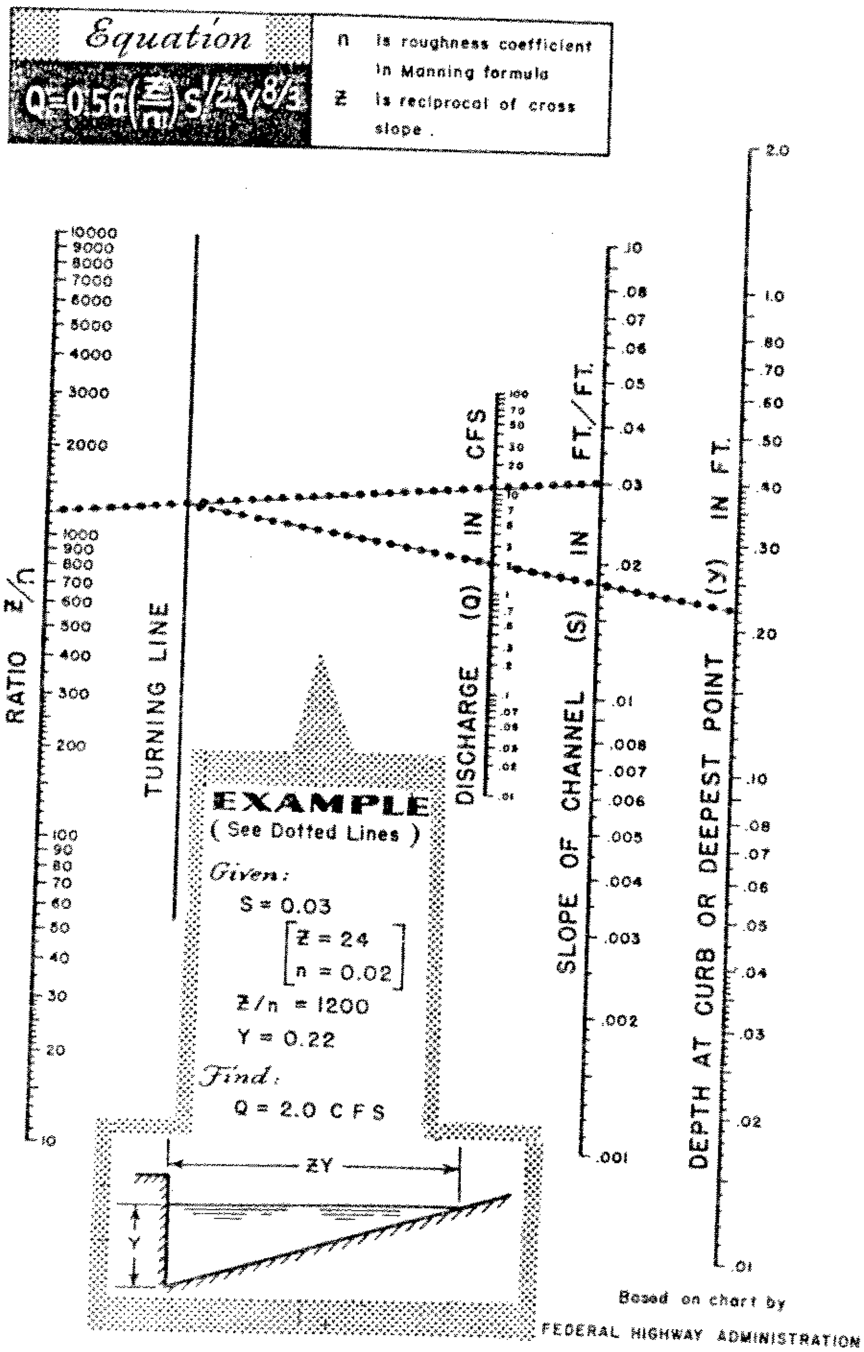


Figure 2-4 Street Capacity Nomograph

inlet. The two inlets shall be separated by approximately 20 feet. Where inlets are not installed in curb and gutter, at least two inlets in series shall always be used.

5. Inlets shall be spaced to prevent surface flow through intersections. Valley gutters in intersections are not permitted.

6. Inlet spacing shall be calculated based on flow, gutter g⁻⁻de, inlet capacity, and expected amount of debris, but in no case shall exceed 400 feet between inlets. Flows shall be calculated using the procedures given in Chapter 1.

7. Inlet capacity shall be determined from Figures 2-5 and 2-6. Figure 2-5 gives the capacities for various lengths of curb opening inlets. Figure 2-6 gives the capacities for two types of grating inlets in use by the California Department of Transportation (CalTrans). Where other types of grating inlets are used, capacities shall be based on manufacturer's data or comparison with the CalTrans standard designs. For single grate inlets, design capacity shall be calculated based on the inlet area being 50 percent plugged. For inlets in series, the first inlet shall be assumed completely plugged. Capacity of combination-type inlets shall be calculated based on the grate area alone, assuming no plugging.

8. The outlet pipe shall be low enough to allow for pipe entrance losses plus 0.75 foot between the design water surface and the opening at the gutter intake.

9. The floor of the inlet shall be sloped at not less than 5:1 (horizontal:vertical).

Figure 2-7 shows typical inlets in gutter depressions.

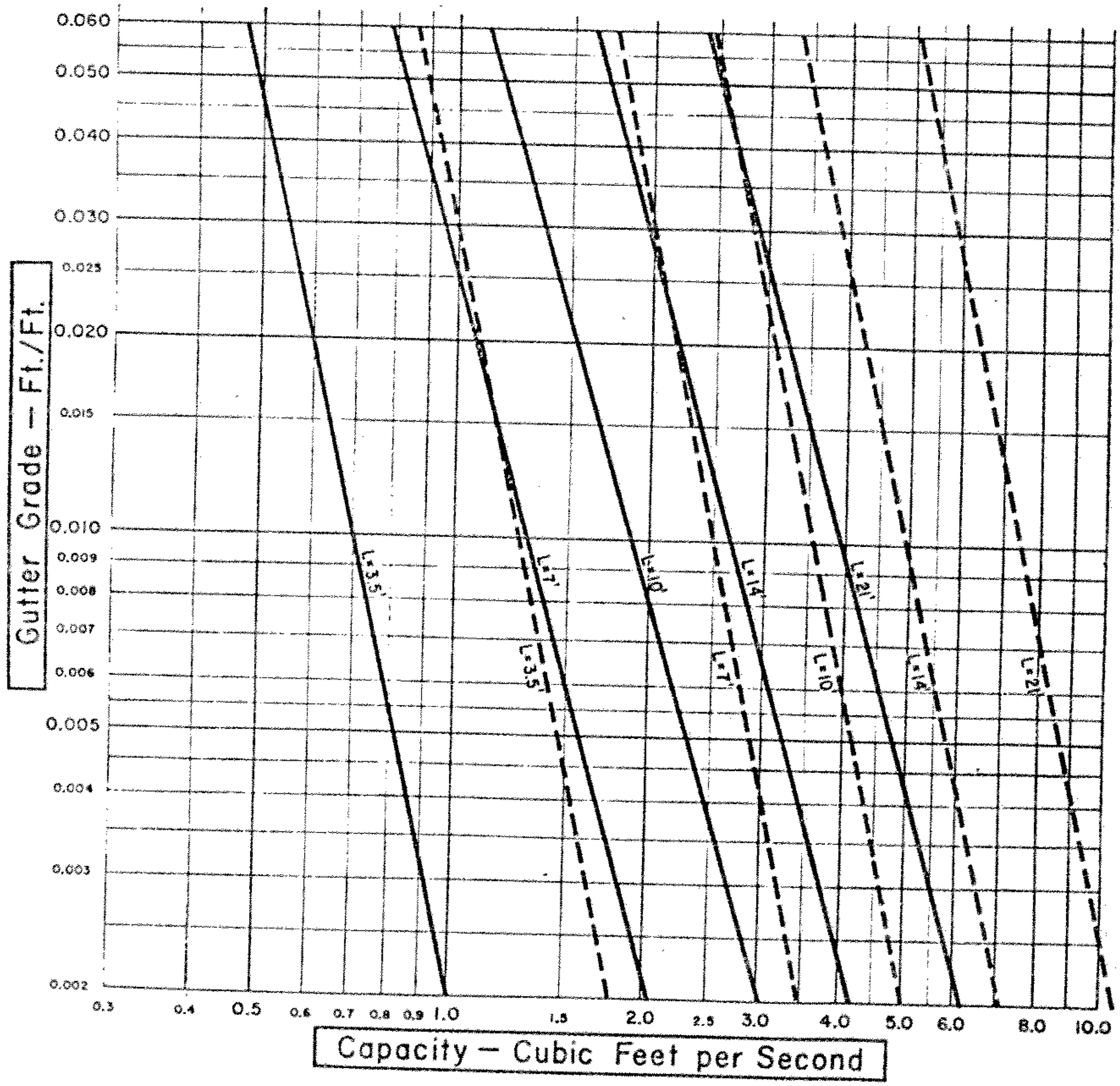
Storm Drains

The following criteria apply to storm drainage pipes, channels, and culverts:

1. Storm drainage pipes shall be sized by a registered civil engineer using the runoff calculation procedures given in Chapter 1.

2. All natural drainageways originating outside the project area shall enter and leave the area at the original horizontal and vertical alignments.

3. Wherever possible, storm drainage facilities shall be parallel to the centerline of the street.



<u>LEGEND</u>

——— 0.10' GUTTER DEPRESSION

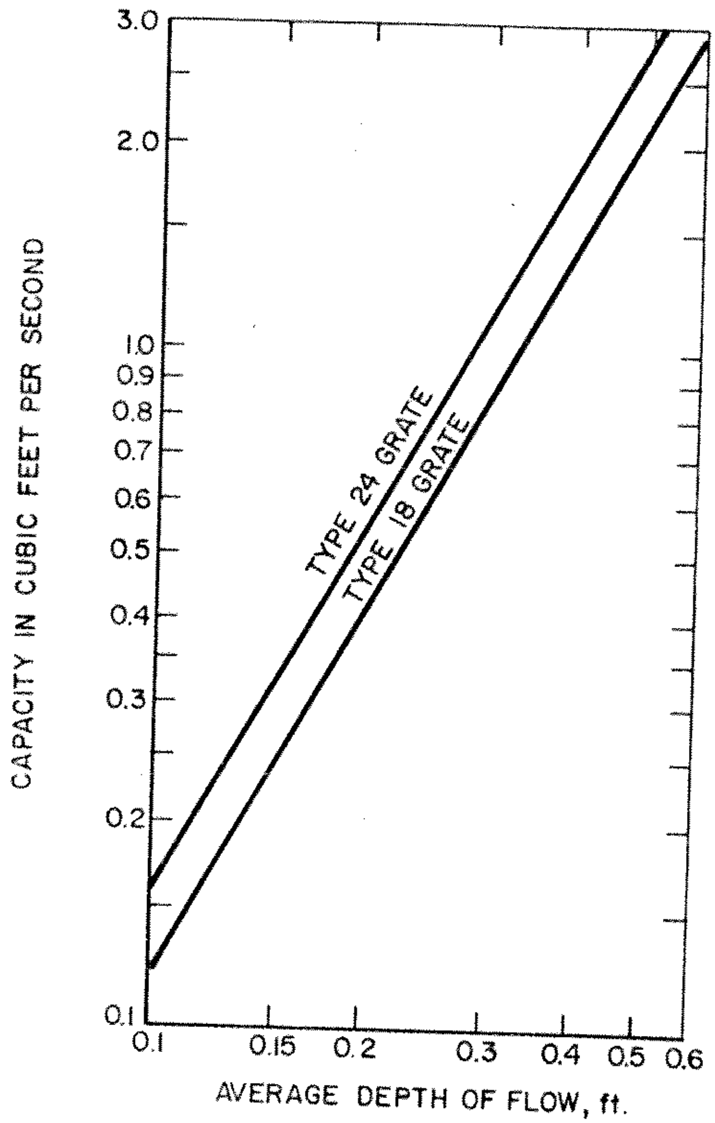
– – – 0.25' GUTTER DEPRESSION

L LENGTH OF OPENING

NOTES: 1. Chart applies to streets with 2 percent cross slope and gutter depressions as shown.

2. 50 percent of capacity shall be used for design of inlet spacing.

Figure 2-5 Curb Opening Inlet Capacities



Notes:

1. Capacities shown are for Caltrans standard Type 18 and Type 24 grates (see Caltrans standard plans). For other grates, capacities should be determined from manufacturer's data or by comparison with Caltrans standard grates.

2. For design of inlet number and spacing required, 50 percent of capacity should be used.

3. Type 18 grate data--Clear length = 35-3/8 inches
   Clear width = 18 inches
   Spacing between bars = 1-3/8 inches

4. Type 24 grate data--Clear length = 35-3/8 inches
   Clear width = 24 inches
   Spacing between bars = 1 inch, 1-3/8 inches, and 2 inches

Figure 2-6 Grate Inlet Capacities

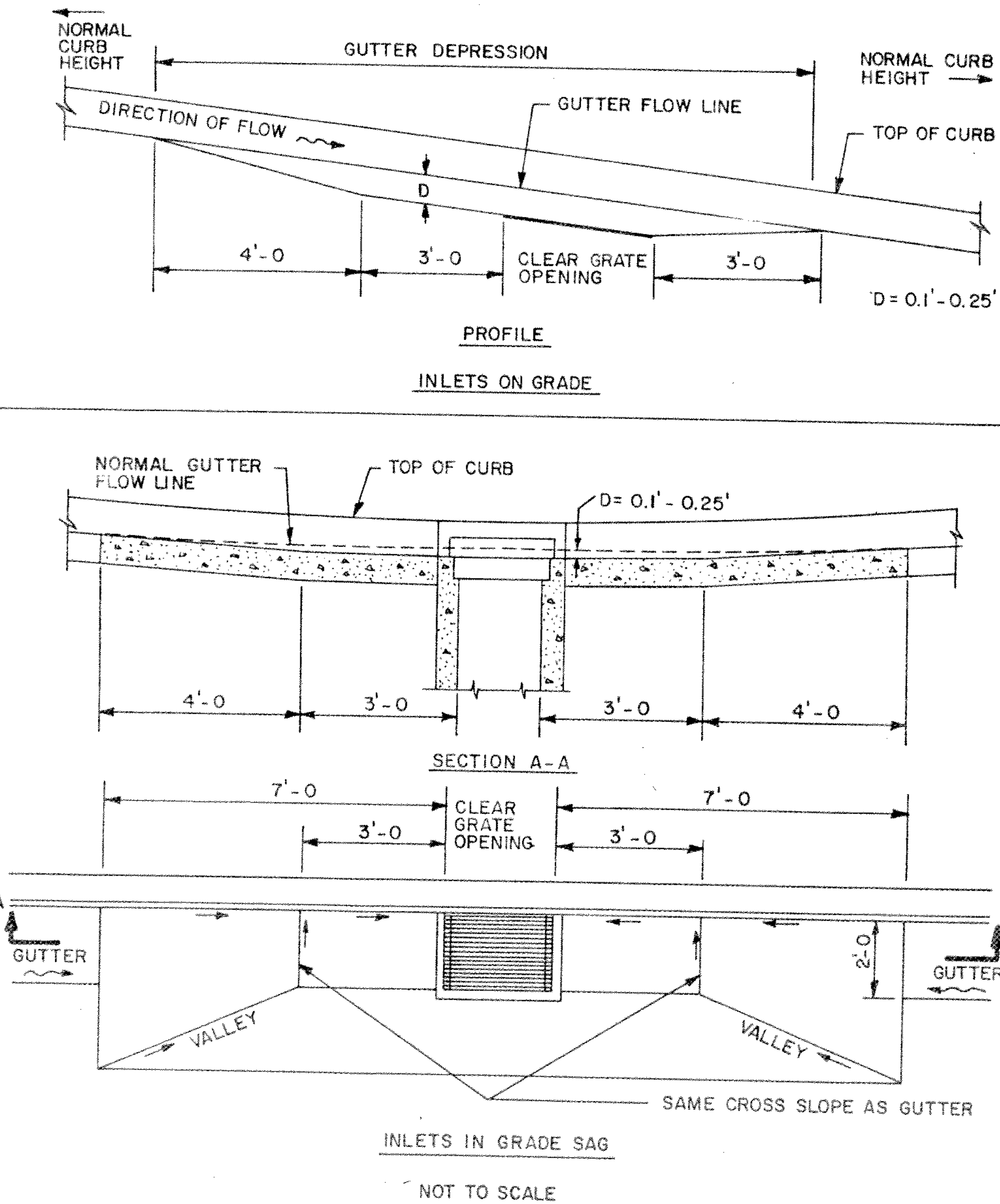


Figure 2-7 Inlets in Gutter Depressions

4. Large angular changes in alignment of storm drains shall be avoided and in no case shall the change exceed 90 degrees.

5. Minimum diameter of closed conduits shall be 18 inches.

6. Direct transitions from a larger pipe upstream to a smaller pipe downstream shall not be permitted, regardless of slope change. This requirement may be avoided if a special transition structure is provided which will minimize the potential for clogging.

7. The crowns of pipe sections shall be matched at size changes. All pipe size and grade changes shall occur at manholes.

8. Pipe shall be sloped to provide a minimum velocity of 2 feet per second (fps) when flowing half full.

9. Maximum design velocity for storm drains shall be 15 fps unless special provisions are made for energy dissipation of junctions, structures, and major bends. In all cases, the design hydraulic grade line shall be not less than 1 foot below the street elevation.

10. Capacity shall be determined based on the pipe flowing full, and shall be calculated using Manning's equation. The appropriate "n" factors to be used for various types of pipe are as follows:

a. Concrete precast pipe	0.013
b. Concrete cast-in-place pipe	0.015
c. Vitrified clay pipe	0.013
d. Corrugated metal pipe (unlined)	0.021
e. Corrugated metal pipe (paved invert)	0.019
f. Corrugated metal pipe (100 percent paved)	0.015

11. Culverts shall be sized to carry the design flow without static head at the entrance.

12. Minimum allowable cover shall be 2 feet for closed conduits and culverts under roadways.

13. Where culverts carry roadside drainage under driveways, pipes shall be sized to carry the design flow of the roadside ditch. Flows shall be calculated using the procedures given in Chapter 1.

14. All culverts shall be provided with end sections, wing walls, riprap, or some other means to prevent erosion at the inlet and outlet.

15. Open channels shall be lined with concrete or riprap to prevent scour. Appropriate "n" factors for use in calculating channel capacities are as follow:

    a. Open channel with concrete lining 0.015
    b. Open channel with cobble or riprap lining 0.030

16. Channels shall be sized to provide a minimum of 1 foot of freeboard at the design flow, or to convey the 100-year flow at bankful capacity, whichever is greater. Velocities at design flow shall not be less than 2.5 fps nor greater than 10 fps.

17. Prior to construction of drainage improvements, a map shall be submitted to the County which shows:

    a. Drainage areas.

    b. Travel paths of drainage design.

    c. Design flow to each inlet or structure in cubic feet per second (cfs).

    d. Overland flow and gutter flow in cfs.

    e. Design flow line elevations for pipes.

    f. Top elevations for structures.

    g. Hydraulic gradients.

    h. Pipe sizes and lengths.

Roadside Drainage Ditches

Where drainage from existing streets is not controlled in curb and gutter, roadside ditches may be used to improve runoff control and prevent erosion. The following criteria apply:

1. Ditch sections shall be designed by a registered civil engineer.

2. Runoff calculations shall be as specified in Chapter 1.

3. Manning's equation shall be used for design. The appropriate "n" factors to be used to determine ditch capacity are:

Channel Type	Manning's "n"
Unlined earth	0.040
Riprap lining	0.040
Concrete lining	0.015
Vegetatively protected	0.050
Grouted riprap lining	0.030

4. The following design velocities are permitted:

	Velocity, feet/second	
Channel Type	Minimum	Maximum
Unlined earth	1	2
Riprap lining	2.5	10
Concrete lining	2	15
Vegetatively protected	2	4
Grouted riprap lining	2	15

5. Where natural topography dictate velocities higher than those listed above, energy dissipators such as stilling pools, check dams, or drop structures shall be used. The design shall be submitted to the County for approval by the Public Works Director.

6. Where unlined earth channels are used, the outlet shall be designed to prevent transport of sediment to surface waters or to the storm drainage system. The use of dry wells or small sediment retention basins is recommended.

Slotted Drains

At the discretion of the civil engineer designing the storm drainage system, slotted drains may be used in place of conventional storm drain inlets. The following design criteria apply:

1. Slotted drain pipe may either be perforated or non-perforated corrugated metal pipe. Perforated pipe shall be used only where the intent is to allow infiltration of a portion of the storm drainage. In this case, the design engineer shall submit to the County information concerning groundwater levels and soil types at the project location. Perforated pipes shall not be installed in slopes in excess of 3 percent. When infiltration capacities are used to decrease the size of downstream facilities, the procedures for measuring the infiltration rates shall be as specified below for dry wells. Copies of the test results shall be submitted to the County.

2. Coupling bands used for joining sections of corrugated metal pipe shall be a minimum of four times the spacing between corrugations.

3. Backfill shall be placed in lifts of 6 inches or less and compacted by hand.

4. Backfill shall be placed so as to prevent soil or other material from entering the pipe.

A typical slotted drain is shown on Figure 2-8.

Dry Wells

Dry wells may be used for on-site runoff control or incorporated into the design of a storm drainage system to reduce runoff volume and downstream system sizing. They are effective infiltration devices where soil types and groundwater levels are favorable. The following design criteria apply to dry wells:

1. Dry wells may be constructed as either a gravel-filled pit or trench. Selection of the appropriate type should be based upon soil depth and permeability and level of groundwater in the project area.

2. Pit type dry wells shall be at least 18 inches in diameter.

3. Dry wells shall be constructed to a depth of at least 3 feet below the soil freezing level.

4. Where possible, several shallower wells shall be used in place of one deeper well.

5. Dry wells may be incorporated into the design of catch basins at storm drainage inlets to reduce the size of conveyance pipes required downstream.

6. Dry wells shall be equipped with an easily removable cover to provide access for removing accumulated sediments and trash.

7. The dry well shall be filled with 1-1/2-inch to 3-inch rock to within 6 inches of the elevation of the surrounding ground or, when used with catch basins, to within 6 inches of the storm drain invert.

8. Where not used in conjunction with a catch basin, a blanket or filter cloth (Mirafi 140 or equivalent) shall be placed over the rock, and clean sand or smaller gravel shall be used for backfilling to grade.

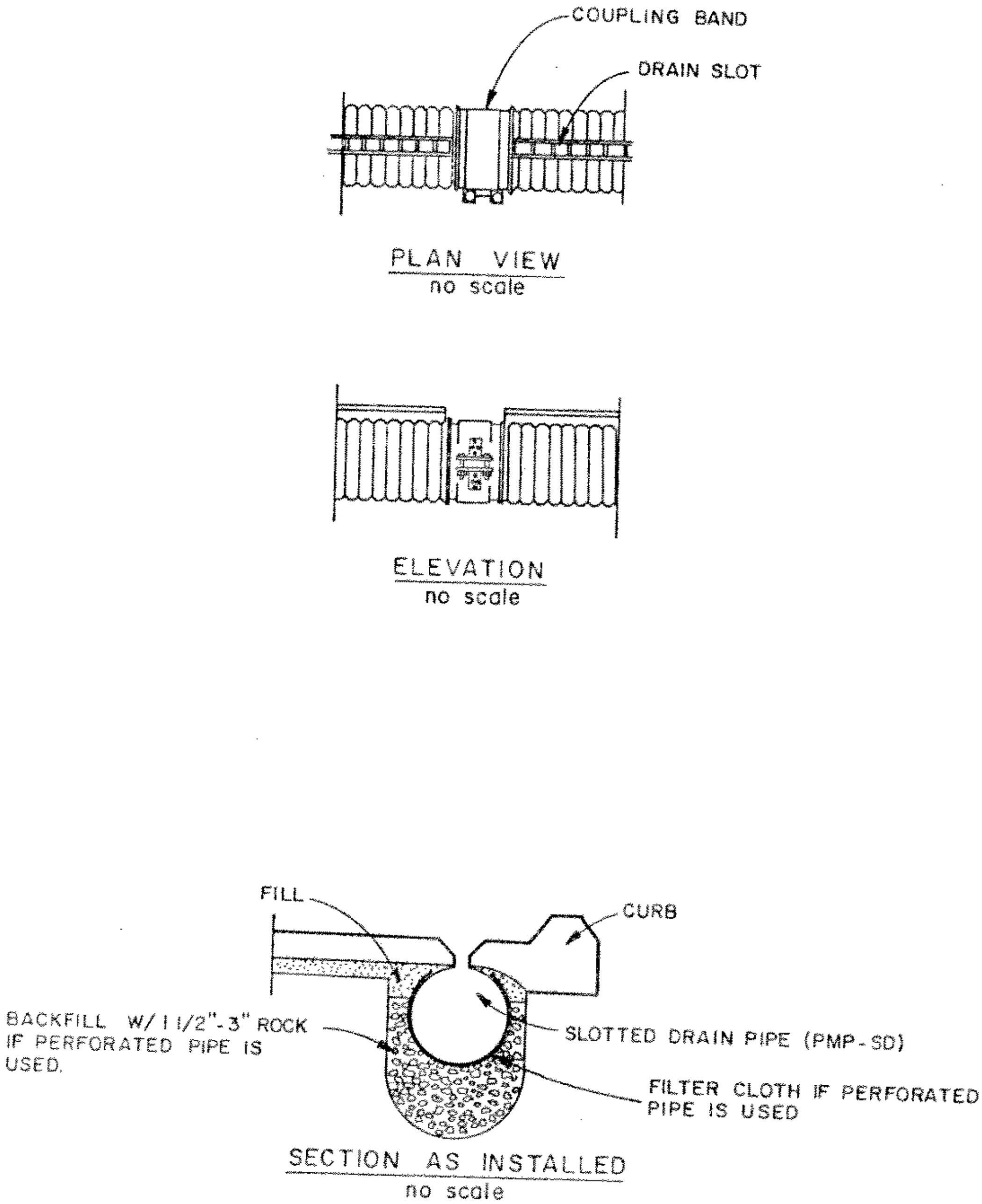


Figure 2-8 Slotted Drain

9. The infiltration capacity of dry wells shall be calculated based on the results of infiltration tests performed at the project site. Design infiltration rate (per unit surface area) shall be one-half the measured rate. The infiltration design flow for each dry well shall be calculated as the product of the design infiltration rate times the area of the bottom of the dry well plus one-third the area of the side walls:

$$Q_i = I\ D_B + 1/3\ I\ D_S$$

Where Q_i = design infiltration flow rate for the dry well, cfs

I = design infiltration rate per unit area, fps

D_B = area of bottom of dry well, ft^2

D_S = area of side wall of dry well, ft^2

10. Infiltration rates shall be measured using standard percolation test procedures.

11. Storage in dry wells shall be calculated based on total volume and the porosity of the rock fill.

Figures 2-9 and 2-10 show typical dry wells for use with and without catch basins.

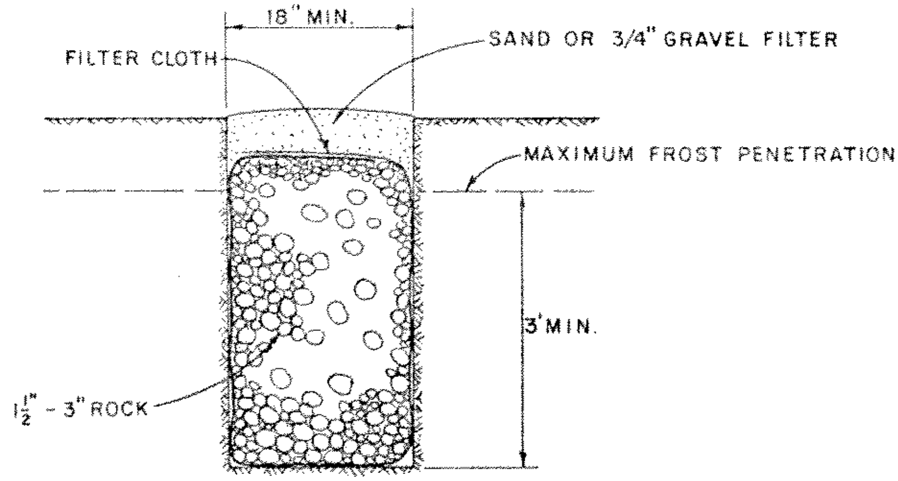
Storm Drainage Systems for
<u>Parking Lots and Other Paved Areas</u>

The design criteria given below apply to all parking lots, paved service areas, corporation yards, service station aprons, and commercial and industrial access areas. Residential parking areas less than 1,000 square feet in total area are excluded. In general, the intent of these design criteria is to provide infiltration capacity for at least the initial portion of runoff from storm events. This prevents high concentrations of pollutants such as grease, oil, and suspended sediments from being directly discharged to surface waters. The following criteria apply:

1. All paved parking lots shall provide infiltration facilities to meet the requirements shown in Chapter 1.

2. Overflow of the infiltration facilities shall be to a storm drainage system.

3. For parking lots greater than 1,500 square feet, multiple infiltration trenches shall be used rather than one large trench.



ELEVATION
WITHOUT CATCH BASIN
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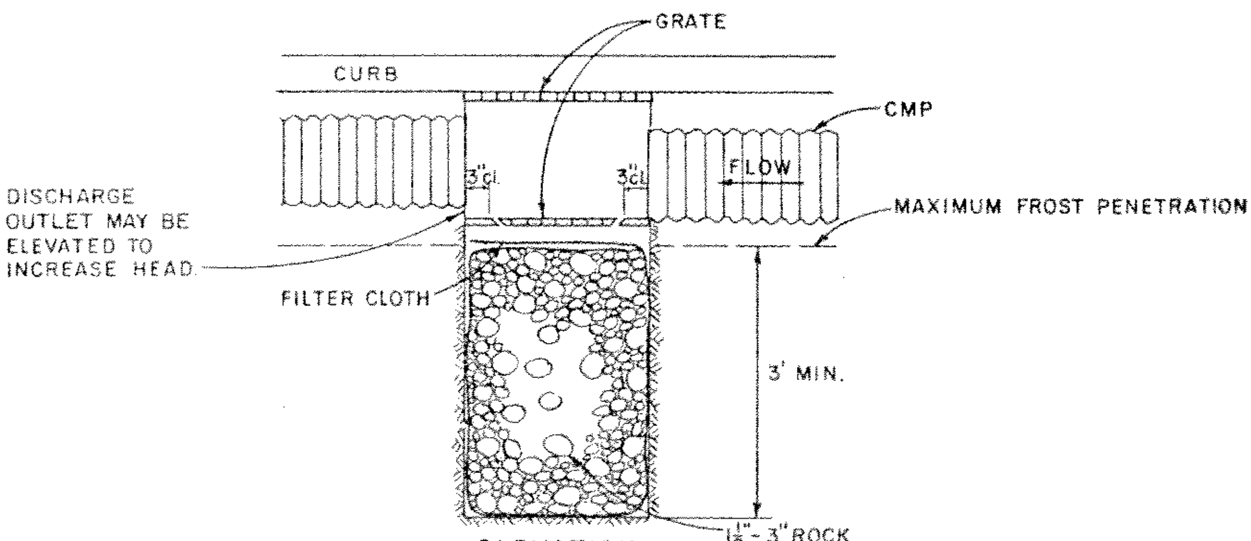

ELEVATION
WITH CATCH BASIN
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Figure 2-9 Dry Wells

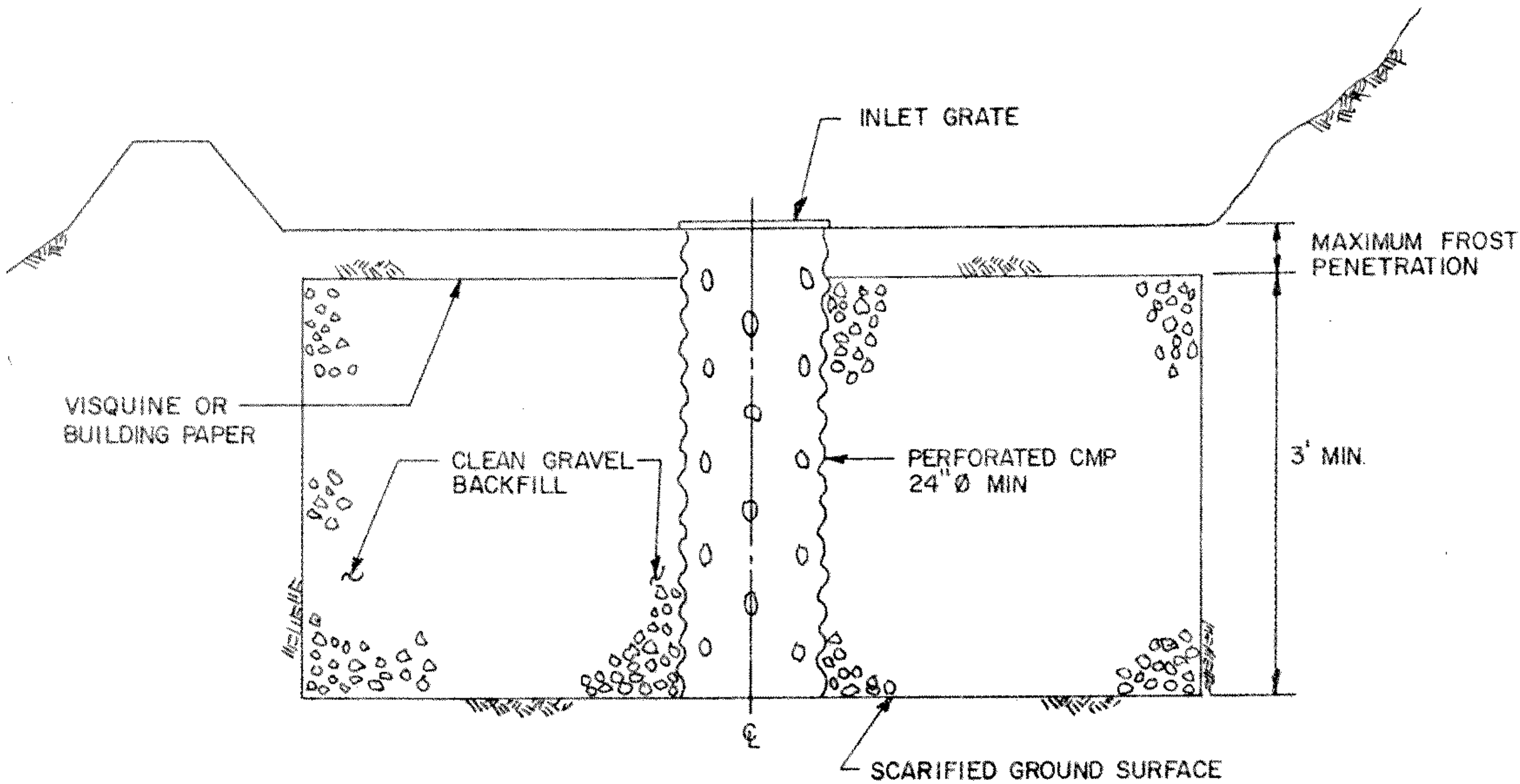


Figure 2-10 Percolation Pit

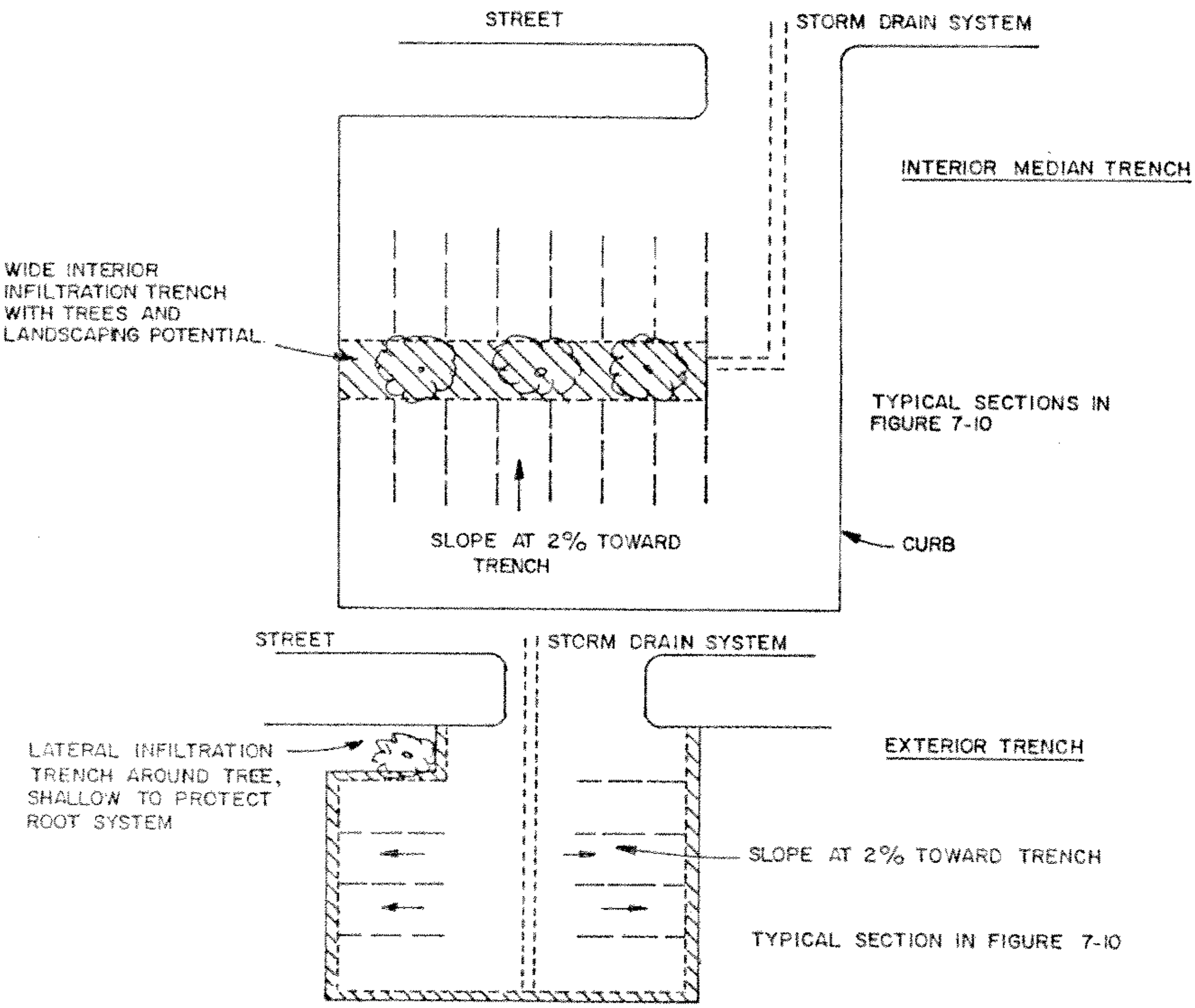
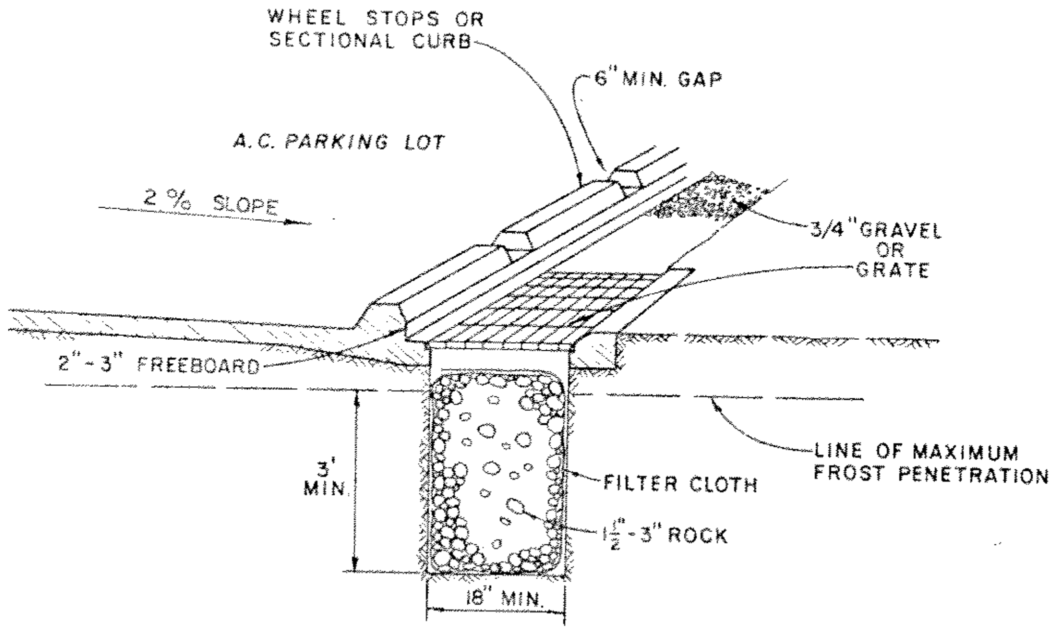


Figure 2-11 Examples of Parking Lot Infiltration Trenches



LATERAL TRENCH

ISOMETRIC

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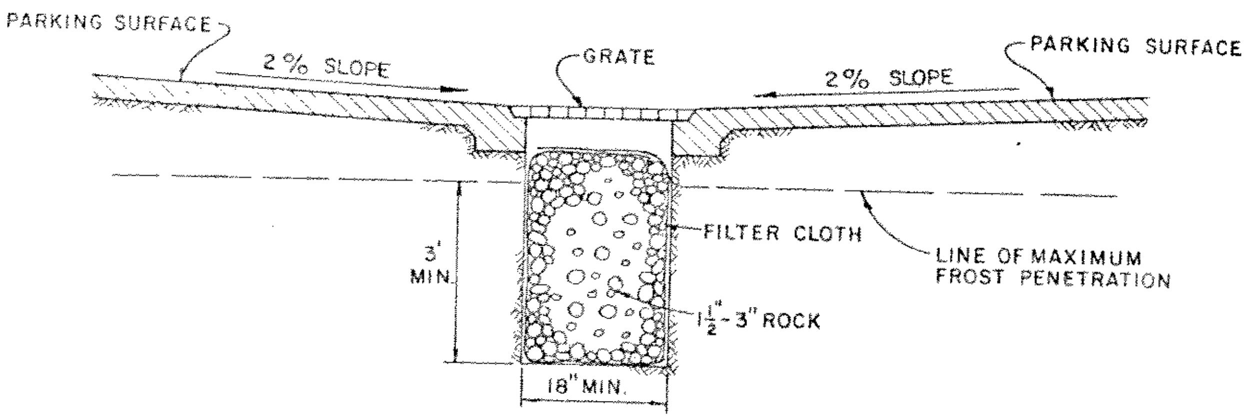


INTERIOR PARKING LOT TRENCH

SECTION

no scale

Figure 2-12 Typical Parking Lot Infiltration Trenches safely. The recommendations given herein apply to basins with tributary areas of less than 20 acres.

Sediment retention and flow detention basins are useful for on-site runoff control, for preventing discharge of sediment to surface waters, and for providing flow storage to decrease the required size of transport facilities downstream. A basin may be constructed for temporary use during construction to meet discharge water quality requirements, or for permanent incorporation into a drainage system. When constructed as a permanent facility, the basin shall provide both peak runoff storage and sediment retention. The following design criteria apply:

1. Design of the basin shall be based upon the total tributary drainage area and shall be based upon the projected land use for the tributary area over the basin's operational life. Calculation of runoff shall be as specified in Chapter 1 and shall be submitted to the County Public Works Director for review.

2. Design of the basin shall be by a registered civil engineer.

3. Vegetation shall be planted on all embankment slopes, borrow areas, or other areas disturbed by construction.

4. The basin shall be sized to store 0.5 inch of runoff per acre of drainage area, or to provide average velocities of 0.5 foot per second (fps), whichever requires a larger basin.

5. The design shall specify the level at which the basin must be cleaned, and a permanent marker shall be provided at this point. The level for cleaning should correspond to elevation at which the remaining basin storage is equivalent to 0.2 inch of runoff per acre, or at which the average flow velocity will be 1.5 fps, whichever requires the lower level.

6. Combined capacity of the outlet pipe and emergency spillway shall be designed to handle the 100-year design flow.

7. The pipe outlet shall consist of a perforated vertical pipe or box-type riser joined to a horizontal conduit which extends through the embankment. The horizontal conduit and riser shall be a minimum of 18 inches in diameter.

8. When used in combination with emergency spillways, the crest elevation of the riser shall be at least 1 foot

below the elevation of the control section of the emergency spillway. If no emergency spillway is provided, the crest elevation of the riser shall be at least 3 feet below the elevation of the crest of the embankment.

9. The upper portion of the riser shall be perforated with 1-1/2 to 4-inch-diameter holes spaced 8 inches vertically and 10 to 12 inches horizontally. Holes in successive rows shall be staggered.

10. An anti-vortex device shall be placed on top of the riser. The device may be a thin vertical plate welded across the top of the riser normal to the centerline of the dam, or other equivalent design.

11. The base of the riser shall be watertight and firmly anchored to prevent flotation.

12. A trash rack, consisting of No. 4 reinforcing bars spaced 4 inches on center each way, or other equivalent designed approved by the County Public Works Director, shall be welded across the top of the riser.

13. Conduits through embankments shall be provided with anti-seepage collars. The collar shall extend a minimum of 1 foot beyond the outside diameter of the pipe on all sides, except that it shall extend a minimum of 2 feet below the bottom of the pipe.

14. The emergency spillway shall discharge over the top of the embankment and shall either be lined with concrete or protected with rock riprap and vegetation.

15. The maximum allowable design:

Concrete-lined	15 fps
Riprap-lined	10 fps

The base of the spillway shall be provided with energy dissipation and erosion control such as a concrete or riprap-lined stilling pool.

16. The embankment shall have a top width of not less than 8 feet, a height of not more than 15 feet, and side slopes no steeper than 2:1.

17. For all basins which will serve drainage areas greater than 1 acre in size, the following shall be submitted to the County:

a. A map showing the tributary drainage area and a specific location of the basin.

b. Plan view of the dam and storage basin.

c. Cross-section of dam, storage basin, emergency spillway, and pipe outlet.

d. Runoff calculations for 10-, 50-, and 100-year storms using the procedures in Chapter 1.

e. Pipe sizing and emergency spillway design calculations.

f. Storage volume vs. elevation curve.

A typical sediment retention/flow detention basin is shown on Figure 2-13.

Roof Drainage and Drip Line Trenches

Drip line trenches prevent erosion of areas which receive direct runoff from rooftops. They are required for all structures which do not have roof gutters and downspouts to convey water to infiltration or storm drainage facilities. The following design guidelines apply:

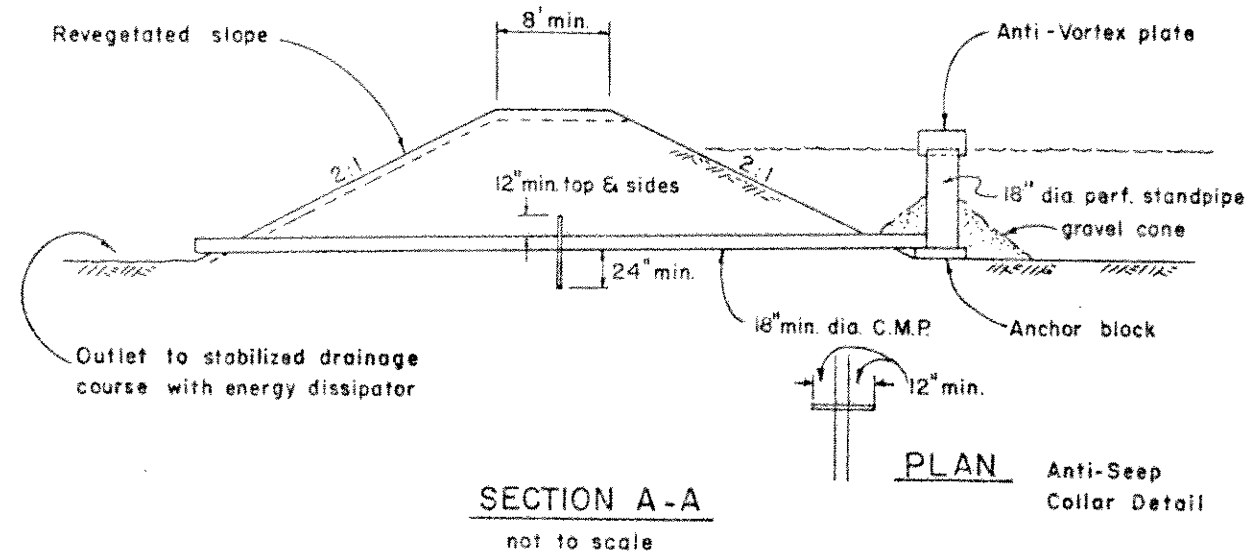
1. Trenches shall be located at the drip line of all structures which do not have roof gutters.

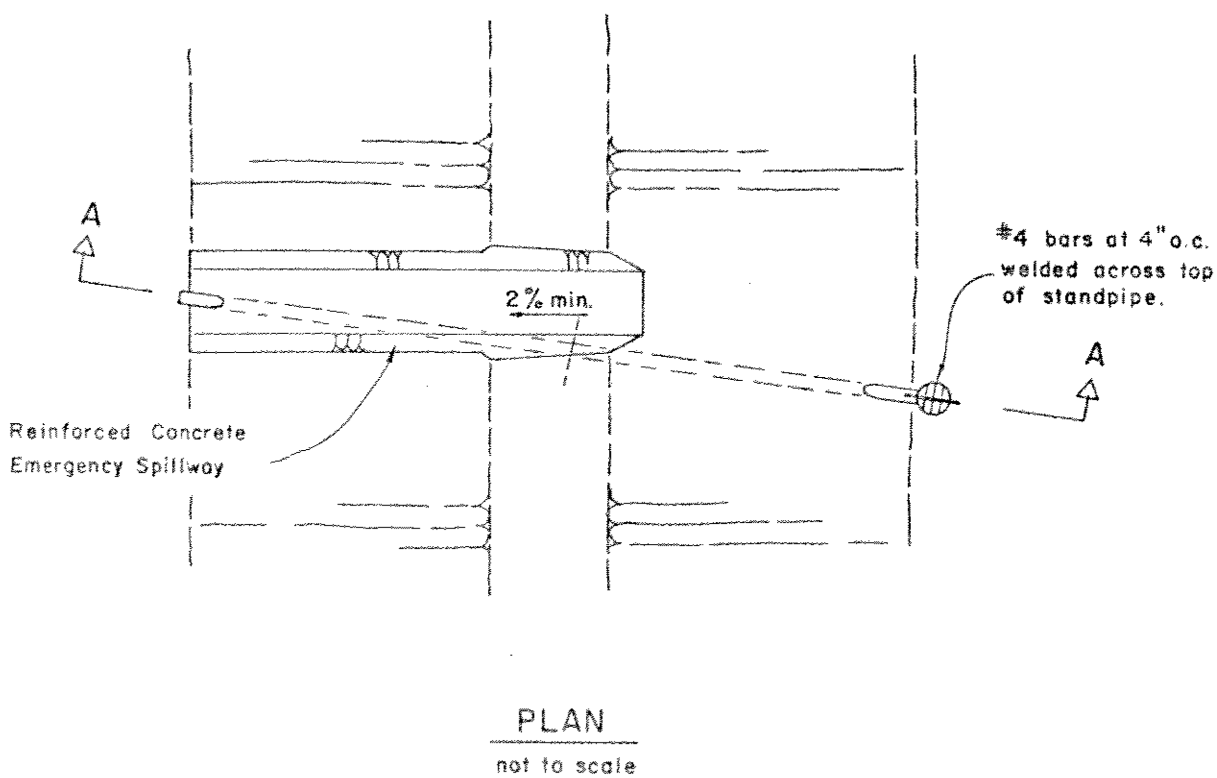
2. Rooftop runoff collected by gutters shall be discharged either to the drip line trench or other infiltration facilities.

3. Trenches shall be at least 2 feet wide and 9 inches deep, centered under the roof drip line.

4. Trench outlets shall be to a storm drainage system.

5. For all structures larger than 3,000 square feet in floor plan area, rooftop drainage shall be discharged to an infiltration facility. Acceptable infiltration facilities include dry wells and infiltration trenches as described previously in this chapter. Overflow from the infiltration facilities shall be discharged to a storm drainage system.





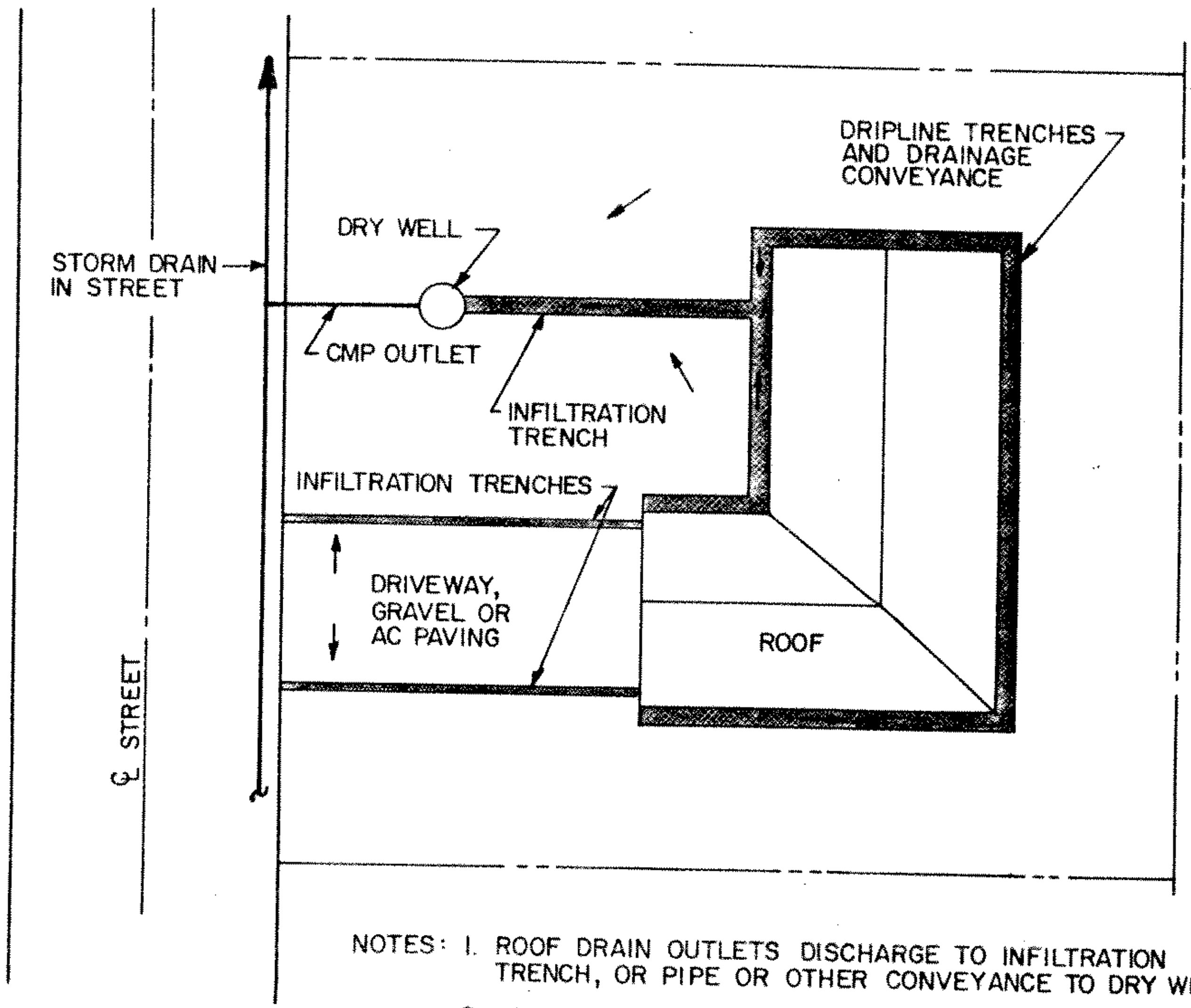
NOTES: 1. Design of the dam may vary substantially depending on site and shall be done by a registered civil engineer and shall be for a specific site.

2. Design must conform to state law

Figure 2-13 Sediment Retention Basin

Typical Residential On-Site
Storm Drainage Retention Facilities

Figure 2-14 shows a typical residential lot with erosion control and onsite storm drainage retention facilities. The figure is intended as an example of the use of these types of facilities rather than a standard design detail. The most practical and economical system should be designed on a lot-by-lot basis. Where on-site retention of storm drainage is required by County ordinance, or where desired by the owner, a system similar to the one shown should be adapted to meet the specific site conditions.



NOTES:
1. ROOF DRAIN OUTLETS DISCHARGE TO INFILTRATION TRENCH, OR PIPE OR OTHER CONVEYANCE TO DRY WELL
2. LANDSCAPING PLAN TO SHOW PLANTINGS TO PREVENT SURFACE EROSION

Figure 2-14 Typical Residential On-Site Storm Drainage Retention Facilities

CHAPTER 3

TEMPORARY RUNOFF MANAGEMENT

This section describes methods which may be used to retain runoff waters on site, transport them over unstable slopes, or to prevent sediment transport off site. The measures are useful during construction activities and prior to construction of permanent drainage facilities.

APPLICABILITY

Straw bale sediment barriers, filter berms, and filter inlets allow runoff to occur, but prevent transport of sediments off site. They are applicable to all sites which have been disturbed by construction activities and have not been treated with soil stabilization techniques. Alternatively, a siltation berm may be used to prevent runoff from the site. Where flows must be transported over unstable slopes for a temporary period of time, flexible downdrains may be used. When flexible downdrains are used, other methods must be used to filter the runoff and limit sediment transport.

All construction activities shall use one or more of the listed methods to maintain runoff suspended sediment concentrations below 60 mg/l and turbidities below 30 JTU. The facilities shall be sized to control runoff flows calculated as specified in Chapter 1.

STRAW BALE SEDIMENT BARRIERS

The methods and material for installation of straw bale sediment barriers are listed below.

1. Bales shall be tied with wire or nylon. Twine is not acceptable.

2. Bales shall be laid on their side and staked in place. At least two wooden or metal stakes shall be driven through each bale and into the ground at least one foot. One of the stakes shall be driven at an angle so as to go through the adjacent bale as well as the one being staked.

3. The bales shall be placed in a 6-inch-deep trench and backfilled by firmly tamping the soil along the upstream face of the barrier.

Figure 3-1 shows a typical detail for a straw bale sediment barrier.

FILTER BERM

Figure 3-2 shows a typical filter berm and installation in am impermeable barrier around a construction site. The filter berm outlet shall be located so as to not create an erosion hazard downstream from the site.

FILTER INLET

Figure 3-3 shows a typical filter inlet around a storm drainage inlet. Filter material shall be coarse (3/4-inch to 1-1/2-inch) gravel or crushed rock. Fines shall be less than 5 percent.

SILTATION BERM

Figure 3-4 shows a typical siltation berm. The methods and materials for construction of siltation berms are listed below:

1. The berm shall be constructed from gravel or coarse soil material.

2. Plastic sheeting, 6-mil-thick (Visqueen R or equal) shall be placed over the berm to form an impermeable barrier.

3. The berm shall be located along the contour of the slope on the downhill margin of the construction site.

4. All trash, debris, and organic materials shall be removed from the berm area prior to construction.

5. The height of the berm shall be sufficient to contain 3.0 inches of rainfall over the entire site. If the berm is constructed so that off-site areas may be tributary to the berm, the berm shall be high enough to contain 3.0 inches of rainfall over the tributary area. However, the berm height shall not exceed 2.5 feet nor be less than 1 foot. Side slopes shall be no steeper than 2:1.

6. Plastic sheeting shall be installed with 4-foot laps at joints. The sheeting shall be anchored with 3/4 to 1-1/2-inch gravel. Gravel shall be placed continuously along both edges of the sheeting.

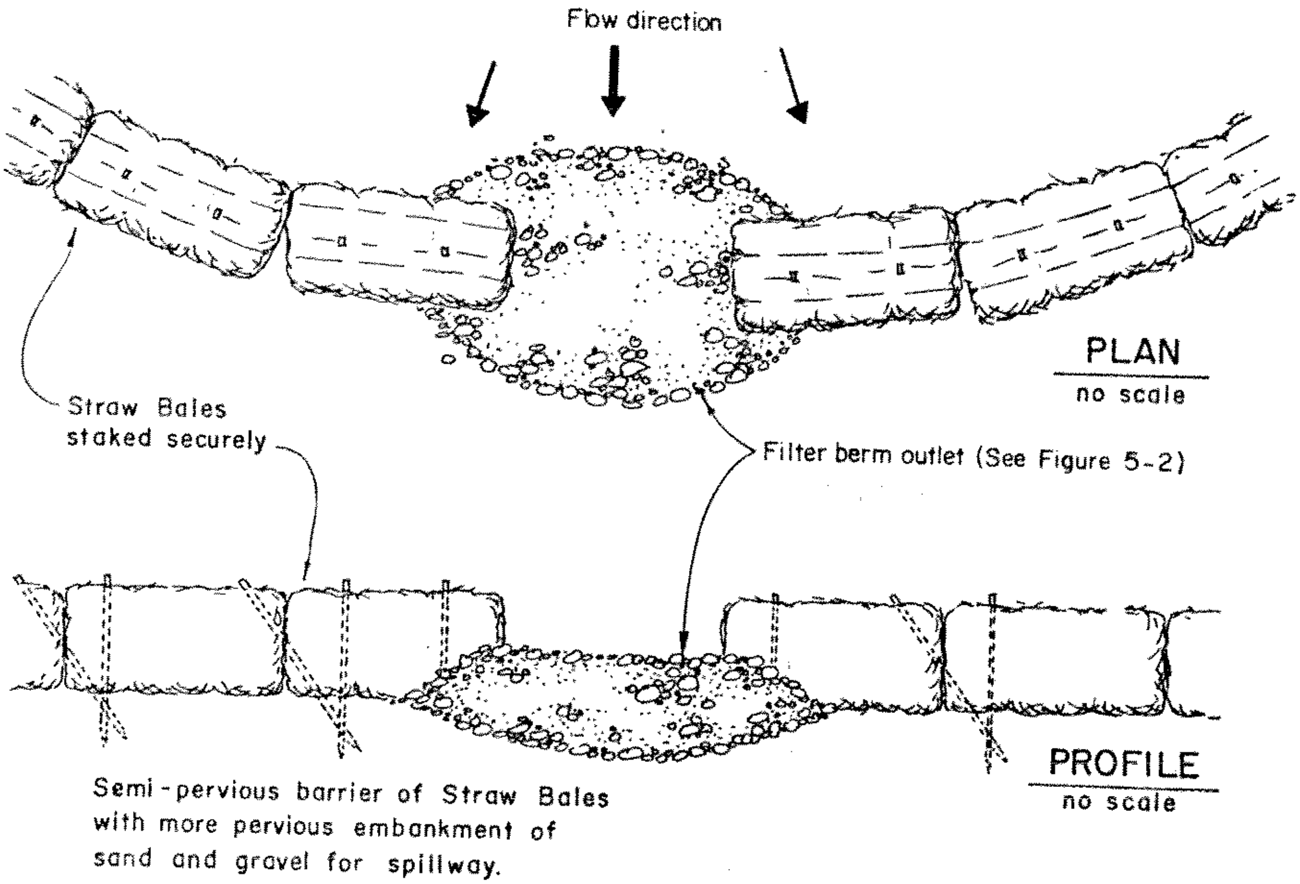


Figure 3-1 Straw Bale Barriers

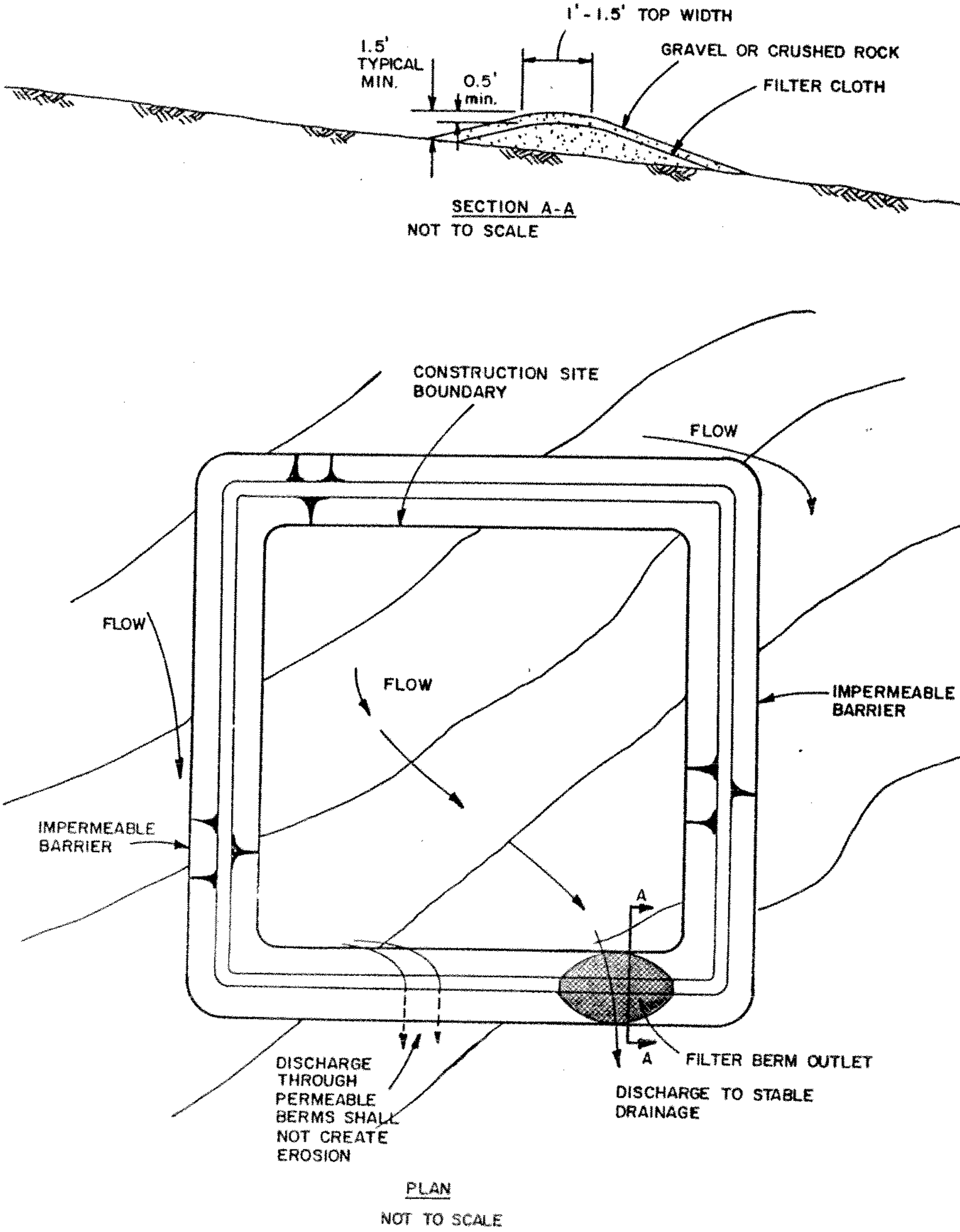
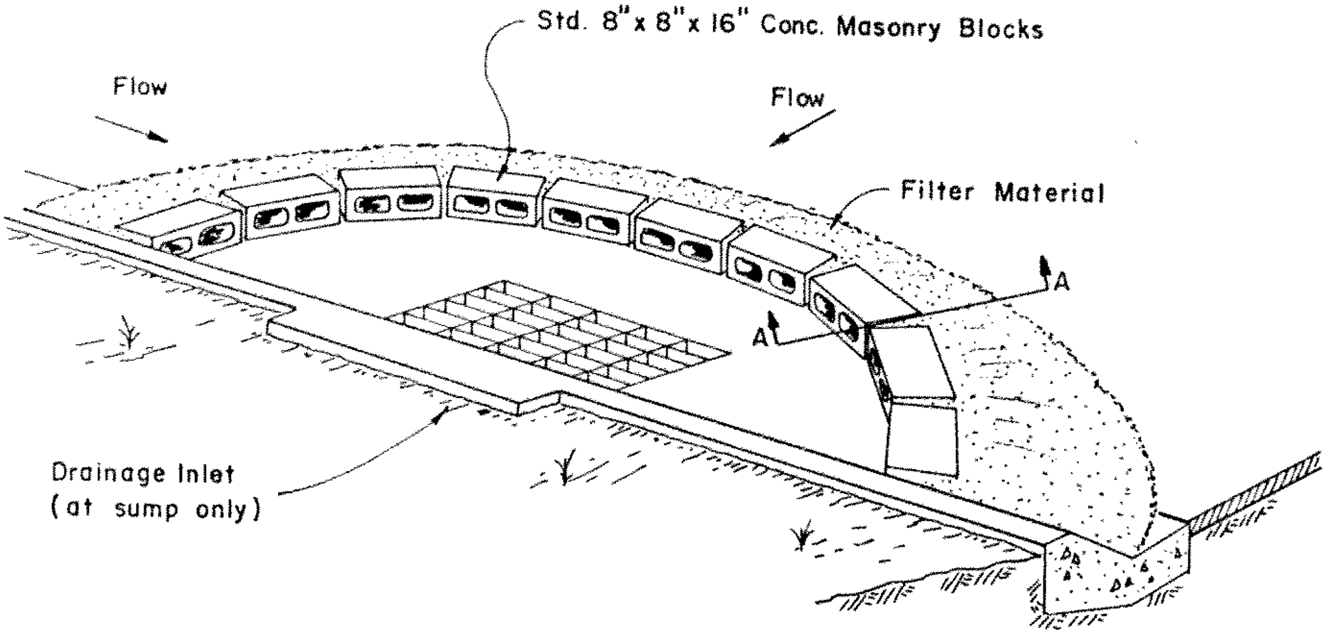


Figure 3-2 Typical Filter Berm



ISOMETRIC
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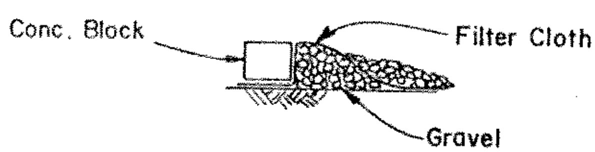


SECTION 'A-A'

Figure 3-3 Filter Inlet

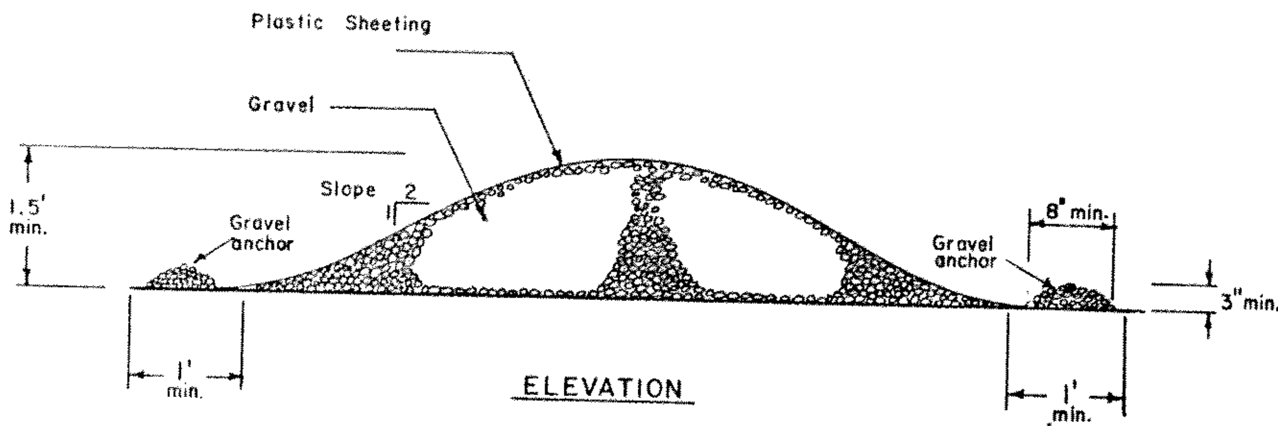


Figure 3-4 Siltation Berm

FLEXIBLE DOWNDRAIN

Figure 3-5 shows a typical flexible downdrain installation. The following design and installation criteria apply to flexible downdrains:

1. Drains shall be placed on undisturbed soil or well compacted fill.
2. The diameter should be sized to carry runoff resulting from precipitation of 1 inch per hour on the tributary area.
3. Standard metal end sections shall be used with extension collars 12 inches long. Extension collars shall be corrugated metal pipe. Helical pipe is not acceptable.
4. Flexible conduit shall be strapped to the collars and cover at least two corrugations of the extension collars.
5. Downdrains shall be staked with metal "T" pins spaced every 10 feet.
6. Discharge shall be to an energy dissipator or other stabilized outlet.

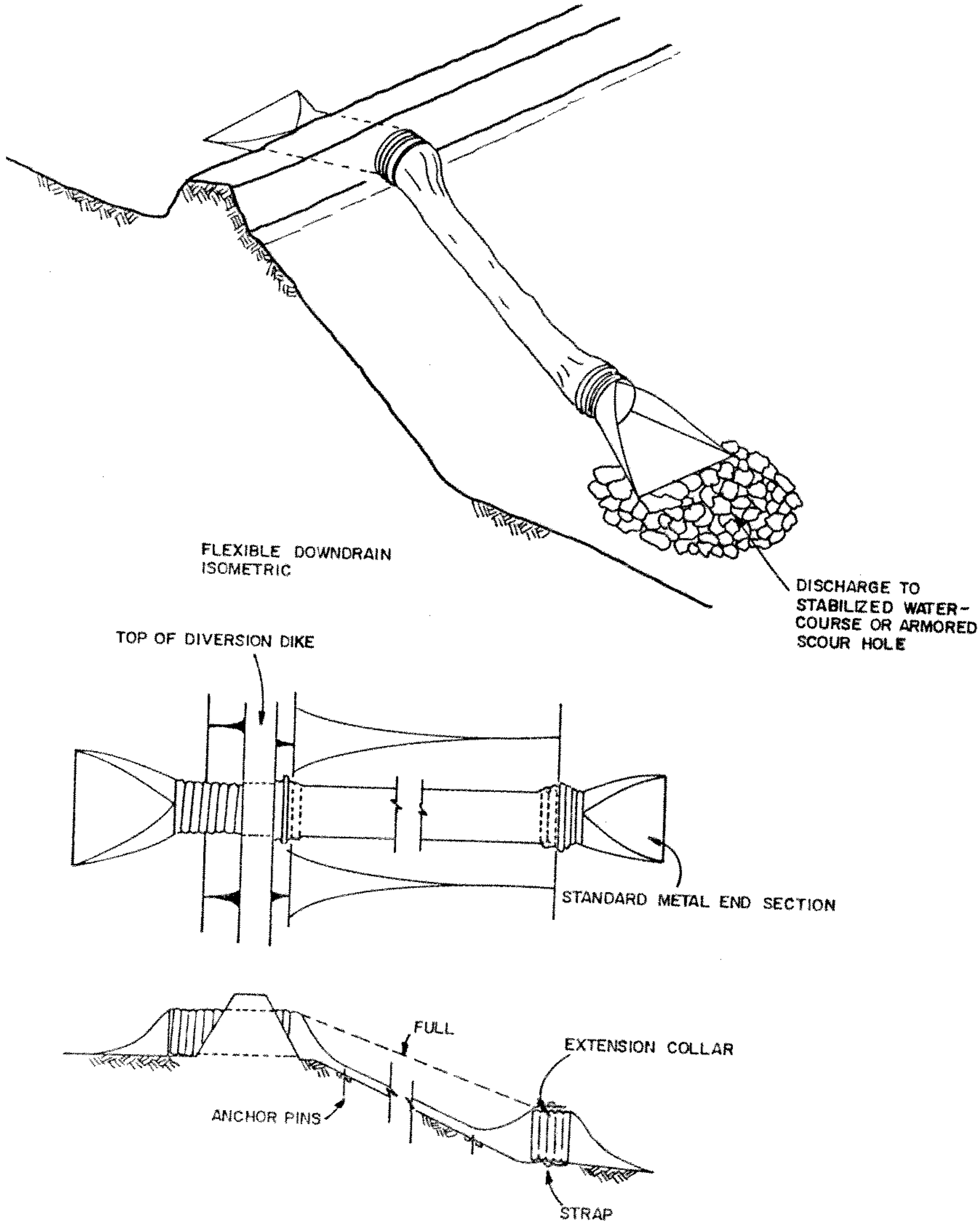


Figure 3-5 Flexible Downdrain

CHAPTER 4

PERMANENT RUNOFF CONTROL ON SLOPES

For slopes to be permanently stable, runoff over and across slopes must be adequately controlled. Control of runoff prevents erosion of the slope and allows vegetation to become established. This section describes several methods which prevent concentrated flows from occurring over slopes.

APPLICABILITY

Five acceptable methods which are described below include diversion dikes, runoff interception trenches, pipe drops, chutes and flumes, and subsurface drainage.

Diversion dikes and runoff interception trenches are used to divert flows away from slopes into stable areas or other drainage improvements. Pipe drops and chutes or flumes are used to transport flows over slopes to a stable outlet. Subsurface drainage is used where required to prevent seepage out of the face of a slope. All slopes shall be constructed with diversion dikes at the top. All slope terraces (see Chapter 7) shall include a runoff interception trench. Pipe drops and chutes or flumes shall be used wherever runoff flows must be transported over slopes. The use of subsurface drainage depends on local groundwater conditions. Subsurface drainage shall be constructed wherever seepage will occur on the face of a slope for any part of the year.

The design runoff flows for all facilities listed herein shall be calculated as specified in Chapter 1.

DIVERSION DIKES

The following criteria apply to the construction of diversion dikes:

1. The diversion outlet shall be to a heavily vegetated or artificially stabilized area or to a downdrain, chute, or flume.

2. The dike shall be designed to prevent flow over the slope during the design runoff flow.

3. The dike shall be a minimum of 1.5 feet high and 2 feet wide at the top with side slopes at 2:1 (horizontal: vertical) or flatter.

4. The dike shall be constructed of low permeability soils, compacted to a minimum of 85 percent relative density.

5. Invert grade of the dike shall be at least 0.5 percent and not more than 5 percent. Dikes with invert slopes greater than 2 percent shall be stabilized with rock, asphalt, or concrete lining.

Figure 4-1 shows a typical diversion dike detail.

RUNOFF INTERCEPTION TRENCH

The following criteria apply to construction of runoff interception trenches:

1. Outlet shall be to a heavily vegetated or artificially stabilized area.

2. Excavated material shall be spread to conform to the natural ground or to the grade of the slope terrace.

3. Trench shall slope at approximately 2 percent towards the discharge point.

4. Depth shall be 12 inches minimum, width shall be 18 inches at the bottom, and side slopes shall be no steeper than 2:1.

5. Trenches shall be spaced on a slope to comply with the procedure for determining the maximum slope length in Chapter 5.

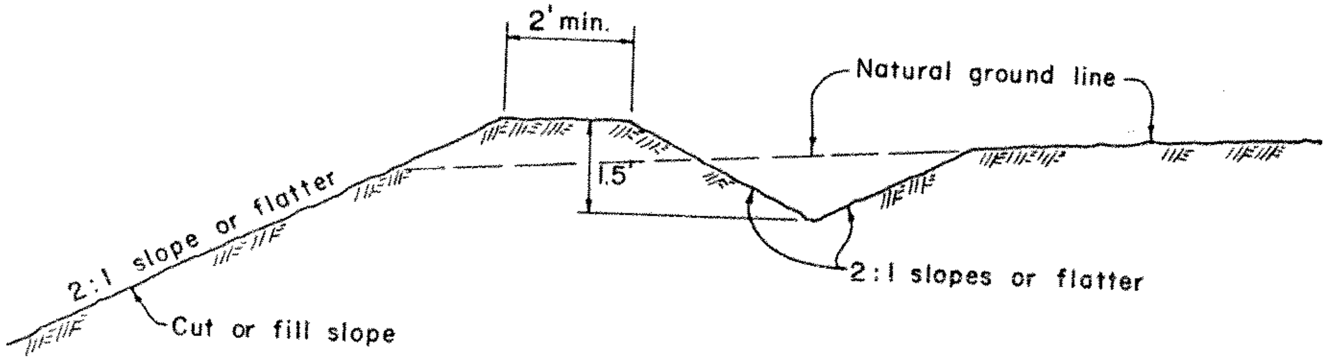
Figure 4-2 shows a typical runoff interception trench.

PIPE DROPS

The following design criteria apply to pipe drops:

1. Drops shall be designed to convey the runoff from a precipitation event with an intensity of 1.5 inches per hour.

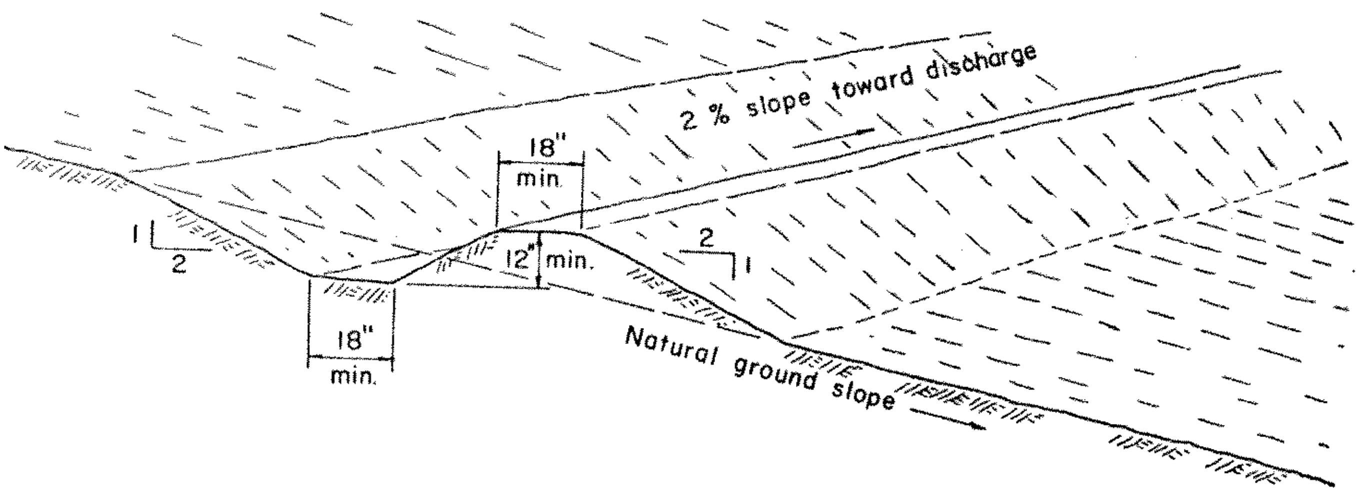
2. Grades around the entrance to the pipe drop shall be designed to prevent bypass of the drop at the design precipitation intensity.



SECTION
not to scale

Diversion dike to be constructed at top of cut or fill slope.
Outlet to stabilized area or drainage system

Figure 4-1 Diversion Dike



ISOMETRIC SECTION
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Figure 4-2 Runoff Interceptor Trench

3. The inlet and outlet to the drop shall be stabilized with concrete, rock, or asphalt. The outlet shall be provided with energy dissipation to prevent erosion downstream.

4. Thrust blocks shall be placed at all grade changes.

5. Pipe collars shall be constructed at intervals of 20 feet maximum to prevent flow of water through the ground along the pipe.

6. The inlet structure shall be sized by applying a safety factor of 1.5 to the design storm (Q inlet = 1.5 x Q design).

Figure 4-3 shows a typical pipe drop.

CHUTES AND FLUMES

The following criteria apply to the construction of chutes and flumes:

1. Chutes and flumes shall be constructed on undisturbed soil or well-compacted fill.

2. Slopes shall be no steeper than 2:1 and no flatter than 20:1.

3. The outlet structure shall be protected against scour with chute blocks, impact basin, rock riprap, or plunge pool. Discharge shall be to stabilized area or storm drainage system.

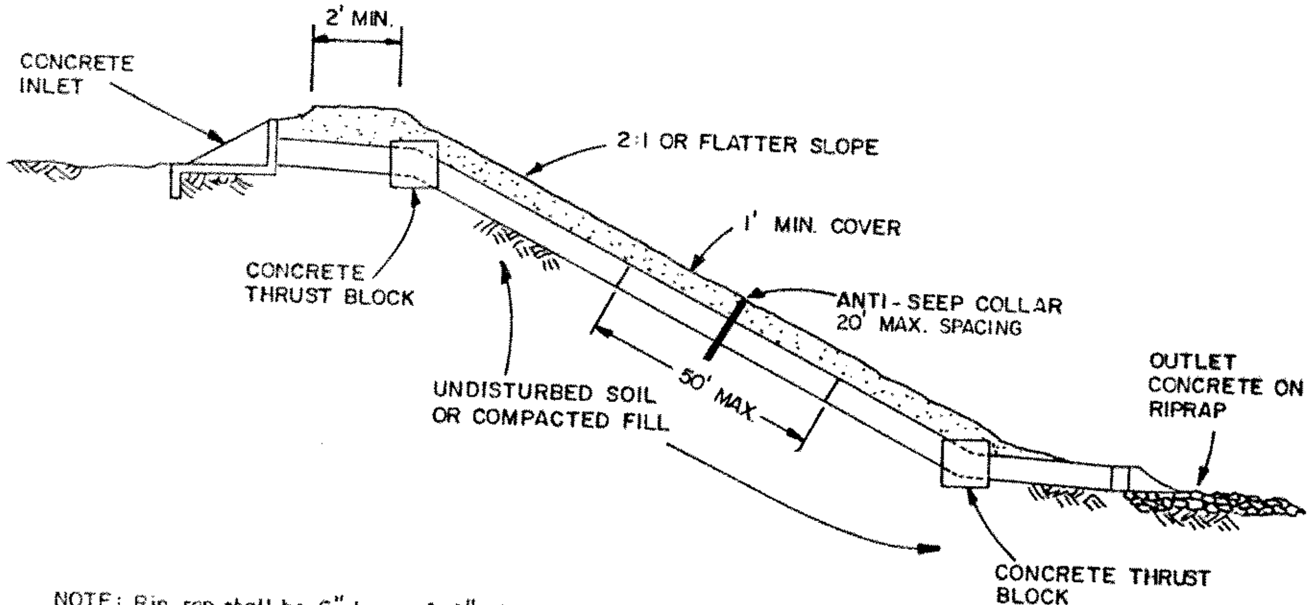
Figure 4-4 shows a typical chute.

SUBSURFACE DRAINAGE

Two basic types of subsurface drainage systems are described below. Well point systems consist of perforated pipe underdrains driven into the slope so as to drain to a common header by gravity. Trench systems are gravity drain systems which use perforated pipe laid in a trench and backfilled with coarse gravel.

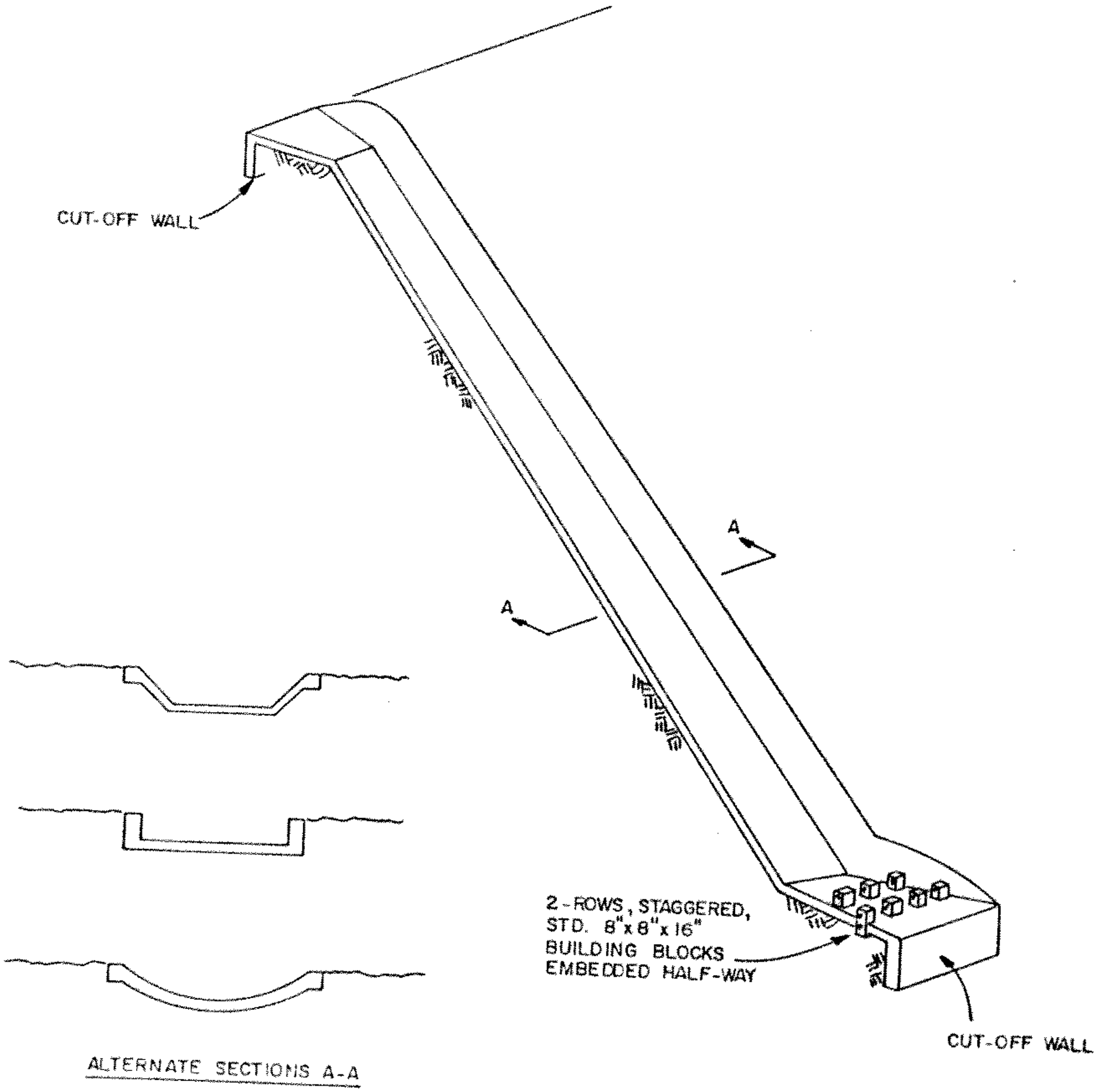
Well Point System

The criteria for construction of well point systems are given below:



NOTE: Rip-rap shall be 6" layer of 4" min. dimension rock or rubble with 3" sand bedding.

Figure 4-3 Pipe Drop



NOTES: 1. Maximum vertical drop shall be 10 feet
2. Maximum design velocity shall be 15 FPS

Figure 4-4 Chute or Flume

1. Perforated pipe underdrains or horizontal drains shall be installed in the permeable soil layer. If an impermeable layer of soil or rock exists, the underdrains shall be installed just above this layer.

2. Pipe shall be perforated steel with upper end pointed and closed for driving into the slope face.

3. Minimum pipe size shall be 2 inches in diameter.

4. Depth, spacing, sizing, and location of drains shall be based on local site conditions. Design of the system shall consider soils, groundwater levels, and topography.

5. Discharge from the system shall be to a stabilized area or drainage system.

Figure 4-5 shows a typical well point system.

Trench System. The criteria for construction of trench systems are given below:

1. Trenches shall be a minimum of 18 inches deep. The trench shall be backfilled with 4 inches minimum of graded filter material, or it shall be lined with filter cloth as provided below.

2. Pipe shall be clay, concrete, or polyvinyl chloride.

3. Filter material or graded aggregate shall completely enclose the pipe. A depth of not less than 3 inches is required under the pipe if a graded aggregate filter is used.

4. All drains shall be laid to line and grade and shall be covered with not less than 3 inches of hand-placed backfill or filter aggregate.

5. The upper end of all drain lines shall be closed with concrete.

6. If used, filter cloth shall completely enclose the aggregate which surrounds the pipe.

7. Earth backfill shall be placed in the trench over the filter material or graded aggregate.

8. Discharge shall be to a stabilized area or storm drainage system.

Figure 4-6 shows a typical subsurface drain trench system.

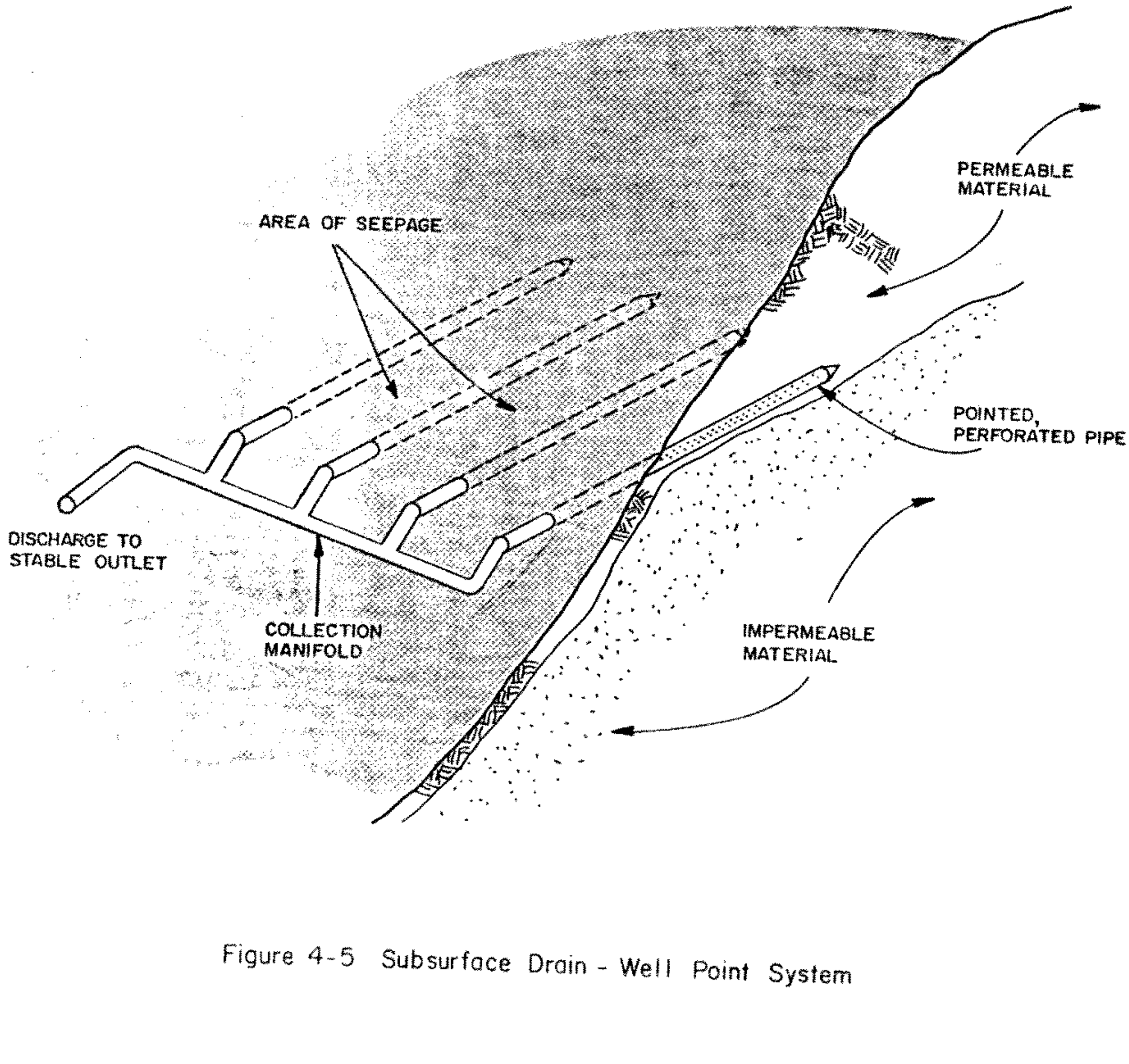


Figure 4-5 Subsurface Drain - Well Point System

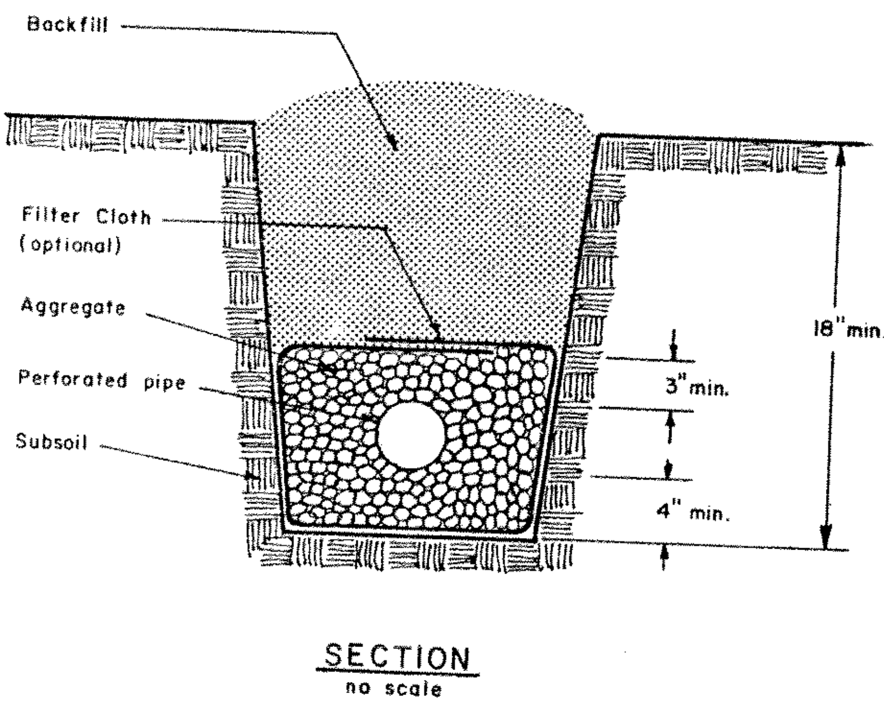


Figure 4-6 Subsurface Drain Trench System

PART II

EROSION CONTROL

CHAPTER 5

SLOPE DESIGN

This chapter specifies design criteria for new slopes constructed by cut and/or fill and regraded slopes.

APPLICABILITY

The criteria below apply to the design of all new and regraded slopes with average gradients of 5 percent or more.

SLOPE STEEPNESS

Slope steepness shall not exceed 2 horizontal to 1 vertical (2:1) or the natural angle of repose for the slope material, whichever is less steep. If the slope is composed of solid rock, slopes may be steeper than 2:1, provided they are designed by a registered civil engineer.

SLOPE CONFIGURATION

Slopes shall be designed to match the natural contours of adjacent land and to minimize the amount of earthwork required. Existing vegetation shall be retained wherever possible.

Maximum slope face length shall be determined from Figure 5-1. Slopes with total lengths greater than the maximum slope face length shall be stabilized by one or more of the methods given in Chapter 6--Temporary Soil Stabilization.

Minimum slope setbacks shall be:

1. Tops of cut slopes shall not be nearer to a property line than 3 feet, plus one-fifth of the height of the cut, except that the distance need not exceed 10 feet.
2. Tops of cut slopes shall be a minimum horizontal distance of 6 feet from fill slopes.
3. Building foundations shall be set back from the top of any slope a minimum distance of 6 feet.

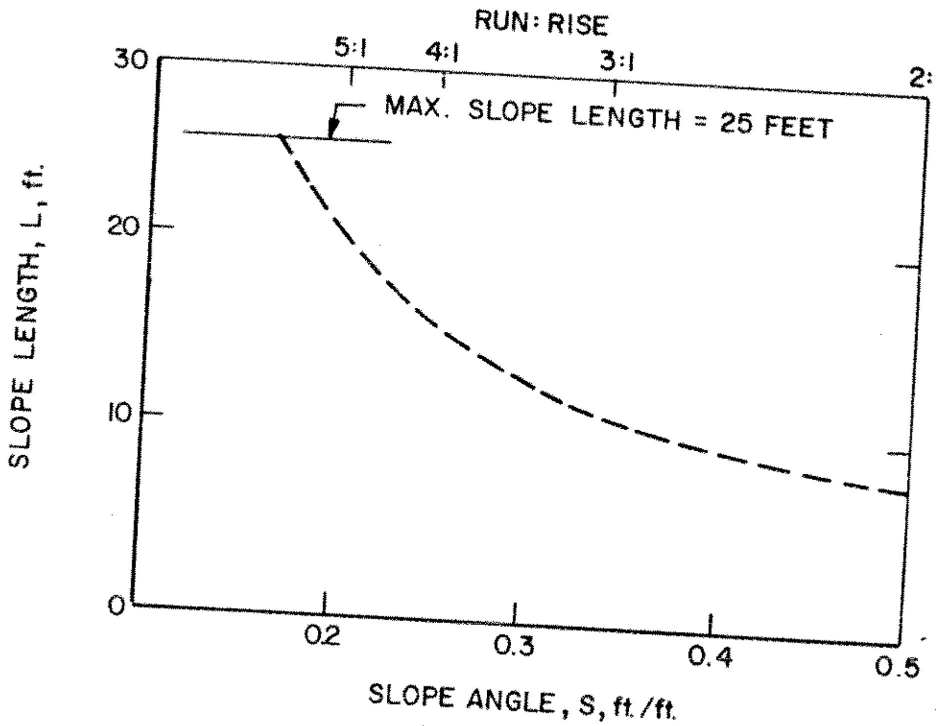


Figure 5-1 Maximum Slope Face Length

4. Top and bottoms of fill slopes shall be located so that no portion of the slope will be closer than 10 feet to any adjacent property line. The toes of fill slopes shall also not be nearer to any adjacent property line than one-half the height of the fill, except that the distance need not exceed 20 feet.

The distances specified above are minimums. Larger distances may be required for safety or stability depending on soil characteristics, groundwater levels, and other factors.

A soils report containing slope stability recomendations shall be submitted to the Mono County Department of Public Works for all slopes greater than 10 feet in vertical height. Figure 5-2 shows typical sections of optimum slope shapes. The optimum shape consists of a rounded top, incorporating a runoff diversion dike as required, contoured into a uniformly sloping face with a rounded toe and slope bottom bench.

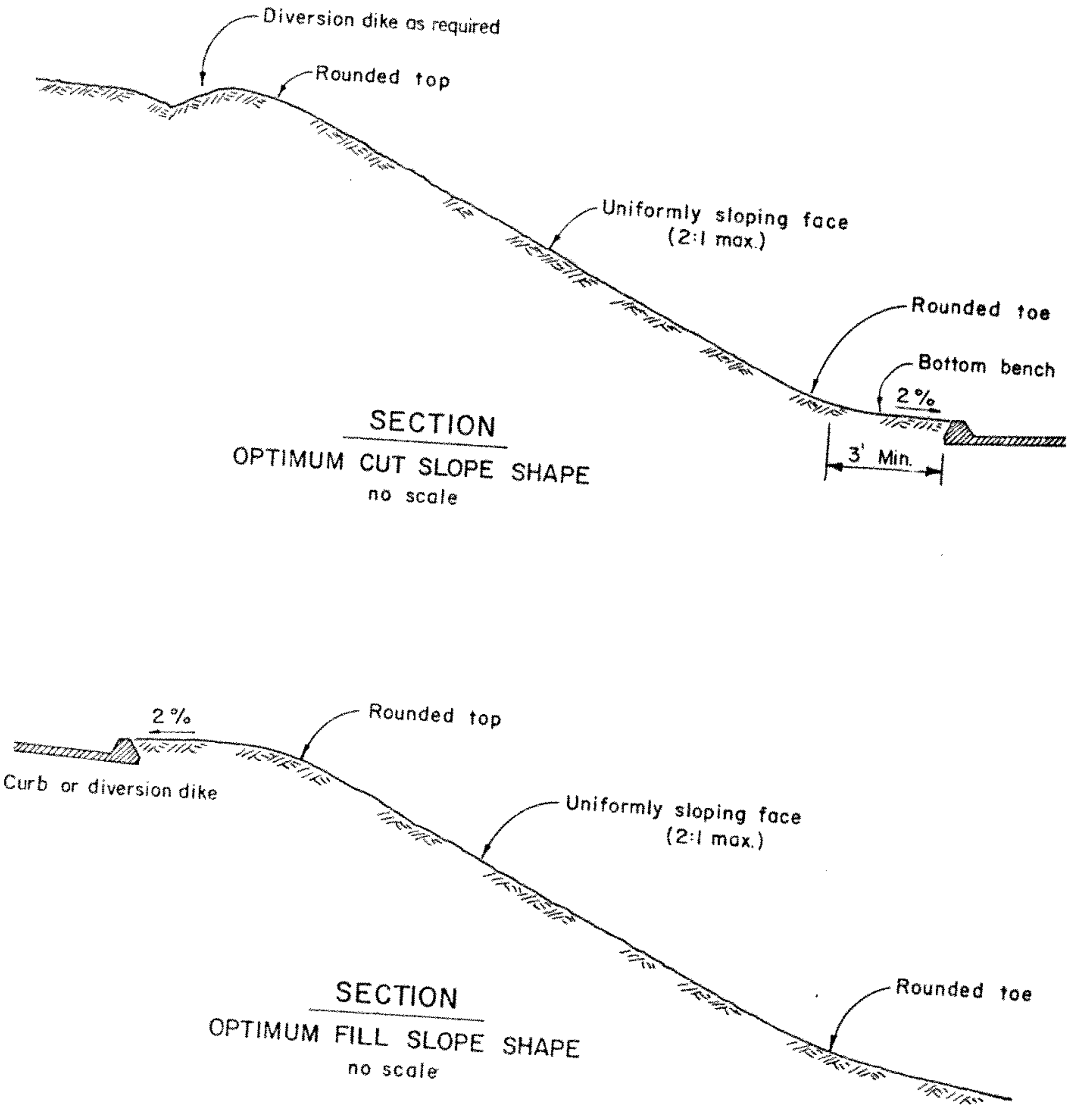


Figure 5-2 Optimum Slope Shapes

JUTE MATTING

This method involves application of a heavy fiber net either alone or over straw or wood fiber mulches. When used over mulches, it is applicable to areas with slopes up to 50 percent, provided that runoff is controlled in drainage improvements. When used alone, it is applicable to areas with slopes up to 30 percent and less than 10 feet in height, or larger areas with slopes up to 20 percent.

Methods and Materials

1. The details of installation are shown on Figure 6-1.
2. Jute mat shall be cloth of a uniform plain weave of undyed and unbleached single jute yarn, 48 inches in width plus or minus 1 inch and weighing an average 1.2 pounds per linear yard of cloth with a tolerance of plus or minus 5 percent, with approximately 78 warp ends per width of cloth and 41 weft ends per linear yard of cloth. The yarn shall be of a loosely twisted construction having an average twist of not less than 1.6 turns per inch and shall not vary in thickness by more than one half of its normal diameter.
3. Individual rolls should be applied up and down the slope, never along the contour.
4. Sides of rolls shall overlap at least 4 inches, and rolls shall have at least a 3-foot overlap when an uphill roll joins to a downhill roll. The uphill roll shall overlie the downhill roll.
5. Staples shall be made of wire, 0.091-inch in diameter or greater, "U" shaped with legs at least 6 inches in length and a 1-inch crown. Longer staples are required in loose or sandy soils.
6. Staples shall be driven perpendicularly into the slope face, and shall be spaced approximately 5 feet apart down the sides and center of the roll. Spacing between staples at the upper end of a roll or at the end overlap of two rolls shall not exceed 1 foot.
7. Matting shall be continued beyond the edge of the mulched or seeded area at least 1 foot at the sides and 3 feet at the top and bottom of the area. If existing vegetation or structures mark the boundaries of the area, the matting shall be continued into the stable vegetated area or to the edge of the structure.

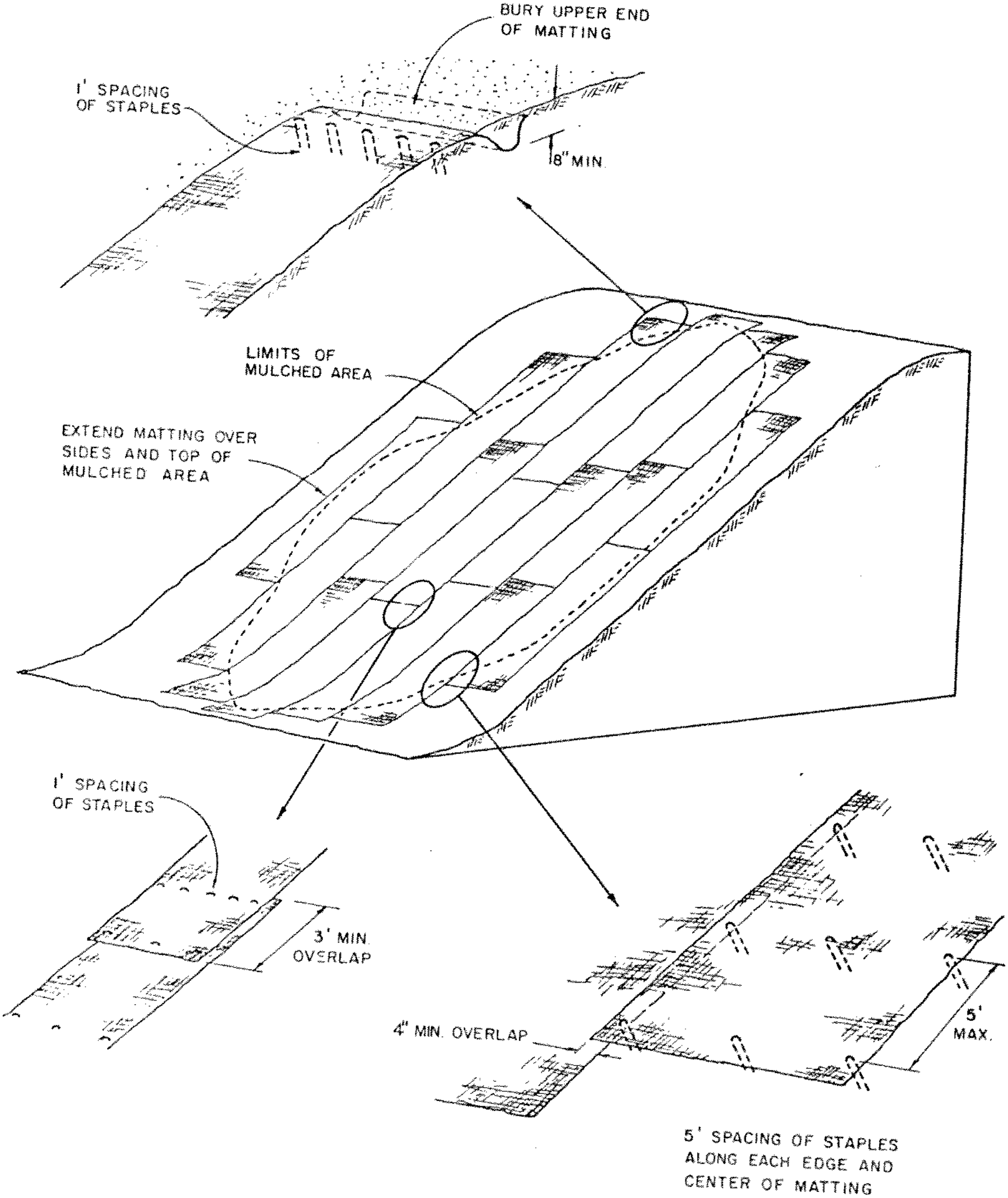


Figure 6-1 Jute Matting

slopes to prevent uncontrolled flow over the slope face. The toe of the slopes shall be protected from erosion and undercutting by appropriate drainage improvements.

Applicability

Physical slope stabilization methods can be used to reduce the amount of space required for slope construction. The method shall be used wherever necessary to provide permanent stability for slopes of any size or steepness.

Retaining Wall Design

Three types of retaining wall design are described below. Other designs may be used provided they meet the general performance standards of permanent slope stability, provision for adequate drainage, and protection against erosion and undercutting of the structure. All retaining walls greater than 3 feet in height shall be designed by a registered civil engineer. The three types of walls and their respective applications are:

1. Native rock retaining wall for use in low-gravity walls up to about 5 feet in vertical height.

2. Gabions for use in higher walls and for slope revetments. Where significant seepage is anticipated, gabions are preferable to other wall types. The walls may be designed as gravity structures or may utilize tie-backs where required for additional structural strength.

3. Redwood retaining walls for use on relative small slopes of loose material which are underlain by rock on firm, nonplastic subsoil with high shear strength. Maximum vertical height of the wall shall be 4 feet.

Figures 7-1 to 7-3 show typical details for the three types of retaining walls.

SLOPE INTERRUPTION METHODS

The methods described below are designed to interrupt the flow of water over the face of the slope. Erosion of the slope is prevented by slowing the velocity of runoff and preventing concentration of the flow into rivulets. The three slope interruption methods described below are wattling, slope serration, and slope terracing.

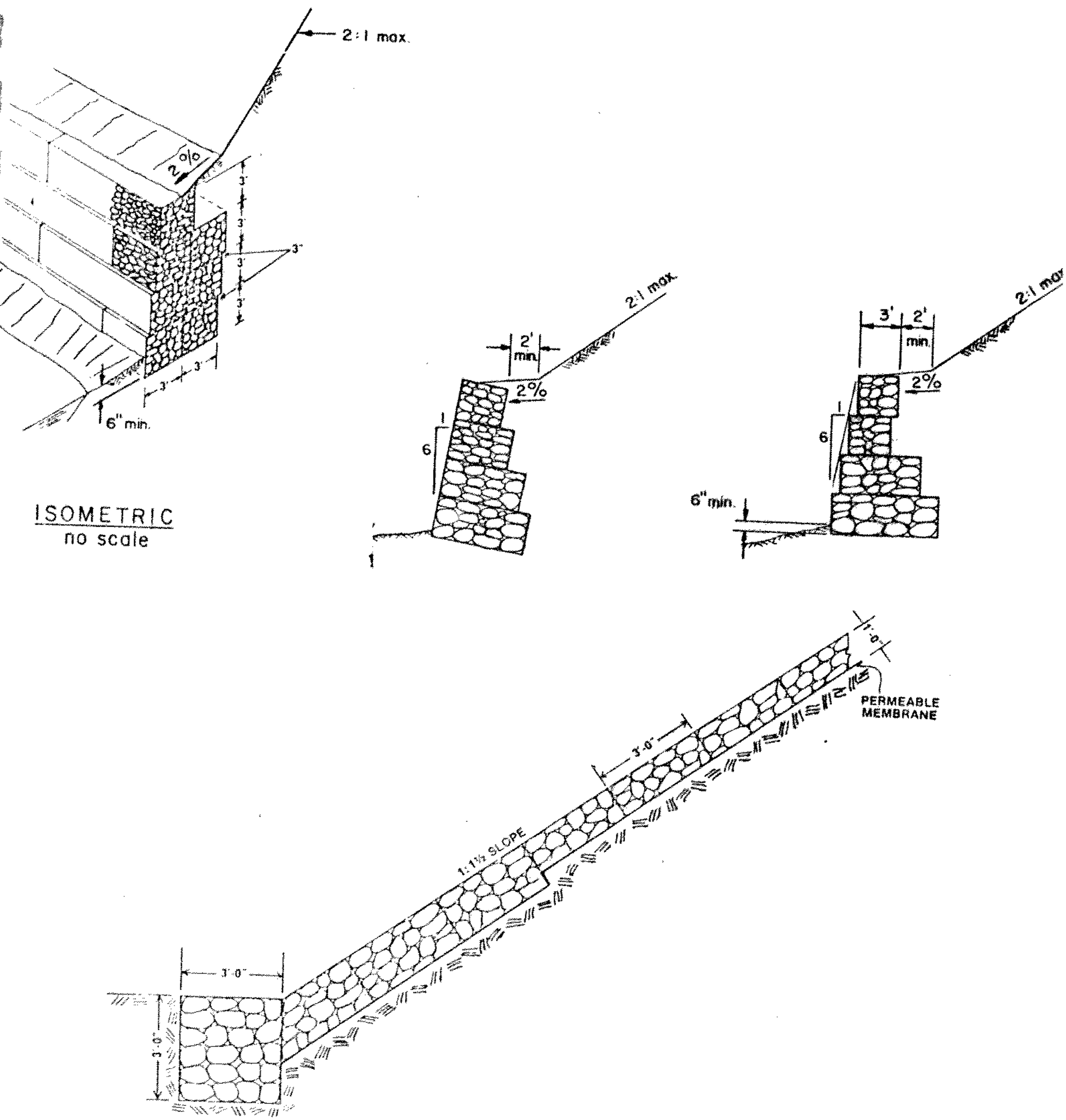


Figure 7-2 Gabion Retaining Walls

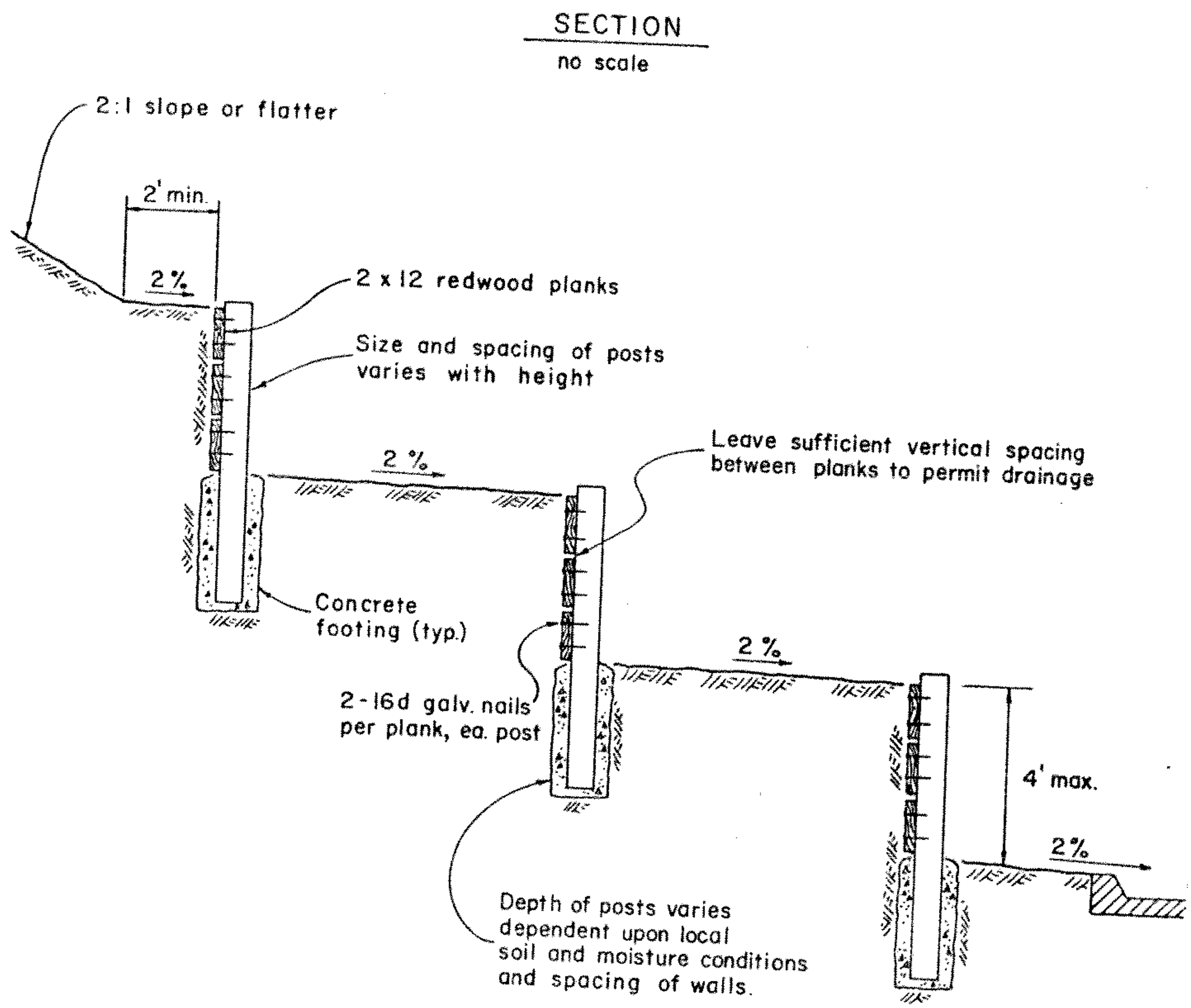


Figure 7-3 Redwood Retaining Wall

Applicability

These methods shall be used wherever necessary to limit the slope length to the maximum length obtained from the procedures in Chapter 5--Slope Design. They may also be used in combination with temporary soil stabilization methods to provide a stable surface on which to establish vegetation. Wattling simultaneously breaks the slope length and provides some revegetation of the slope. To be effective, the methods must be used in conjunction with drainage improvements, temporary soil stabilization, and revegetation.

Wattling

The materials and methods to be used for installing wattling are described below.

Preparation of Bundles.

1. Wattling bundles shall be prepared from living branches of shrubby material of species which will root, such as *Salix*, spp. (Willow) and *Alnus* spp. (Alder).

2. Wattling bundles may vary in length depending on materials available, but shall be at least 5 feet long. Bundles shall taper at the ends and shall be 1 to 1-1/2 feet (maximum 2 feet) longer than the average length of the individual branches to achieve this taper. Butts of branches shall be no more than 1-1/2 inches in diameter.

3. The direction of branches in each bundle shall be alternated so that approximately one-half of the butt ends lie at each end of the bundle.

4. When compressed and tied, each bundle shall be 6 to 10 inches in diameter.

5. Bundles shall be tied on not more than 16-inch centers with two wraps of binder twine or heavier tying material using a nonslip knot.

6. Bundles shall be prepared not more than two days prior to placement, unless they are kept covered and moist. In that case, they can be prepared up to seven days prior to placement.

7. Willow wattling should be cut in the spring prior to the appearance of any substantial foliage or late in the fall once the branches have returned to a dormant state. Cutting and planting of willows when they are foliated during the summer will lead to a rapid drying of the

branches and greatly reduce the success of willow growth. If wattling must be cut and planted in the summer months, strip all leaves from the branches to reduce moisture loss.

Installation.

1. Existing gullies and rills shall be filled and compacted prior to installation of wattling. Disturbance of the slope face and any existing vegetation shall be minimized.

2. Grade for wattling trenches shall be staked with an Abney level or similar device and shall follow slope contours.

3. Determine trench spacing on large slopes using the procedure for determining the maximum slope length in Chapter 5.

4. Bundles shall be placed in contour trenches dug 3 to 5 inches in depth and 6 to 10 inches across.

5. Place stakes on 16-inch centers on the downhill lip of the trench.

6. Stakes shall be live wattling material of greater than 1-inch-diameter or 2-inch by 4-inch lumber or construction stakes. Live stakes are preferred. Lumber stakes may be used in compacted soils which prohibit effective use of live stakes. Stakes shall be 24 inches to 36 inches long. Steel reinforcing bar can be substituted only as specified below.

7. Bundles shall be placed in the trenches so that the end of two bundles shall overlap at least 1 foot. The overlap should be as long as necessary to permit staking as specified.

8. Bundles of wattling shall be staked through the center on approximately 30-inch centers. Place extra stakes on the downhill lip of the trench and through the bundles at each overlap of two bundles. Stakes can also be placed between rows of wattling to aid in revegetation.

9. All stakes shall be driven in to a firm hold, a minimum of 18 inches deep. Where soils are soft, longer stakes shall be used. Where soils are so compacted that 24-inch wooden stakes cannot be driven to 18 inches, 24-inch sections of 3/8-inch to 1/2-inch-diameter steel reinforcing bars may be used for staking.

10. Work shall proceed from the bottom of the slope to the top. Each row of wattling shall be covered with soil and packed firmly on the uphill side by tamping or walking on the wattling as the work progresses up the hill. The downhill lip of the wattling may be left exposed when staking and covering are completed.

11. Additional wattling shall be placed as necessary for stability in seeps or other wet areas. A slope bottom bench shall be placed below the slope as shown on Figure 5-2.

12. Figure 7-4 shows a typical wattling installation.

Slope Serration

The methods and materials for construction of a serrated slope are described below.

1. Slopes shall be serrated along contours by a dozer or tractor equipped with a special blade containing a series of 10-inch square grooves.

2. Serrations shall be approximately horizontal.

3. Loose material collected at ends of serrations shall be removed and the ends of the serrations blended into the natural ground surface.

4. Serration of slopes in rapidly weathering material shall be completed early in the summer to allow initial sloughing of material off the step faces prior to fall revegetation.

5. A slope bench shall be constructed at the bottom of the slope as shown on Figure 5-2.

Slope Terracing

1. Terraces shall be constructed to slope towards the face of the slope at 5 percent.

2. Terraces shall be a minimum of 6 feet wide.

3. Each terrace shall be provided with a drainage ditch or other improvement to prevent runoff from the terrace over the face of the slope. Ditches shall be sloped to downdrains or other improvements to remove drainage from the slope.

4. A slope bench shall be constructed at the bottom of the slope as shown on Figure 5-2.

5. A typical terraced slope is shown on Figure 7-5.

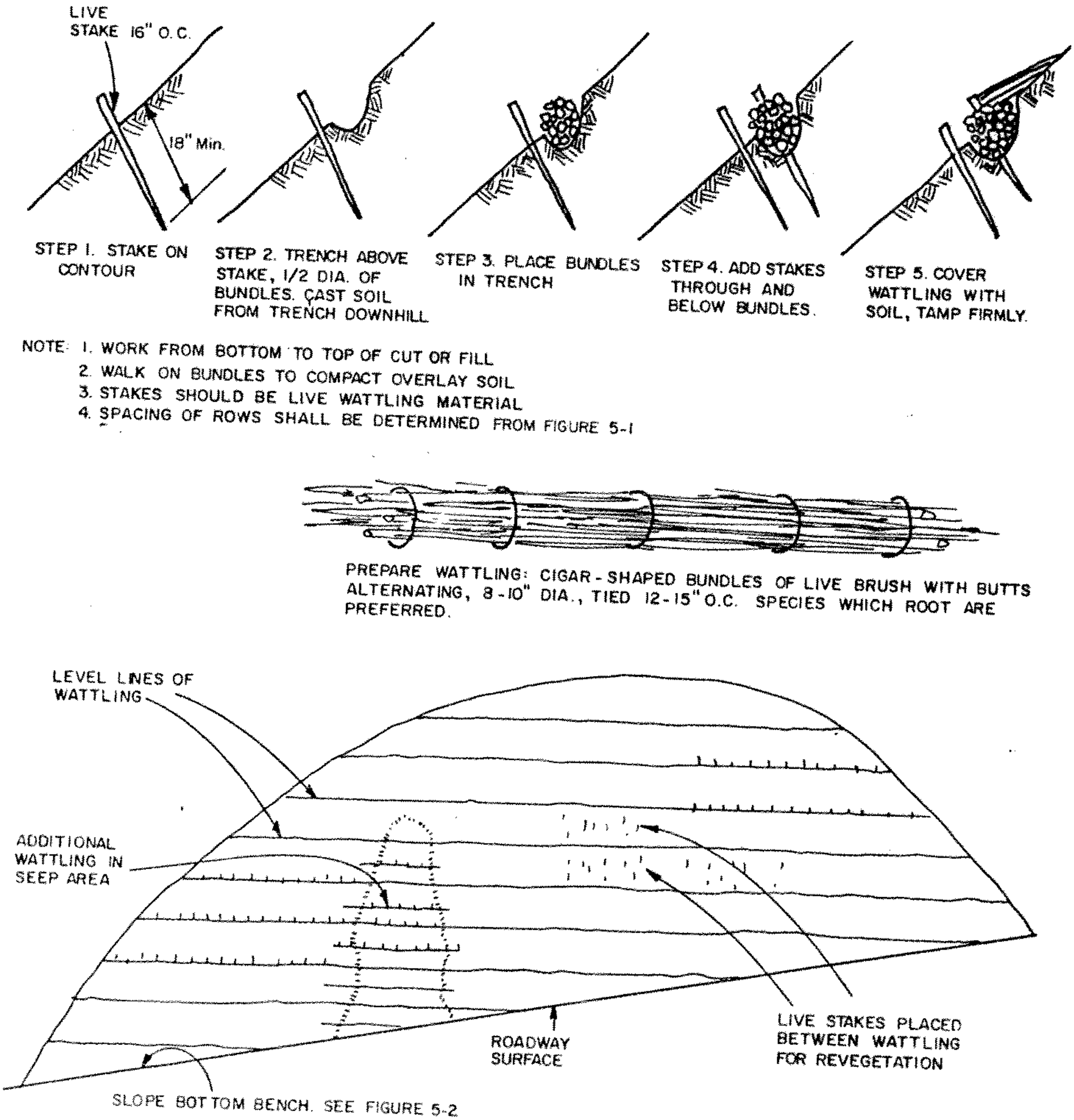
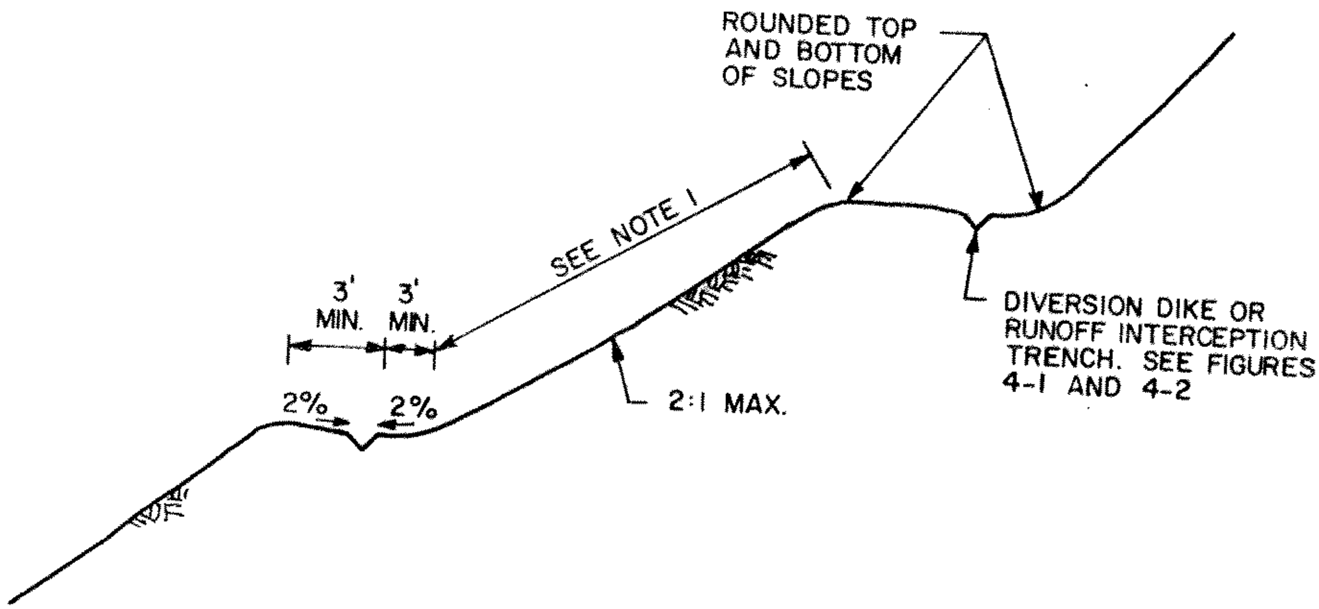


Figure 7-4 Wattling Installation



NOTE: 1. Maximum slope face length shall be determined from Figure 5-1

Figure 7-5 Slope Terracing

CHAPTER 8

REVEGETATION

This chapter describes revegetation of disturbed areas. Although the methods presented in previous chapters for temporary and permanent soil stabilization are effective means of reducing erosion, revegetation is virtually the only long-term means of preventing surface soils from being eroded and carried into surface waters. The methods presented herein are general. However, the design of individual revegetation plans should be specific and done by a qualified specialist. Revegetation plans shall be submitted to the County with the construction plan.

APPLICABILITY

The guidelines given herein apply to all disturbed sites.

METHODS AND MATERIALS

The following design guidelines for revegetation apply:

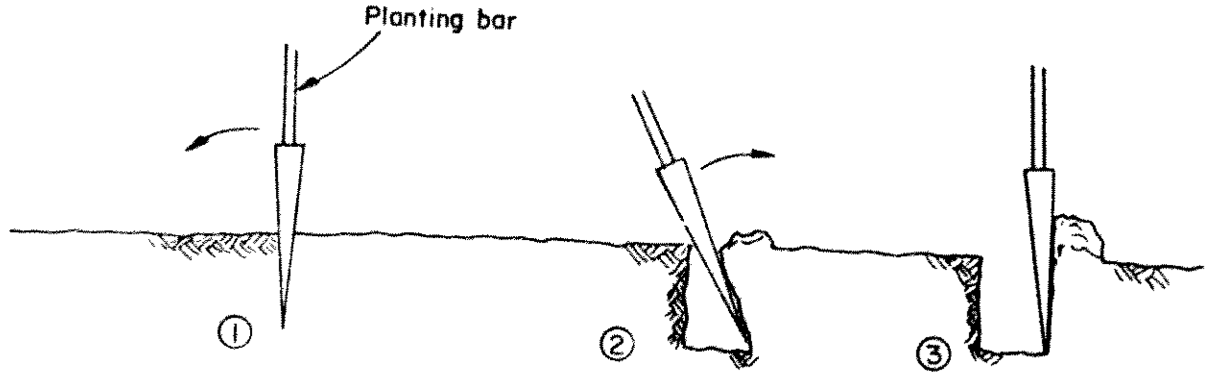
1. Revegetation shall be attempted only after slopes are physically stable. Soil may be stabilized using one of the methods listed in Chapters 6 and 7, and slopes shall be stabilized using one of the methods in Chapter 7.
2. Revegetation shall be initiated as soon as possible after construction has been completed. Temporary soil stabilization methods shall be maintained until vegetation is established.
3. All disturbed sites on the property shall be revegetated, regardless of time of disturbance or prior ownership.
4. Shrubs and vegetation used in revegetation shall match the vegetation existing on or near the site.
5. Native species are recommended for reasons of aesthetics and survival.
6. The revegetation plan shall consider local soils conditions, nutrients, precipitation, and temperature.

7. Planting shall be conducted in the spring or fall. The specific planting time shall be selected to maximize plant survival.

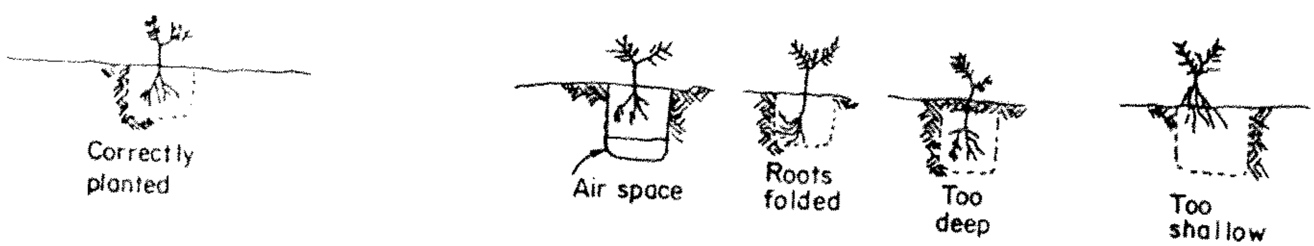
8. The revegetation plan shall include the design of an irrigation system where required to ensure survival of the plants.

9. The use of fertilizer for planting and maintenance shall be specified in the revegetation plan.

Figures 8-1 and 8-2 show recommended planting details for small shrubs.

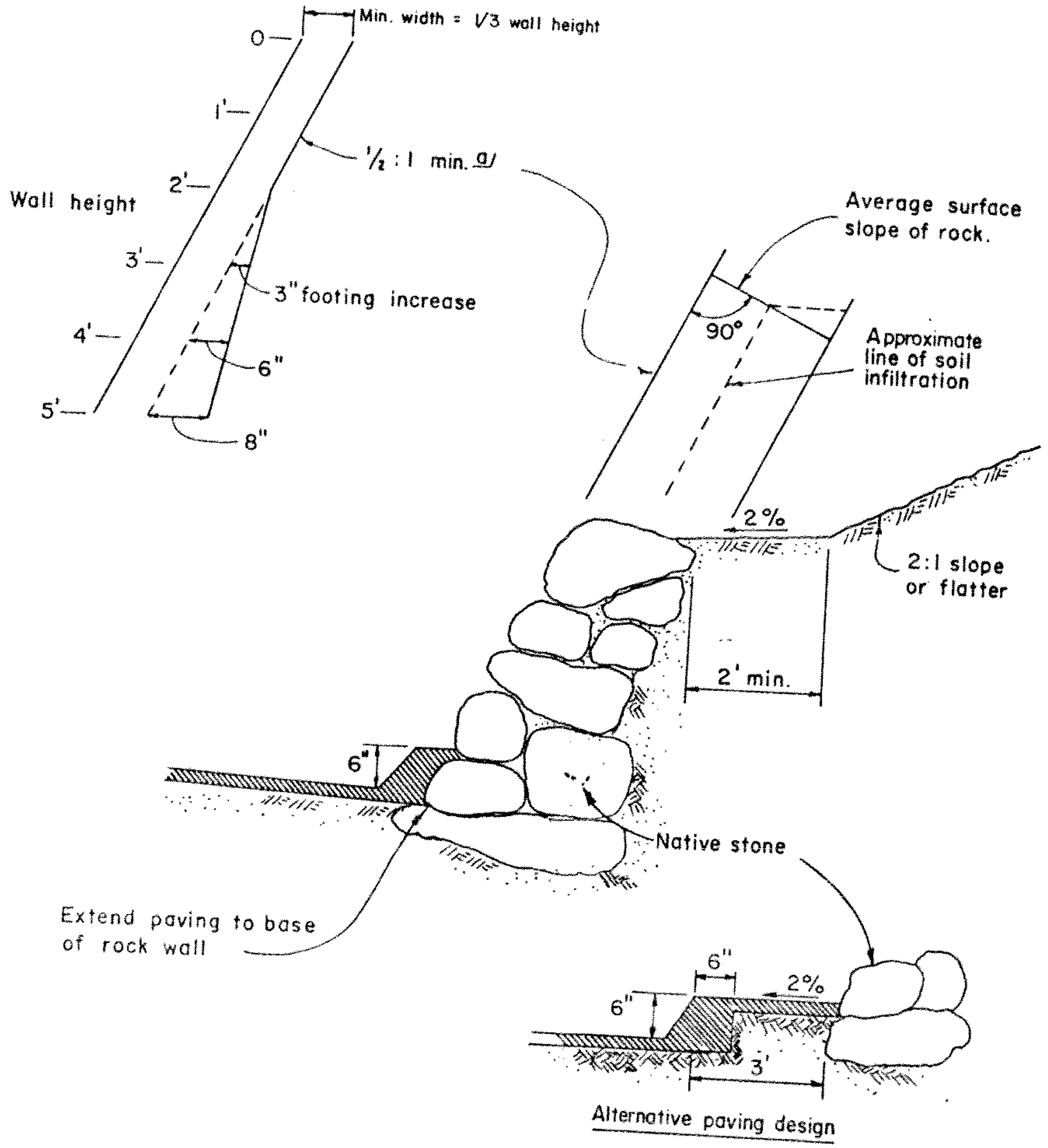


Preparation of planting hole using planting bar (Dibble)



Incorrectly planted

Figure 8-1 Planting Method



a/ The wall may vary from vertical to an angle of 1/2:1

Figure 7-1 Native Rock Retaining Wall