COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF WATER MANAGEMENT

EROSION AND SEDIMENT POLLUTION CONTROL PROGRAM MANUAL

April 15, 2000

BUREAU OF WATERSHED MANAGEMENT
DIVISION OF WATERWAYS, WETLANDS AND EROSION CONTROL

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT

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AUTHORITY: Pennsylvania Clean Stream Law (35 P.S. §691.1 et seq.) and regulations at 25 Pa. Code Chapter 102.

POLICY: It is the policy of the Department of Environmental Protection (DEP) to provide guidance and procedures for those engaged in earth disturbance activities on ways to minimize accelerated erosion and resulting sediment pollution to the waters of the Commonwealth.

PURPOSE: The purpose of this guidance is to tell those engaged in earth disturbance activities and in the preparation of erosion and sediment control plans how to comply with Chapter 102 rules and regulations.

APPLICABILITY: This guidance applies to all those engaged in the preparation of erosion and sediment control plans for earth disturbance activities in the Commonwealth of Pennsylvania.

DISCLAIMER: The guidance and procedures outlined in this document are intended to summarize existing requirements. The policies and procedures herein are not an adjudication or regulation. There is no intent on the part of DEP to give this document that weight or deference. The guidance and procedures merely summarize how and on what basis DEP will administer and implement its responsibilities with respect to erosion and sediment control on earth disturbance sites. DEP reserves the discretion to deviate from the guidance and procedures in this document if circumstances warrant.

PAGE LENGTH: 180 pages

LOCATION: Volume 34, Tab 6

DEFINITIONS: See 35 P.S. §691.1 and 25 Pa. Code Chapter 102 & 102.1.

FOREWORD

The various Best Management Practices (BMPs) described herein are primarily utilized during earth disturbances associated with land development and construction activities. Other special Best Management Practices for agricultural plowing or tilling activities which provide for the economic viability of farms, maintenance of the land, and protection of Pennsylvania waterways are described in the Natural Resources Conservation Services' ***Pennsylvania Soil and Water Conservation Technical Guide***. An overview of these Agricultural Best Management Practices is also provided in ***A Conservation Catalog Practices for the Conservation of Pennsylvania's Natural Resources*.** Persons conducting agricultural plowing or tilling activities are encouraged to review the practices described in the Catalog and contact their local County Conservation District or Natural Resources Conservation District office for more detailed planning information and assistance.

This manual lists various BMPs and design standards which are acceptable in Pennsylvania. BMPs, when designed according to these standards, and properly implemented and maintained, will achieve the regulatory standard of minimizing the potential for accelerated erosion and sedimentation. At the same time, their proper implementation will protect, maintain, reclaim and restore water quality and existing and designated uses of Commonwealth waters.

Alternate BMPs, not listed in this manual, that provide the same (or greater) level of protection, may also be used to attain the regulatory standard. It is incumbent on the person proposing the use of alternative BMPs to demonstrate their effectiveness with appropriate test results or other documentation.

BMPs that fail after installation must be repaired to function properly or be replaced by alternative BMPs that will serve the intended purpose. For example, if a skimmer in a basin or trap does not function as intended, it may need to be replaced by a perforated riser that does function as intended. Likewise, if unforeseen conditions occur on a site, and the installed BMPs are obviously not effective, then alternate BMPs must be designed and installed. The need for redesign will be determined on a case-by-case basis.

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EROSION AND SEDIMENT CONTROL PLAN CONTENT

The basic concept of providing effective, efficient and practical erosion and sediment control should be considered when determining the locations and types of Best Management Practices. All off-site surface water should be diverted away from areas to be disturbed, all site stormwater should be collected and conveyed to a sediment basin, sediment trap, or other BMP for sediment removal. Temporary stabilization should be provided for earth exposed areas where earthwork is delayed or stopped and permanent stabilization should ultimately be provided for all disturbed areas. Sediment removal treatment for water pumped from excavations may be needed. Access to the site and removal of mud from vehicle tires before vehicles exit onto existing paved areas may be required.

There are eleven factors that must be considered when developing an Erosion and Sediment Control Plan for earth disturbance activities other than agricultural plowing or tilling. They are:

1. ***The existing topographic features of the project site and the immediate surrounding area***. These features must be shown on a map or maps included with or part of the drawings. The scale of the map(s) must be large enough to clearly depict the topographic features and the contours must be at an interval that will adequately describe the topography of the site. Scales of 1 inch equals 50 feet or less, with 2-foot maximum contour intervals are recommended. The map(s) must include the location of the project with respect to roadways, municipalities, streams, watercourses, existing structures and other identifiable landmarks. Other information to be shown on the map(s) includes lakes, ponds, wetlands, floodplains and the type and extent of existing vegetation. A complete legend for any symbols that may be used on the drawings must also be included.

   The coverage of the map(s) must include enough of the surrounding area so those watercourses receiving runoff from the project area can be identified and evaluated for resistance to erosion. The scale of the map(s) and a north arrow must be clearly shown. These requirements also apply to all offsite disposal or borrow areas.

   In most applications, an erosion and sediment control plan will consist of two parts: a plan narrative and maps/drawings. Maps and drawings are used to show both the existing and proposed topography, as well as the construction details and maintenance details for the proposed Best Management Practices (BMPs). The narrative is used to document the design calculations for the BMPs.

   In addition to the topographic map, a location map is required that shows the relationship of the project to municipal boundaries and major highways. The location map may be included on the topographic map as an insert or may be included as a separate sheet in the narrative report. A reprint or a copy of a portion of a 7½ minute USGS quadrangle map is recommended for this purpose. The name of the USGS quadrangle map must be included on the location map. For permit applications, a location map reprinted or copied from USGS quadrangle maps is required.

2. ***The types, depth, slope, locations, and limitations of the soils***. The locations of the soils may be delineated on the map or drawing discussed above, or on a separate map of the site. A photocopy of a portion of the county soil survey on which the proposed project can be clearly shown may also be used. The types, depth, slope and limitations of the soils may be included in the narrative portion of the plan or included on the drawings/maps. Data on the physical characteristics of the soils, such as their texture, resistance to erosion and suitability for intended use is to be included in the narrative report. This information is available in soil survey reports, published by the USDA, Natural Resources Conservation Service (formerly Soil Conservation Service), in cooperation with the Pennsylvania State University College of Agriculture and others. The reports are available from the county conservation districts. The means to address the identified soils limitations must be included on the drawings. For example, a note to use only certain areas as

borrow areas for fill for sediment basins or traps, or special fertilization requirements for portions of the project, etc.

3. ***The characteristics of the earth disturbance activity, including the past, present, and proposed land uses and the proposed alteration to the project site***. The proposed alteration to the project area and the limits of the project area must be shown on a map(s) or drawings. This map should be at the same scale as the original topographic map. The use of the original contour map as a base map, with the new contours superimposed and identified in the legend, is recommended to depict the alteration to the area. Such information as the limits of clearing and grubbing, the areas of cuts and fills and the locations of roads, paved areas, buildings and other structures is to be included. Final contours of the project area at an interval that will adequately describe the topography of the site must be included on this map(s). Separate maps/drawings, or inserts on the main project drawings must be included for off site borrow or disposal areas which are part of the project. These drawings or inserts must include all information required on the main drawings. A legend that describes all of the alterations and BMPs to be used for erosion and sediment control must be shown on the map(s) or drawings.

4. ***The amount of runoff from the project area and the upstream watershed area.*** The area draining to a particular BMP must be determined. In some instances the drainage area will increase or decrease as the site grading proceeds. In such cases, the maximum drainage area to the BMP must be used to determine the design capacity. Design capacity requirements are included in the discussion for the various BMPs.

   An analysis must be included in the narrative showing the impact that runoff from the project site will have on existing downstream watercourses' resistance to erosion. Design computations for appropriate protective measures for downstream watercourses must be included if necessary.

5. ***The location of waters of the Commonwealth which may receive runoff within or from the project site and their classification pursuant to Chapter 93***. All streams in Pennsylvania are classified based on their designated and existing water uses and water quality criteria. Designated uses for commonwealth waters are found in 25 Pa. Code §§93.9a through 93.9z. Existing uses of Commonwealth Waters are usually the same as the designated use, except where information has been provided to or obtained by the Department which indicates that a particular water body actually attains a more stringent water use than the designated use. Existing uses are protected pursuant to 25 Pa. Code §93.4a through §93.4c. If the runoff from a project area discharges to a stream that is classified for Special Protection, more stringent criteria are used to design the BMPs for that site. The criteria are found in Chapter 102 and are repeated here for emphasis:

   (i) Special Sediment Basin Requirements

      (a) Principal spillways shall be designed to skim water from the top 6 inches of the dewatering zone, or shall have permanent pools greater than or equal to 18 inches deep.

      (b) The basin shall be designed with a flow length to basin width ratio of 4:1 or greater.

      (c) The basin shall be designed such that it dewaters in no less than 4 days and no more than 7 days when at full capacity.

   (ii) Channels, collectors, and diversions shall be lined with permanent vegetation, rock, geotextile, or other non-erosive material.

   (iii) Temporary BMPs that divert or carry surface water shall be designed to have a minimum capacity to convey the peak discharge from a 5-year frequency storm.

(iv) Upon completion or temporary cessation of the earth disturbance activity, or any stage thereof, the project site shall be immediately stabilized.

(v) The department or County Conservation District may approve alternate BMPs that will maintain and protect existing water quality and existing and designated uses.

6. ***A narrative description of the location and type of perimeter and on site BMPs used before, during, and after the earth disturbance activity.***

7. ***A sequence of BMP installation and removal in relation to the scheduling of earth disturbance activities, prior to, during, and after earth disturbance activities.***

   These two factors are usually combined and are presented as a narrative list of temporary or permanent BMPs to be installed and a schedule for their installation and removal as related to the various phases of the project. A temporary BMP such as silt fence is often installed as a first item of work on a given site. Other BMPs are constructed when needed to accommodate the planned sequence of project installation. The narrative must include a complete schedule of installation and removal of erosion control BMPs as they relate to the various phases of earthmoving activities. Appropriate BMPs for sediment pollution control must be in place before earth disturbance occurs within a given drainage area. All of the steps to be taken from the initial site clearing through the final stabilization of the site must be included. The information required by items 6 and 7 is to be shown on the plan drawings.

8. ***Supporting calculations.*** All design information for all BMPs must be included in the narrative report. The information will vary according to the BMP, but may include such information as the drainage area, anticipated flow rate, velocity and the proposed method of stabilization. The STANDARD WORKSHEETS included in this publication give guidance for the design calculations and information required. Plan preparers are not required to use the STANDARD WORKSHEETS, but must furnish the information indicated.

9. ***Plan drawings.*** The locations of the BMPs must be shown on the map(s) described earlier. A legend, describing all symbols must be included on all plan maps or drawings. All construction details and specifications for the facilities must be included on the drawings. Typical sketches may be used; however, these sketches must provide sufficient detail to show critical dimensions and construction details. Standard Construction Details may be copied from those in this manual and inserted into the erosion and sediment control plan drawings of specific projects. Proposed new contours must tie into existing contours.

10. ***A maintenance program which provides for inspection of BMPs on a weekly basis and after each measurable rainfall event, including the repair of BMPs to ensure effective and efficient operation.*** A maintenance program for both the temporary and permanent erosion and sediment control BMPs, including disposal of materials removed from the BMPs or project area, must be included in the narrative. The maintenance program must include a schedule for inspection of the various BMPs that provides for inspection after each measurable runoff event as well as on a weekly basis. The type of maintenance, such as cleanout, repair, replacement, regrading, restabilizing, etc. for each of the BMPs is to be included in the plan. For sediment basins, the elevation corresponding to top of sediment storage level must be specified and a means to identify this elevation must be identified. The means of disposal of the materials removed from the BMPs must be specified. If materials removed from the BMPs are to be removed from the project area, the site and method of disposal must be indicated. The information required by item 10 is to be shown on the plan drawings.

11. ***Procedures which ensure that the proper measures for the recycling or disposal of materials associated with or from the project site will be undertaken in accordance with Department regulations.*** Individuals responsible for earth disturbance activities must ensure that proper

mechanisms are in place to control waste materials. Construction wastes include, but are not limited to, excess soil materials, building materials, concrete wash water, sanitary wastes, etc. that could adversely impact water quality. Measures should be planned and implemented for housekeeping, materials management, and litter control. Wherever possible, recycling of excess materials is preferred, rather than disposal. A note requiring recycling of waste materials, where feasible, should be added to the drawings.

DESIGN DISCHARGE CAPACITY

Numerous methods are available to determine discharge capacity. Two methods, the SCS (now NRCS) Technical Release 55 – Urban Hydrology for Small Watersheds and the Rational Equation are mentioned in this handbook because of their popularity and simplicity. Other methods are also acceptable.

SCS TR-55 Urban Hydrology for Small Watersheds – Technical Release 55 (TR-55) presents simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs. These procedures are applicable in small watersheds, especially urbanizing watersheds, in the United States. Limits: NRCS type distributions, 24-hour duration rainfall, 10 subwatersheds, minimum 0.1 hour and maximum 10-hour time of concentration.

Designers are referred to http://www.ncg.nrcs.usda.gov/tech_tools.html to download the text version or the computer version of TR-55.

On pages B-4 through B-9 of the TR-55 publication, 24-hour rainfall amounts for 2, 5, 10, 25, 50, and 100 year frequency storms are shown for the continental United States. Data from these maps was used to develop Table 1 **(Note: Table 1 is not to be used to determine rainfall intensity "I" for the rational equation.)**

Due to the irregular topography, the maximum sheet flow length to be used for unpaved areas in Pennsylvania is 150 feet with a most likely maximum length of 50-100 feet. The theoretical maximum length of 300 feet is achieved only in unique situations such as uniformly sloped paved parking lots. The maximum flow path length (L) for any disturbed area is 50 feet. The sheet flow equation is not used for newly graded fills or cut slopes. Runoff from these areas is considered shallow concentrated flow.

Weather Bureau Technical Paper 40, U.S. Department of Commerce, Hershfield, D.M. - Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. T.P. 40 is out of print; however, it is the basis for the maps in TR-55 described above and for the following table.

TABLE 1
Pennsylvania Rainfall By Counties
(For Use With Technical Release 55 - Urban Hydrology for Small Watersheds)

COUNTY	24 HR RAINFALL FOR VARIOUS FREQUENCIES							COUNTY	24 HOUR RAINFALL FOR VARIOUS FREQUENCIES						
	1 yr.	2 yr.	5 yr.	10 yr.	25 yr.	50 yr.	100 yr.		1 yr	2 yr.	5 yr.	10 yr.	25 yr.	50 yr.	100 yr.
Adams	2.5	3.0	3.9	4.8	5.3	6.0	6.7	Lackawanna	2.4	2.9	3.9	4.7	5.2	5.8	6.5
Allegheny	2.3	2.6	3.3	3.9	4.4	4.9	5.2	Lancaster	2.5	3.1	4.1	5.0	5.5	6.2	6.9
Armstrong	2.3	2.6	3.3	3.9	4.4	4.9	5.2	Lawrence	2.2	2.5	3.2	3.7	4.2	4.7	4.8
Beaver	2.3	2.6	3.2	3.8	4.3	4.7	4.9	Lebanon	2.5	3.0	4.0	4.8	5.3	6.0	6.7
Bedford	2.4	2.8	3.6	4.5	4.9	5.5	6.0	Lehigh	2.5	3.1	4.1	4.9	5.5	6.1	6.9
Berks	2.5	3.1	4.1	4.9	5.5	6.1	6.9	Luzerne	2.4	2.9	3.9	4.7	5.2	5.8	6.4
Blair	2.4	2.8	3.6	4.3	4.8	5.3	5.8	Lycoming	2.4	2.8	3.6	4.3	4.9	5.5	5.9
Bradford	2.3	2.8	3.6	4.2	4.9	5.4	5.8	McKean	2.2	2.6	3.3	3.9	4.4	4.8	5.2
Bucks	2.5	3.3	4.2	5.0	5.8	6.4	7.2	Mercer	2.2	2.5	3.2	3.7	4.2	4.7	4.8
Butler	2.3	2.6	3.3	3.8	4.3	4.8	5.0	Mifflin	2.4	2.8	3.6	4.4	4.8	5.5	6.0
Cambria	2.4	2.8	3.4	4.2	4.8	5.2	5.7	Monroe	2.5	3.0	4.0	4.8	5.4	6.1	6.8
Cameron	2.3	2.7	3.4	4.0	4.5	5.0	5.4	Montgomery	2.6	3.2	4.2	5.0	5.7	6.4	7.1
Carbon	2.5	3.0	4.0	4.8	5.3	6.0	6.7	Montour	2.4	2.9	3.7	4.5	5.0	5.6	6.2
Centre	2.3	2.8	3.6	4.3	4.8	5.4	5.8	Northampton	2.5	3.1	4.1	4.9	5.5	6.1	6.9
Chester	2.6	3.2	4.2	5.0	5.6	6.3	7.1	Northumberland	2.4	2.9	3.8	4.6	5.0	5.7	6.3
Clarion	2.2	2.6	3.3	3.7	4.4	4.8	5.1	Perry	2.4	2.9	3.8	4.6	5.0	5.7	6.3
Clearfield	2.3	2.7	3.5	4.0	4.6	5.1	5.5	Philadelphia	2.6	3.3	4.3	5.0	5.7	6.4	7.3
Clinton	2.3	2.8	3.6	4.2	4.8	5.3	5.7	Pike	2.6	3.0	4.0	4.9	5.4	6.1	7.0
Columbia	2.4	2.9	3.7	4.6	5.1	5.7	6.2	Potter	2.3	2.7	3.4	4.0	4.6	5.0	5.4
Crawford	2.2	2.5	3.1	3.6	4.2	4.7	4.8	Schuylkill	2.5	3.0	3.9	4.7	5.3	5.9	6.5
Cumberland	2.4	2.9	3.8	4.7	5.1	5.8	6.4	Snyder	2.4	2.9	3.7	4.5	5.0	5.6	6.1
Dauphin	2.5	2.9	3.9	4.8	5.2	5.9	6.5	Somerset	2.4	2.6	3.5	4.3	4.8	5.3	5.8
Delaware	2.6	3.3	4.2	5.0	5.7	6.4	7.3	Sullivan	2.4	2.8	3.7	4.4	4.9	5.5	6.0
Elk	2.3	2.7	3.4	3.9	4.5	4.9	5.3	Susquehanna	2.4	2.9	3.8	4.5	5.0	5.7	6.2
Erie	2.1	2.5	3.1	3.6	4.1	4.6	4.7	Tioga	2.3	2.7	3.5	4.2	4.7	5.1	5.6
Fayette	2.4	2.7	3.4	4.1	4.6	5.1	5.6	Union	2.4	2.8	3.7	4.4	4.9	5.5	6.0
Forest	2.2	2.6	3.3	3.8	4.3	4.8	5.1	Venango	2.2	2.5	3.3	3.7	4.2	4.7	4.9
Franklin	2.4	2.9	3.8	4.8	5.1	5.9	6.4	Warren	2.2	2.5	3.2	3.8	4.3	4.8	4.9
Fulton	2.4	2.8	3.7	4.6	4.9	5.6	6.2	Washington	2.3	2.6	3.3	3.9	4.4	4.9	5.2
Greene	2.3	2.6	3.4	3.9	4.4	4.9	5.2	Wayne	2.4	2.9	3.9	4.7	5.2	6.0	6.7
Huntingdon	2.4	2.8	3.7	4.6	4.9	5.5	5.9	Westmoreland	2.3	2.7	3.4	4.0	4.6	5.0	5.4
Indiana	2.3	2.7	3.4	4.0	4.5	5.0	5.4	Wyoming	2.4	2.9	3.8	4.5	5.0	5.6	6.2
Jefferson	2.3	2.6	3.4	3.9	4.5	4.9	5.3	York	2.5	3.1	4.1	4.9	5.5	6.2	6.9
Juniata	2.4	2.9	3.7	4.5	4.9	5.6	6.1								

THE RATIONAL EQUATION is a method for estimating peak flow rates in small watersheds (200 acres or less). The method uses or incorporates the following assumptions:

(1) That rainfall occurs uniformly over the drainage area and that the design average rainfall intensity occurs over a period of time equal to the time of concentration of the drainage area.

(2) That the drainage area's time of concentration is the travel time for water to flow from the furthermost (hydraulically) point of the watershed to the downstream point of interest.

(3) That the frequency of runoff equals the frequency of rainfall used in the equation.

$$Q = C\ I\ A$$

Where:
Q = Peak runoff rate in cubic feet per second (cfs)
$C = C_w$ = Runoff coefficient (dimensionless)
(See following steps for explanation of C_w)
I = Rainfall intensity (inches/hour)**
A = Drainage area (acres)

**** Note: Do not use Table 1 to determine rainfall intensity "I" for the rational equation**

PROCEDURE (Standard Worksheets 19 and 20 are recommended for organizing and documenting the parameters used):

Runoff Coefficient (C): Select an appropriate runoff coefficient "C" from Table 2. The coefficient chosen must represent the maximum runoff conditions during site construction (not necessarily the pre- or post-construction conditions). For drainage areas with mixed land uses, compute a weighted average (C_w) of the "C" values for the individual subareas according to the following formula:

$$C_w = \frac{(C_1 \times A_1) + (C_2 \times A_2) + (C_n \times A_n)}{A\ (\text{total})}$$

TABLE 2
Runoff Coefficients for Rational Equation

Land Use	C Min.	C Max.	Approximate CN Range	Percent Impervious
Construction Sites <30% slope				
Bare packed soil, smooth	.30	.60	60-90	0
Bare packed soil, rough	.20	.50	66-77	0
Wooded Areas				
Heavy Ground Litter	.10	.20	55-70	0
Light Ground Litter	.15	.30	60-73	0
Steep Rocky Slopes	.20	.50	66-77	0
Reverting Farmland/Meadow				
100% Vegetative Cover	.10	.20	48-65	0
80% Vegetative Cover	.15	.30	56-70	0
50% Vegetative Cover	.25	.60	60-80	0
Open Grass-Covered Areas				
80% + Covering	.10	.20	61-74	1
50-80% Covering	.20	.50	69-79	1
Rural Areas				
1 home per 10 acres	.15	.30	74-82	5
Residential				
1 Acre Lots	.15	.40	68-79	20
½ Acre Lots	.25	.50	70-80	25
¼ Acre Lots	.40	.60	75-83	36
Multiunits (attached)	.60	.75	85-90	65
City Business Area				
75% Area Covered	.50	.70	88-91	72
Dense Development	.70	.95	92-94	85
Industrial Area				
Light to Medium Density	.50	.80	88-91	70
High Density	.60	.95	92-94	70
Streets and Parking Lots				
Asphalt	.70	.95	98	95
Concrete	.80	.95	98	95

Rainfall Duration Frequency Tables for Pennsylvania - This 1983 publication was prepared by the Department. The rainfall data provided in this publication was compiled from the Department's Research Publication Number 70 "Analysis of Rainfall- Duration-Frequency for Pennsylvania" (Kerr et. al., 1970). Techniques are presented for quick and accurate estimates of the mean annual rainfall (2.33 years) and 5, 10, 25, 50, and 100 year amounts at any location in Pennsylvania for both 1-hour and 24-hour durations. Techniques are also provided to compute rainfall depths for shorter durations of 5, 10, 15, and 30 minutes and rainfall intensity for the desired frequency.

The 1-hour rainfall amounts generated by this method may be used for determining the Rainfall Intensity "I" value in the Rational Equation. The slight difference between the 2.33 and 2-year storms is considered negligible

RAINFALL INTENSITY (I): Determine the 1-hour rainfall amount from the "Rainfall Duration Frequency Tables for Pennsylvania" or other standard rainfall prediction source.

TIME OF CONCENTRATION

Calculate time of concentration (travel time for the hydraulically longest watershed flow path).

Sheet Flow (Overland Flow)

Travel time for very smooth uniform paved areas with sheet flow, up to a maximum of 150 feet, may be estimated by the use of the formula:

$$T_{c\,(\text{sheet flow})} = \left[\frac{2\,(L)\,(n)}{3\,(s)^{0.5}} \right]^{0.4673}$$

Where:
- T_c = Time of concentration (minutes)
- L = Length of flow path (ft)
- s = Surface slope (ft/ft)
- n = Roughness coefficient (See Table 3)

NOTE: The maximum flow path length (L) for any disturbed area is 50 feet. Do not use the sheet flow equation for newly graded fills or cut slopes. Runoff from these areas is considered shallow concentrated flow.

TABLE 3
Roughness Coefficient for T_c Computations

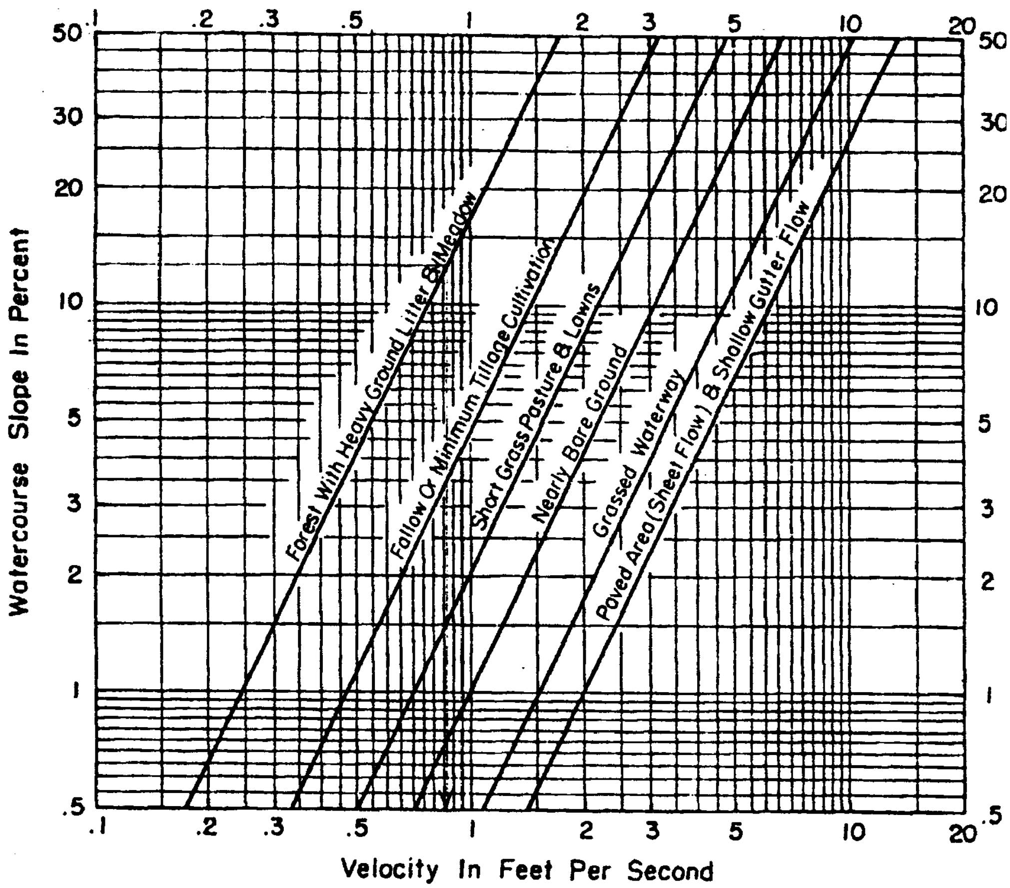
n	Type of Cover
0.02	Smooth pavement
0.1	Bare packed soil
0.3	Poor grass cover
0.4	Average grass cover
0.8	Dense grass or thick brush cover

Shallow Concentrated Flow - That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated. The average velocity for shallow concentrated flow may be determined from Figure 1, in which average velocity is a function of slope and type of watercourse.

Channel Flow - For open channels, calculate flow velocities by use of Manning's equation as detailed on page 17 of this manual. Assume full bank conditions.

Time of Concentration - Add all flow times to determine time of concentration (T_c) in minutes.

FIGURE 1
Nomograph to Determine Shallow Concentrated Flow Velocity



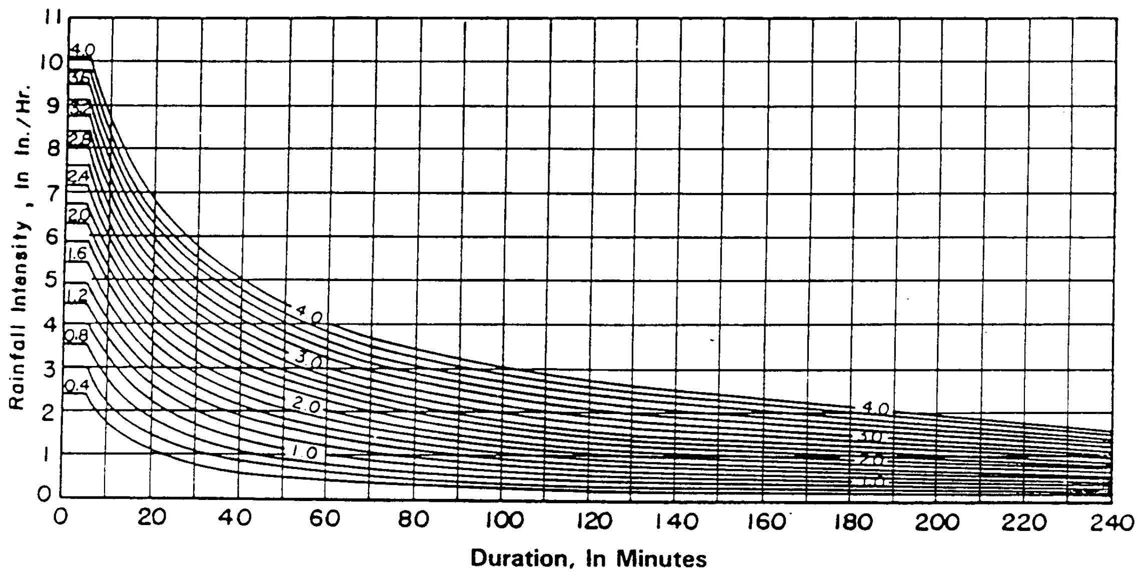
Use Figure 2 to determine Rainfall Intensity

If the Penn State "Storm Intensity-Duration-Frequency Charts" (developed for PA DOT and the Federal Highway Administration) are used in lieu of Figure 2, provide a copy of the location map (with the project location shown) and the appropriate regional chart.

RAINFALL INTENSITY COMPUTATION*

The following figure contains generalized rainfall intensity-duration curves to be used especially for storm durations less than 60 minutes. A one-hour storm must be supplied from the previously described rainfall estimating procedure and entered at duration 60 minutes in the following Figure. From the intersection of the 1-hour storm intensity and the 60-minute ordinate the user follows the path of the nearest curve to the duration of the design storm, then moves horizontally to the y-axis to read the corresponding storm intensity in inches/hour. Curve numbers correspond to 1-hr. values of rainfall or supply indicated by respective curves; all points on the same curve are assumed to have the same average frequency of occurrence. From *Engineering Manual* by Corps of Engineers, U.S. Army.

FIGURE 2
Standard Rainfall Intensity-Duration Curves



Example: Given a 1-hour storm of 2.5 in./hr., find the 30-minute intensity for the same storm recurrence frequency. Start at 60-minute duration and 2.5 in./hr. intensity, move along curves to 30 minutes, and read the 30-minute intensity as 3.9 in./hr.

*Reference: Research report “Recommended Hydrologic Procedures for Computing Urban Runoff from Small Watersheds in Pennsylvania”, Penn State University, January 1982.

DRAINAGE AREAS - Determine the drainage area in acres. Since drainage areas often change during grading operations, the area is the maximum during construction area tributary to the facility in question. This will not necessarily be either the pre- or post-grading drainage areas.

Perform the calculations to determine the peak flow rate (cfs) for each desired frequency storm.

SAMPLE COMPUTATION

In this example, the peak runoff from a ten acre watershed (6.5 acres wooded and 3.5 acres in meadow) above a proposed temporary diversion channel will be calculated. The channel is 1000 feet long, and the longest flow path above the channel is 435 feet. The slope above the channel is 8%. The proposed channel is trapezoidal, 2 foot deep and 2 feet wide at the bottom with 2:1 (H:V) side slopes. The average bed slope is 0.01 ft/ft, and a grass lining with a temporary liner is provided.

Determine the Weighted Runoff Coefficient (C_w).

Although 8% is a fairly steep slope, the coefficient for the wooded portion of the watershed would not fall within the "Steep Rocky Slopes" range on Table 2. The forest is mature, so ground litter is light. From the soils map, it is determined that the predominant soil type is poorly drained. Therefore, the coefficient is weighted toward the maximum value. A value of 0.25 is chosen for the wooded area. The meadow is well-vegetated, so a value of 0.20 is chosen.

The value of $C \times A$ is calculated to be 1.63 for the wooded area (0.25×6.5), and 0.70 for the meadow (0.2×3.5). The sum of $C \times A$ values is thus 2.33. The Weighted Runoff Coefficient (C_w) is determined to be 0.23 by dividing 2.33 by 10 (total number of acres).

Calculate the Time of Concentration (T_c).

Sheet Flow - The maximum sheet flow length is not appropriate due to the steepness of the watershed area. Therefore, 100 feet is selected. A value of 0.3 is chosen for the "n" value due to the poor grass cover in the wooded area (Table 3). By plugging these figures into the Overland Flow equation, we can calculate a travel time of 7.32 minutes.

Shallow Concentrated Flow - Since only 100 feet of the 435' flow path is sheet flow, the remainder (335') is considered shallow concentrated. On Figure 1, the watercourse slope of 0.08 ft/ft is located along the left hand side. Following a horizontal line to the intersection with the "Short Grass Pasture and Lawns" line, the average velocity (2.0 fps) is read along the bottom. The travel time for this distance (2.79 minutes) is determined by dividing the flow length (335') by the average velocity. ($335/2 \div 60$ seconds per minute = 2.79 minutes)

Channel Flow - In this portion of the calculation, the proposed channel dimensions are used to estimate the travel time within the temporary channel. Using Manning's equation (see Channel Design Section) the flow velocity within the channel is calculated to be 3.95 fps. By dividing the length of the channel (1,000 ft) by the average velocity, the travel time for this segment is determined to be 4.22 minutes ($1000/3.95 \div 60$ seconds per minute).

Total Time of Concentration (T_c) is the sum of the sheet flow, shallow concentrated, and channel flow.(7.32 + 2.79 + 4.22 = 14.33 minutes)

Determine Rainfall Intensity (I)

In this example, the site is located near Dauphin, Pa, in the northeast corner of the Harrisburg West 7 ½ minute quadrangle. Using Plate 1 in the "Rainfall Duration Frequency Tables for Pennsylvania", the 1-hour duration and 2.33-year frequency rainfall depth is found to be 1.3 inches.

Enter Figure 2 with a rainfall depth of 1.3" and a time of concentration of 14 minutes. Read a rainfall intensity of 3.5 in/hr.

Calculate the Peak Runoff Rate for a 2-year frequency storm using the Rational Equation:

$$Q = C \times I \times A$$
$$Q_2 = 0.23 \times 3.5 \times 10 = 8.1 \text{ cfs}$$

If this had been proposed as a permanent channel, the ten-year frequency rainfall depth would be required. Plate No. 1 shows the Harrisburg West quadrangle to be in Region III. Referring to Table 3 (in the "Rainfall Duration Frequency Tables for Pennsylvania"), and using a mean annual rainfall of 1.30, read a ten-year rainfall of 2.13".

Determination of Time of Concentration (T_c) Using Standard Worksheet #19

OVERLAND FLOW

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME - T_{of} (minutes)
DC-1	100	0.3	0.08	7.32

$$T_{of} = \left[\frac{2\ (\ L\ )\ (n)}{3\ (\ s\ )^{0.5}} \right]^{0.4673}$$

Refer to Table 3 for Roughness Coefficient "n)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME - T_{sc} (minutes)
DC-1	335	Meadow	0.08	2.0	2.79

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME-T_{ch} (minutes)	T_c* (minutes)
DC-1	1,000	12	0.01	10.9	1.1	0.04	3.95	4.22	14.33

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)
DC-1	2.0	2:1	2:1	2.0	10.0

* T_c = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

Determination of Peak Runoff (Q) Using the Rational Formula and Standard Worksheet #20

DETERMINE WATERSHED "C" VALUE

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DC-1	A	Woods	0.25	6.5	1.63	
	B	Meadow	0.20	3.5	0.70	
	Total			10.0	2.33	.23

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	R_2	R_{10}	I_2	I_{10}
DC-1	14.33	1.3		3.5	

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C VALUE	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_{10} (cfs)
DC-1	0.23	3.5	10.0	8.1	

CHANNEL DESIGN

GENERAL - The purpose of this chapter is to provide plan preparers with methods and procedures, examples, work forms and references to other commonly applied methods to design channels. Methods listed or referenced in this chapter are generally considered to be the most commonly used methods and procedures in the field of erosion and sediment control. However, the listed or referenced materials are not all inclusive and the Department will, on a case by case basis, accept other methods and procedures that are correctly selected and applied by persons qualified and/or licensed to perform such computations. The Department encourages the use of methods and procedures listed or referenced in this manual. Such use will facilitate review of erosion and sediment pollution control plans by the Department.

Channels are used for several purposes. They may be used to collect runoff from disturbed areas and convey it to a sediment removal facility prior to discharge into waters of the Commonwealth. They may be used to divert runoff from upslope undisturbed areas and convey it around disturbed areas. Temporary berms constructed on sloping ground to convey sediment laden water to sediment traps or basins should be designed and stabilized as temporary channels. They may also be used to convey discharges from sediment removal facilities or stormwater outfalls to waters of the Commonwealth. In steep slope situations (bed slope $\geq$ 10%) consideration should be given to use of a slope pipe. See Standard Construction Detail # 27

Design temporary channels to convey either 1.6 cfs/acre or the calculated peak discharge from a 2-year frequency storm event. In Special Protection watersheds, design temporary channels to convey 2.25 cfs/acre or the peak discharge from a 5 year frequency storm. Design all permanent channels to convey either 2.75 cfs/acre or the calculated peak discharge from a 10-year storm event. If the Rational method is used, Standard Worksheets 19 & 20 are recommended for determination of the required capacity (Q_r).

Designs for temporary and permanent channels must include calculations which clearly demonstrate that the channels have sufficient capacity to safely convey the design flows to the points of discharge and that the channel beds and side slopes will be stable. Standard Worksheet 21 is recommended for this purpose.

Align all channels and berms so as to provide positive drainage throughout. Sharp turns, high angles of confluence, and very low gradients (< 1 % bed slope) should be avoided wherever possible. Channels that discharge to sediment traps or basins must have a suitable erosion resistant lining in place before they are used if the design shear stress exceeds those listed in Table 6. All other channels must have an erosion resistant lining in place before they are used. The permissible velocity design method may be used for linings of channels with bed slopes less than 10% and the allowable shear method is acceptable for all channel bed slopes. Use of rock check dams is not an acceptable alternative to a properly designed channel lining. Wherever it is necessary for construction vehicles to cross one of these channels, an adequately sized temporary-crossing pipe, clean rock fill, and clean rock approaches should be provided.

The permissible velocity or allowable shear stress used for lining design should be sustainable for a reasonable period of time. Using a manufacturer's permissible velocity or allowable shear stress that is only sustainable for a short period of time is not recommended; therefore the long term values should be used for design purposes.

Manning's Equation - Flow capacity and velocity in open channels are typically computed by use of Manning's equation. Use of this equation (including derivative forms) is recommended by the Department:

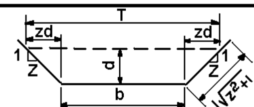
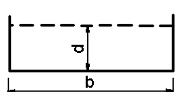
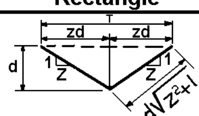
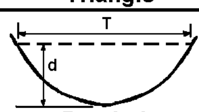
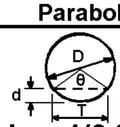
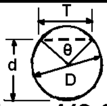
$$Q = \frac{1.486}{n} a\, r^{2/3}\, s^{1/2}$$

and

$$V = \frac{1.486}{n} r^{2/3}\, s^{1/2}$$

Where:
- Q = Quantity of flow (cfs)
- V = Velocity (fps)
- n = Manning's coefficient of roughness
- a = Cross-sectional area of channel (sqft)
- p = Wetted perimeter of channel (ft)
- r = Hydraulic radius of channel (ft) = a/p
- s = Slope of channel bottom (ft/ft)

TABLE 4
Geometric Elements of Channel Sections

Section	Area a	Wetted Perimeter P	Hydraulic Radius r	Top Width T
 Trapezoid	$bd + zd^2$	$b + 2d\sqrt{z^2+1}$	$\dfrac{bd + zd^2}{b + 2d\sqrt{z^2+1}}$	$b + 2\,zd$
 Rectangle	bd	$b + 2d$	$\dfrac{bd}{b + 2d}$	b
 Triangle	zd^2	$2d\sqrt{z^2+1}$	$\dfrac{zd}{2\sqrt{z^2+1}}$	$2\,zd$
 Parabola	$\dfrac{2}{3}dT$	$T + \dfrac{8d^2}{3T}$ 1	$\dfrac{2\,dT^2}{3\,T^2+8\,d^2}$ 1	$\dfrac{3\,a}{2\,d}$
 Circle < 1/2 full 2	$\dfrac{D^2}{8}\left(\dfrac{\pi\theta}{180} - \sin\theta\right)$	$\dfrac{\pi D\theta}{360}$	$\dfrac{45D}{\pi\theta}\left(\dfrac{\pi\theta}{180} - \sin\theta\right)$	$D\sin\dfrac{\theta}{2}$ or $2\sqrt{d(D-d)}$
 Circle > 1/2 full 3	$\dfrac{D^2}{8}\left(2\pi - \dfrac{\pi\theta}{180} + \sin\theta\right)$	$\dfrac{\pi D(360-\theta)}{360}$	$\dfrac{45D}{\pi(360-\theta)}\left(2\pi - \dfrac{\pi\theta}{180} + \sin\theta\right)$	$D\sin\dfrac{\theta}{2}$ or $2\sqrt{d(D-d)}$

1 Satisfactory approximation for the interval $0 < d/T \leq 0.25$
When $d/T \geq 0.25$, use $p = 1/2\sqrt{16d^2 + T^2} + \dfrac{T^2}{8d}\sinh^{-1}\dfrac{4d}{T}$

2 $\theta = 4\sin^{-1}\sqrt{d/D}$

3 $\theta = 4\cos^{-1}\sqrt{d/D}$

Insert θ in degrees in above equations

Design Procedure

1. Calculate the required capacity (Q_r) for the channel or channel segment.

2. Determine the soil erodibility factor (K**).** The type of soil(s) in which the channel will be constructed can be determined by locating the proposed channel on the appropriate soils map in the NRCS Soil Survey for the county in which the project is located. Once the soil type has been identified, the K factor may be determined from Table 6. Soils having K factors less than or equal to 0.37 are considered to be *"erosion resistant."*

3. Select a channel shape and initial dimensions. Calculate the anticipated velocity (V_d), using Manning's equation, and the design shear stress (τ_d), using the equation: $\tau_d = 62.4\ d \times s$.

   Where: d = Anticipated flow depth (ft)
   s = Channel Bed Slope (ft/ft)

   Slopes may not be averaged. If a proposed channel will intercept significant changes in slope, each segment of the channel should be designed with sufficient capacity for the gentlest bed slope and adequate protection for the steepest bed slope within that segment.

   The maximum bottom width to depth ratio for a trapezoidal channel should be 12:1. Experience has shown that in channels with ratios exceeding 12:1, the flow tends to concentrate within the channel resulting in erosion of the channel bottom.

4. Determine whether a protective lining is needed (See Table 6) for channels discharging to sediment traps or basins. If the anticipated shear stress exceeds the maximum permissible for the type of soil present, a protective lining is needed. Geotextiles designed for this purpose may be used as temporary linings.

   All channels not discharging to sediment traps or basins require a protective lining. Determine whether the permissible velocity design method (for channels with bed slopes less than 10%) or the shear stress lining design method will be used. If the permissible velocity method is used, make sure that the design velocity does not exceed the permissible velocity listed in Table 7a, Table 9, or Table 13 as applicable. If the shear stress method is used, make sure the anticipated shear stress does not exceed that shown in Table 6.

   Wherever vegetative stabilization is proposed, use Table 7 to determine the retardance. Use Figure 3a, 3b, or 3c to determine the "n" value. When rock riprap is proposed, use Figure 3 to determine the "n" value.

   The seed mixture used in vegetative channels should be suitable for the anticipated flow conditions based on the channel location and type of soil(s) encountered. The Department recommends the use of the Penn State Publication Erosion Control and Conservation Plantings on Noncropland for selection of species to be used.

TABLE 5
Erodible Soils in Pennsylvania*

Series*	Texture	K
Abbottstown	Loam, Silty Loam	.43
Aldino	Silt, Silt Loam	.43
Allis	Silt Loam, Silty Clay Loam	.43
Baile	Silt Loam, Loam, Silty Clay Loam	.43
Bedford	Silt Loam	.43
Beltsville	Silt Loam, Loam	.43
Birdsall	Silt Loam, Very Fine Silt Loam	.49
Blairton	Silt Loam, Loam	.43
Brooke	Silty Clay Loam, Clay Loam, Silty Clay	.43
Butlertown	Silt Loam, Loam, very fine sandy Loam	.43
Cambridge	Silt Loam, Loam	.43
Cambridge	Gravelly Silt Loam, Gravelly Loam	.43
Canadice	Silty Clay Loam, Silt Loam	.49
Caneadea	Silt Loam, Silty Clay Loam	.43
Captina	Silt Loam	.43
Chalfont	Silt Loam	.49
Conowingo	Silt Loam, Silty Clay Loam	.43
Croton	Silt Loam, Silty Clay Loam	.43
Dalton	Silt Loam, Very Fine Sandy Loam	.49
Dormont	Silt Loam	.43
Doylestown	Silt Loam, Silty Clay Loam	.43
Ernest	Silt Loam, Loam	.43
Ginat	Silt Loam, Loam	.43
Guernsey	Silt Loam, Silty Clay Loam	.43
Guthrie	Silt Loam	.43
Haven	Loam, Silt Loam, Very Fine Sandy Loam	.43
Hollinger	Silt Loam, Loam	.43
Howell	Fine Sandy Loam, Loam, Silt Loam	.43
Kanona	Silty Clay Loam, Loam, Silt Loam	.43
Kanona	Shaly Silty Clay Loam, Shaly Loam, Shaly Silt Loam	.43
Lawrence	Silt Loam	.43
Lawrenceville	Silt Loam, Loam	.43
Leadvale	Silt Loam, Loam, Fine Sandy Loam	.43
Letort	Silt Loam, Loam	.43
Lickdale	Loam, Silt Loam	.43
Mahoning	Silt Loam, Loam	.43
Manor	Loam, Silt Loam	.43
Melvin	Silt Loam, Loam, Fine Sandy Loam, Silty Clay Loam	.43
Monongahela	Fine Sandy Loam, Loam, Silt Loam	.43
Newark	Silt Loam, Loam, Silty Clay Loam	.43
Nolin	Silt Loam, Silty Clay Loam	.43
Opequon	Silt Loam	.43
Pekin	Silt Loam, Loam	.43
Penlaw	Silt Loam	.43
Pequea	Silt Loam, loam	.43

* Unlisted soils and textures have K factors $\leq$ 0.37 and are considered to be “erosion resistant.”

TABLE 5
Erodible Soils in Pennsylvania*
(Continued)

Series*	Texture	K
Platea	Silt Loam	.43
Purdy	Silt Loam, Loam, Silty Clay Loam	.43
Rainsboro	Silt Loam	.43
Readington	Silt Loam, Loam	.43
Reaville	Silt Loam	.43
Rohrersville	Silty Clay Loam, Silt Loam	.43
Rowland	Silt Loam, Loam, Sandy Loam	.43
Scio	Silt Loam, Very Fine sandy Loam	.49
Steff	Silt Loam, Loam	.43
Tilsit	Silt Loam, Loam	.43
Towhee	Silt Loam	.43
Tygart	Silt Loam, Loam	.43
Tyler	Silt Loam	.43
Unadilla	Silt Loam, Very Fine sandy Loam	.49
Upshur	Silt Loam, Silty Clay Loam	.43
Urbana	Silt Loam	.43
Wallington		.49
Warners		.43
Watchung	Silt Loam, Loam, Silty Clay Loam	.43
Watchung	V. Stony Silt Loam, v. St'y Loam, St'y Silty Clay Loam	.43
Watchung	Ex. St'y Silt Loam, Ex. St'y Loam, Ex. St'y Silty cl Loam	.43
Wayland	Silt Loam, Silty clay Loam	.43
Williamson	Silt Loam, fine sandy Loam, very fine sandy Loam	.49
Zipp	Silt Loam, Loam, Silty clay Loam	.43

* Unlisted soils and textures have K factors $\leq$ 0.37 and are considered to be "erosion resistant."

TABLE 6
Maximum Permissible Shear Stresses for Various Channel Liners

Lining Category	Lining Type	lb/ft^2
Unlined - Erodible Soils*	Silts, Fine -Medium Sands	0.03
	Coarse Sands	0.04
	Very Coarse Sands	0.05
	Fine Gravel	0.10
Erosion Resistant Soils**	Clay loam	0.25
	Silty Clay loam	0.18
	Sandy Clay Loam	0.10
	Loam	0.07
	Silt Loam	0.12
	Sandy Loam	0.02
	Gravely, Stony, Channery Loam	0.05
	Stony or Channery Silt Loam	0.07
Temporary Liners	Jute	0.45
	Straw with Net	1.45
	Coir - Double Net	2.25
	Coconut Fiber -Double Net	2.25
	Curled Wood Mat	1.55
	Curled Wood-Double Net	1.75
	Curled Wood - Hi Velocity	2.00
	Synthetic Mat	2.00
Vegetative Liners	Class B	2.10
	Class C	1.00
	Class D	0.60
Riprap***	R-1	0.25
	R-2	0.50
	R-3	1.00
	R-4	2.00
	R-5	3.00
	R-6	4.00
	R-7	5.00
	R-8	8.00

* Soils having an erodibility “K” factor greater than 0.37.
** Soils having an erodibility “K” factor less than or equal to 0.37
*** Permissible shear stresses based on rock at 165 lb/cuft. Adjust velocities for other rock weights used. See Table 12.

Manufacturer’s shear stress values based on independent tests may be used.

TABLE 7
Classification of Vegetative Covers as to Degree of Retardance

Retardance	Cover	Condition
B	Bermuda grass	Good stand, tall (average12”) (30 cm)
	Native grass mixture (little bluestem, bluestem, blue gamma, and other long and short midwest grasses) Good stand, unmowed	
	Weeping lovegrass	Good stand, tall (average 24”) (61 cm)
	Lespedeza sericea	Good stand, not woody, tall (average 9”) 48 cm)
	Alfalfa	Good stand, uncut (average 11”) (28 cm)
	Weeping lovegrass	Good stand, unmowed (average 13”) (33 cm)
	Blue gamma	Good stand, uncut (average 13” (28 cm)
C	Bermuda grass	Good stand, mowed (average 6”) (15 cm)
	Common lespedeza	Good stand, uncut (average 11”) (28 cm)
	Grass-legume mixture - summer (orchard grass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (average 6” to 8”) (15 to 20 cm)
	Centipedegrass	Very dense cover (average 6”) (15 cm)
	Kentucky bluegrass	Good stand, headed (6” to 12”) 15 cm to 20 cm)
D	Bermuda grass	Good stand, cut to 2.5” height (6 cm)
	Common lespedeza	Excellent stand, uncut (average 4.5”) (11 cm)
	Buffalo grass	Good stand, uncut (3” to 6”) (8 to 15 cm)
	Grass-legume mixture - fall, spring (orchard grass, redtop, Italian ryegrass, and common lespedeza	Good stand, uncut (4” to 5”) (10 to 13 cm)
	Lespedeza sericea	After cutting to 2” height (5 cm) Very good stand before cutting

TABLE 7a
Maximum Permissible Velocities for Channels Lined with Vegetation

Cover	Slope Range Percent	Erosion resistant Soil[1]	Easily Eroded Soil [2]
Kentucky Bluegrass Tall Fescue	<5 5-10 >10	7 [3] 6 [3] 5	5 4 3
Grass Mixture Reed Canarygrass	<5 5-10	5 4	4 3
Serecea Lespedeza Weeping Lovegrass Redtop Red Fescue	<5	3.5	2.5
Annuals Temporary cover only Sudangrass	<5	3.5	2.5

[1]Cohesive (clayey) fine grain soils and coarse grain soils with a plasticity index OF 10 TO 40 (CL,CH,SC and GC). Soils with K values less than 0.37.

[2]Soils with K values greater than 0.37.

[3]Use velocities exceeding 5 ft/sec only where good cover and proper maintenance can be obtained.

ADDITIONAL NOTES REGARDING THE USE OF TABLE 7a

1. A velocity of 3.0 ft/sec should be the maximum if because of shade, soils or climate, only a sparse cover can be established or maintained.
2. A velocity of 3.0 to 4.0 ft/sec should be used under normal conditions if the vegetation is to be established by seeding.
3. A velocity of 4.0 to 5.0 ft/sec should be used only in areas if a dense, vigorous sod is obtained quickly or if water can be diverted out of the waterway while vegetation is being established.
4. A velocity of 5.0 to 6.0 ft/sec may be used on well established, good quality sod. Special maintenance may be required.
5. A velocity of 6.0 to 7.0 ft/sec may be used only on established, excellent quality sod, and only under special circumstances in which flow cannot be handled at a lower velocity. Under these conditions, special maintenance and appurtenant structures will be required.
6. If stone centers, or other erosion resistant materials supplement the vegetative lining, the velocities in the above table may be increased by 2.0 ft/sec.
7. When base flow exists, a rock lined low flow channel should be designed and incorporated into the vegetative lined channel section.

Wherever vegetative linings are proposed, a suitable temporary liner shall be provided. Separate calculations should be provided showing sufficient capacity and adequate protection both before and after establishment of the vegetation. Maximum shear stress and roughness coefficients for the temporary liners should conform to Table 6 or the manufacturer's specifications. Wherever manufacturer's specifications are used, they should be documented in the narrative. Table 8 provides roughness coefficients for some commonly used temporary liners. Additional information on the design and use of channel linings may be obtained from the Federal Highway Administration's Hydraulic Engineering Circular No. 15 (April 1988). Copies of this publication may be obtained by contacting:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: (703) 605-6000
Publication No.: PB-86-184-835

TABLE 8
Manning's Roughness Coefficient ("n") for Commonly Used Temporary Channel Linings

Lining Type	Manning's "n" Dept Ranges 0 - 0.5 ft. (0 - 0.15 m)	0.5 - 2.0 ft. (0.15 - 0.61 m)	>2.0 ft (>0.61 m)
Jute Net	0.028	0.022	0.019
Curled Wood Mat	0.066	0.035	0.028
Synthetic Mat	0.036	0.025	0.021

The maximum permissible shear stresses for Riprap channel linings are given in Table 6. The value of Manning's "n" used should be taken from Figure 3. Since the roughness coefficient varies significantly with the size of the rock and the depth of flow, use of standard "n" values may result in undersizing of the channel or of the riprap protection. **NOTE: Due to the rapid increase in shear stress with increasing bed slope, reno mattresses or gabions should be considered for gradients > 10% (0.10 ft/ft).**

TABLE 9
Riprap Gradation, Filter Blanket Requirements, Maximum Velocities

NSA No.	Graded Rock Size (in) Max.	d_{50}*	Min.	Filter Blanket Requirements** Size NSA No.	Placement Thickness	V_{max} (ft/sec
R-1	1.5	.75	No. 8	FS-1	N/A	2.5
R-2	3	1.5	1	FS-1	N/A	4.5
R-3	6	3	2	FS-1	3	6.5
R-4	12	6	3	FS-2	4	9.0
R-5	18	9	5	FS-2	6	11.5
R-6	24	12	7	FS-3	8	13.0
R-7	30	15	12	FS-3	10	14.5

* The d_{50} stone size is the size exceeded by 50% of the total weight of the tonnage shipped (i.e. 50% by weight shall consist of pieces larger than the d_{50} stone size").

** This is a general standard. Soil conditions at each site should be analyzed to determine actual filter size. A suitable woven or non-woven geotextile underlayment, used according to manufacturer's recommendations, may be substituted for the filter stone.

Filter Stone Specifications - Pieces smaller than the minimum size shown in Table 10 shall not exceed 15% of the tonnage shipped. Filter stone shall be placed to the full course thickness indicated on the drawings in one continuous operation.

TABLE 10
Gradation of Filter Rock

NSA Size in Inches Number	Max.	d_{50}	Min.
FS-1	.375	No. 30	No. 100
FS-2	2	No. 4	No. 100
FS-3	6.5	2.5	No. 16

TABLE 10A
Comparison of Various Gradations of Coarse Aggregates
Total Percent Passing

AASHTO NUMBER	NSA NUMBER	PA NUMBER	6 1/2	4"	3 1/2"	2 1/2	2"	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#100	#200
	FS-3		100			50									0			
1		4		100	90-100	25-60		0-15		0-5								
3		3A				100	90-100	35-70	0-15		0-5							
467							100	95		35-70		10-30	0--5					
	FS-2						100						50				0	
		2A					100			52-100		36-70	24-50	16-38	10-30			0-10
5								100	90-100	20-55	0-10	0-5						
57		2B						100	90-100		25-60		0-10	0-5				
		2 NS						100	90-100		0-15							
67		2							100	90-100		20-55	0-10	0-5				
		1NS							100		90-100		0-15					
7										100	90-100	40-70	0-15	0-5				
8											100	85-100	10-30	0-10	0-5			
		1B									100	75-100	10-30	0-10				
10		1										100	75-100				10-30	
	FS-1											100				50	0	

TABLE 11
Riprap Size Adjustment Factor for Various Rock Types

Rock Type	Average Unit Weight (lb/ft^3)	Adjustment Factor
Diabase	184	0.5
Granite	167	1.0
Limestone	165	1.0
Sandstone	151	1.5

Example: To use riprap composed of sandstone, multiply the maximum, minimum and d_{50} stone sizes from Table 10 by 1.5. Thus, for an R-5 sandstone riprap, the maximum stone size should be 27”, the d_{50} stone size 14”, and the minimum stone size 8”. Since quarries generally grade rock riprap to the common "R" sizes, in this example the sandstone would need to be an R-7 gradation.

TABLE 12
Recommended n Values to be Used with Manning's Equation

Surface	Min.	Design	Max.
Asphalt Lining		0.015	
Brick in cement mortar; brick sewers	0.012	0.015	0.017
Concrete-lined channel	0.012	0.015	0.018
Cement-rubble surface	0.017		0.030
Neat cement surfaces	0.010	0.012	0.013
Plastic-lined channel	0.012		0.014
Shotcrete	0.016		0.017
Asbestos Cement Pipe		0.009	
Concrete pipe	0.012	0.015	0.016
Vitrified Clay Pipe	0.010	0.013	0.017
Common-clay drainage tile	0.011	0.012	0.017
Semi-circular metal flumes, smooth	0.011		0.015
corrugated	0.023	0.025	0.030
Channels and ditches			
Earth, straight and uniform	0.017	0.023	0.025
Rock cuts, smooth and uniform	0.025	0.030	0.035
jagged and irregular	0.035	0.040	
Dredged earth channels	0.025	0.028	0.033
Earth bottom, rubble sides	0.028	0.030	0.035
Natural Streams			
1. Clean, straight bank, full stage no rifts or deep pools	0.025		0.033
2. Same as 1, but some weeds and stones	0.030		0.040
3. Winding, some pools and shoals, clean	0.033		0.045
4. Same as 3, lower stages, more ineffective slope and sections	0.040		0.055
5. Same as 3, same weeds and stone	0.035		0.050
6. Same as 4, stony sections	0.045		0.060
7. Sluggish river reaches, rather weedy or with very deep pools	0.050		0.080
8. Very weedy reaches	0.075		0.150

Figure 3
"n" Values for Riprap Channels

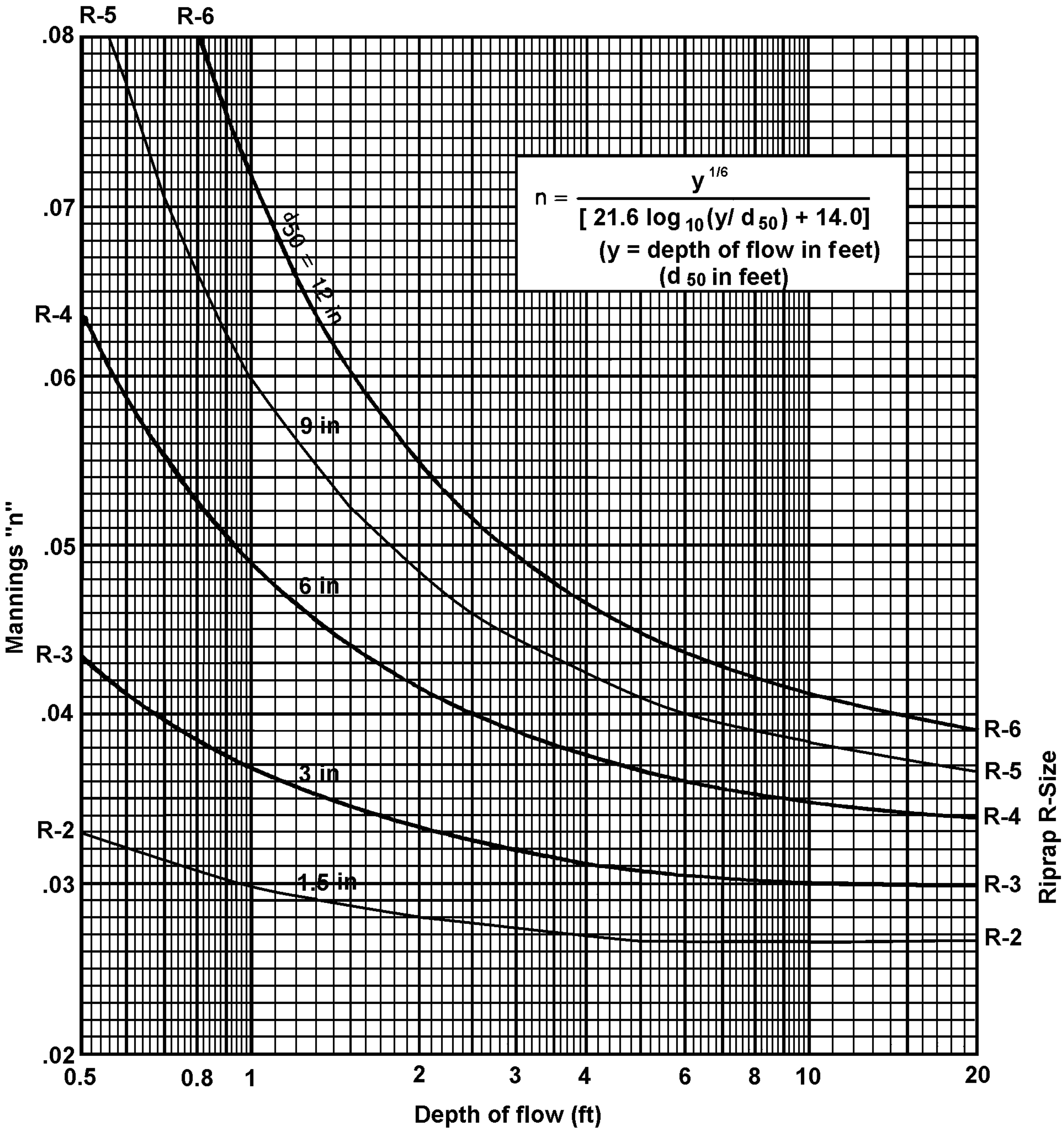


Figure 3a
"n" Values for Vegetated Channels, B Retardance

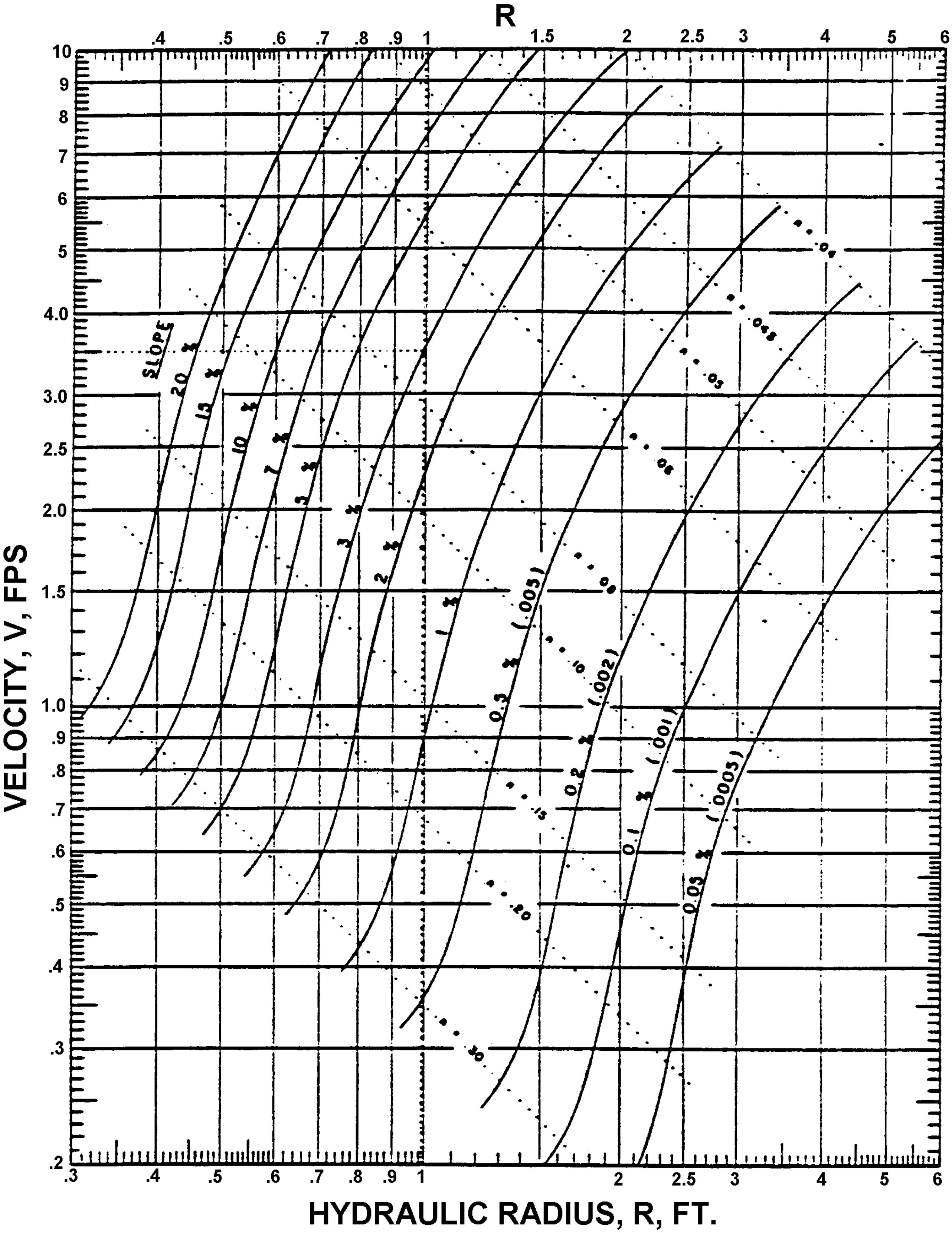


Figure 3b
"n" Values for Vegetated Channels, C Retardance

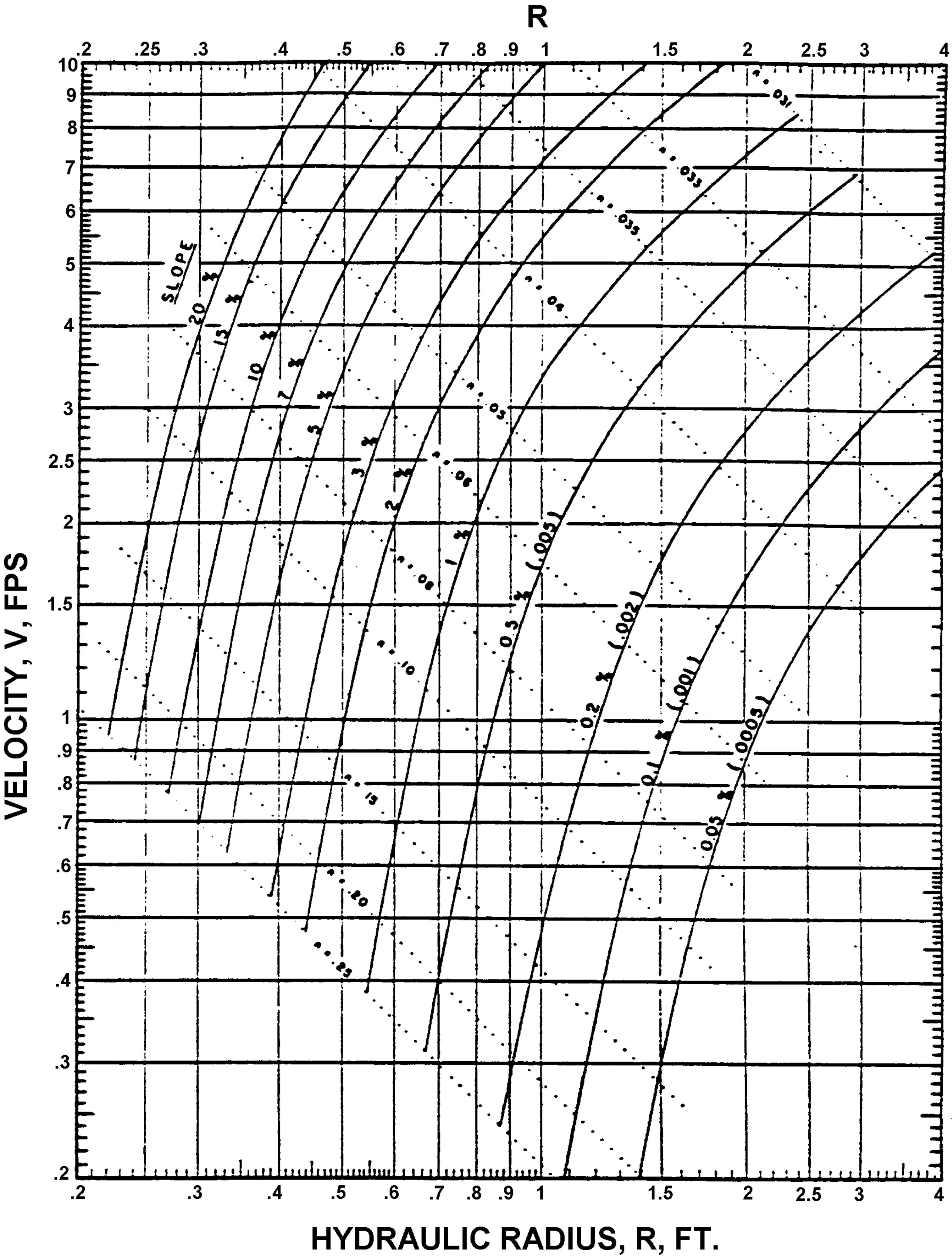
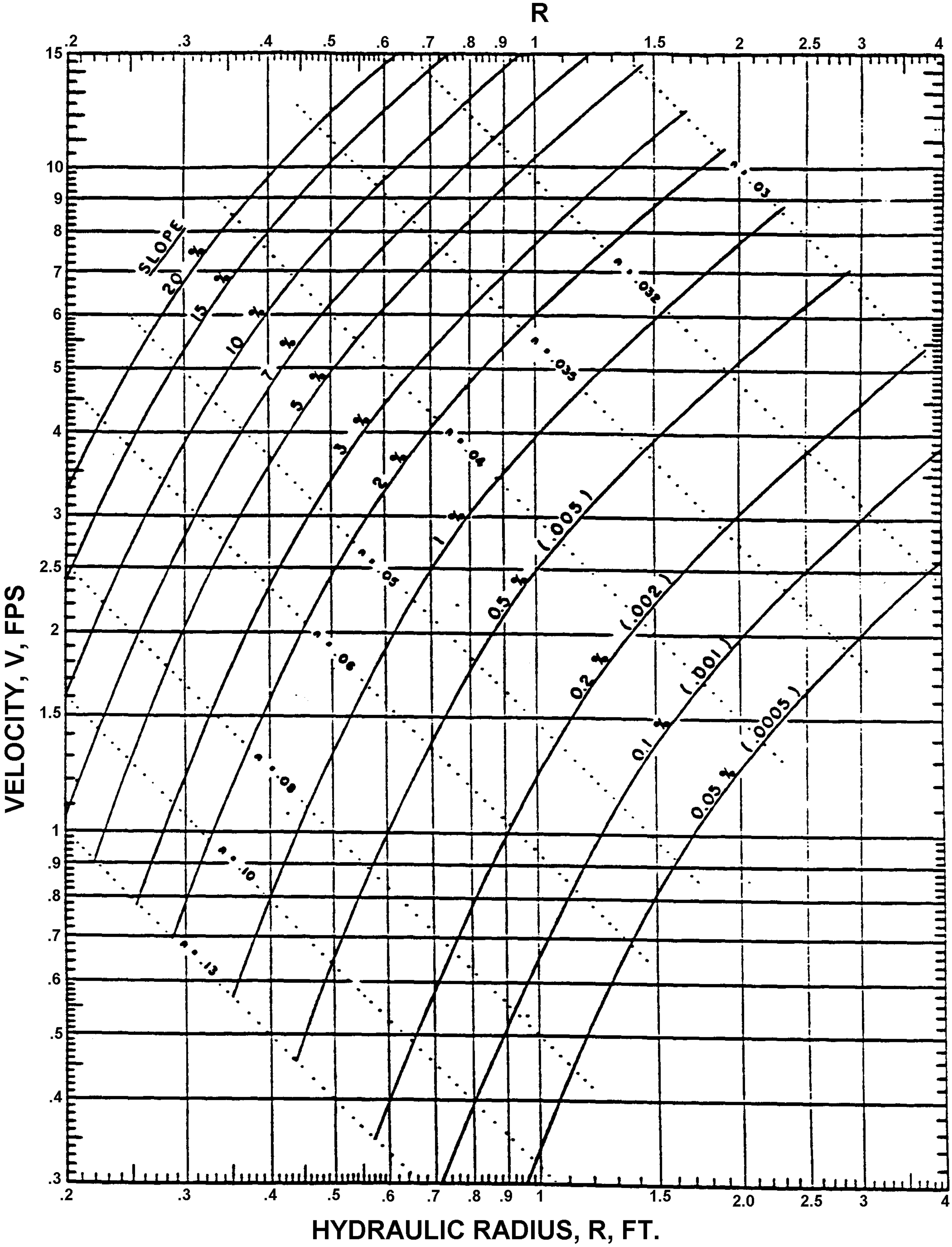


Figure 3c
"n" Values for Vegetated Channels, D Retardance



Riprap Specifications - Rock utilized for riprap shall consist of sound, durable rock, insoluble in water. (**Note: This does not exclude limestone** since the rate of dissolving for limestone is very low.) It shall be free of structural defects, shale seams, and foreign materials such as quarry dust, soil, shale, and organic matter. Individual pieces shall be sharply angular, whenever possible, block-shaped and have a minimum specific gravity of 2.5. Where rock having average unit weights different than 165 lb/ft^3, the size of the individual pieces shall be adjusted according to Table 11. No piece should have a length exceeding three (3) times its width or depth. Each load shall be well-graded from the smallest to the largest stone size. Pieces smaller than the minimum size may not exceed 15% of the tonnage shipped. Minimum Riprap Thickness should be equal to the maximum stone size (d_{max}).

TABLE 13
Maximum Permissible Velocities for Reno Mattress & Gabions

Type	n	Thickness Inches	Rock Fill Gradation (in)	Permissible* Velocity (fps)	Permissible** Shear Stress (lb/ft^2)
Reno Mattress	.025 - .030	6	3 - 6	6.0	8.35
	.025 - .030	6 - 10	3 - 6	12.0	8.35
	.025 - .030	10 - 12	3 - 6	15.0	8.35
	.025 - .030	12 - 18	4 - 6	18.0	8.35
Gabion	.027	>18	5 - 9	22.0	8.35

* Permissible velocities may be increased by the introduction of sand mastic grout. Refer to manufacturer's recommendations/specifications for permissible velocities and for recommendations regarding filters or geotextile fabric underlayment when using Reno mattresses or gabions for channel linings.
**Based on vegetation completely grown.

5. Calculate the Required Freeboard.

Determine whether stable or unstable flow conditions exist. Uniform flow at or near "critical depth" is unstable due to waves present at the water's surface. Since the height of the waves may exceed the top of the channel, sufficient freeboard must be provided to prevent channel failure. The procedure for determining whether channel flow conditions are stable or unstable is as follows:

Compute the channel's critical slope:

$$S_c = 14.56\, n^2 D_m / R^{4/3}$$

Where:
- S_c = critical slope (ft/ft)
- n = Manning's "n"
- D_m = mean depth of flow = A/T (ft)
- A = cross-sectional area of the channel (sqft)
- T = channel top width at the water surface (ft)
- R = hydraulic radius = A/P (ft)
- P = wetted perimeter (ft)

Unstable flow occurs when S_o is between $0.7S_c$ and $1.3S_c$ where: S_o = channel bed slope.

Compute the minimum required freeboard.

If unstable flow conditions exist, compute the minimum required freeboard as follows:

$$F = (0.025\ V)\ (3\ D) = 0.075\ VD$$

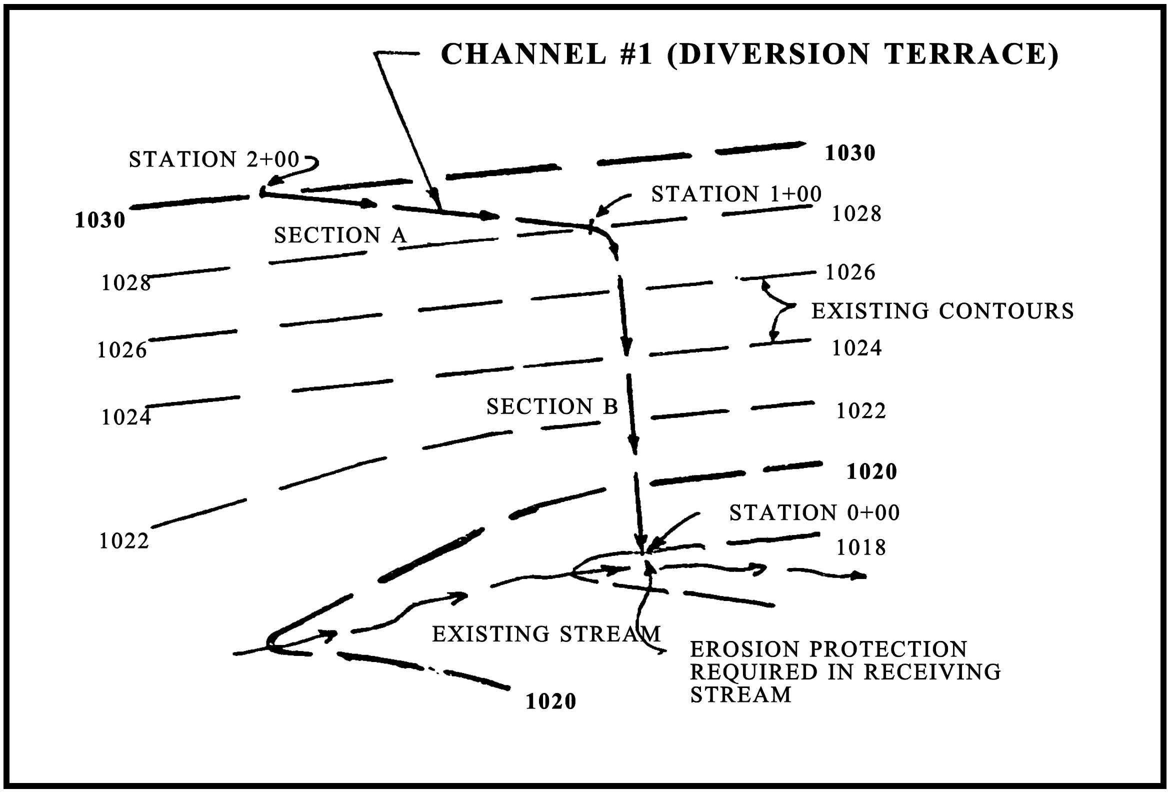
Where: F = freeboard in feet
V = velocity in fps
D = flow depth in feet

For stable flow conditions, the minimum freeboard should be 25% of the flow depth. The minimum freeboard for any channel is 6”.

6. Provide suitable outlet protection for all channels. See Outlet Protection section of this manual.

Sample Channel Design

FIGURE 4
Plan Map of Sample Channel



A 200 foot long temporary channel will be designed. The first 100 feet (measured from the discharge end) will have a bed slope of 10%, while the upper 100 feet will have a 2% slope (see Figure 4). Therefore, it will be designed in 2 segments. The gentler upper segment will be “Section A”, and the steeper lower segment will be “Section B.” The soils map in the NRCS Soil Survey indicates that the channel will be constructed in Guernsey silt loam.

1. **Capacity (Q_r)** - In this example, the tributary acreage of 9.4 acres is measured from a topographic map. Using 1.6 cfs/acre as the capacity, Q_r = 15 cfs.

2. **Soil Erodibility Factor K** - In Table 5, Guernsey silt loam has an erodibility factor of 0.43. Since erosion resistant soils have K values less than 0.37, this soil is considered “erodible.”

3. **Channel Shape and Initial Dimensions** - A trapezoidal channel with a 2 foot bottom width and (H:V) side slopes is selected for section A. The channel is checked for the "bare earth unlined condition" first for demonstration purposes only. Since diversion terraces require a suitable erosion resistant lining. The

shear stress method was selected to see if the anticipated shear stress exceeds maximum allowable shear stress. Compute the anticipated shear stress (τ_d):

$$\tau_d = 62.4\ d \times s.$$

where : τ_d = shear stress in pounds per square foot
d = flow depth in feet
s = channel bed slope in feet per foot

The shear stress exceeds the maximum allowable shear stress; therefore this channel design would not even be suitable for a channel to a sediment basin or trap.

Kentucky bluegrass is selected as a vegetative lining and checked for adequacy. Retardance C is chosen and the value of Manning's "n" is determined by use of Figure 3b. The permissible velocity method was selected to determine the protective lining adequacy. Through trial and error, it is determined that at a flow depth of 1.2 feet, with an "n" value of 0.053, a capacity of 16.8 cfs is provided. The design velocity of 3.2 fps is less than the allowable velocity of 5 fps for easily eroded soil (Table 7a).

It should be noted that Guernsey silt loam appears on the potential hydric soils list in many counties in Pennsylvania. Since Kentucky bluegrass does not grow well under wet soil conditions, it is not the proper species for this type of application. Birdsfoot trefoil tolerates wet soil (see Table 15). It has the same "n" value as the Kentucky bluegrass, so it was checked for lining adequacy using the allowable velocity method. Its allowable velocity is 4 fps which is greater that the anticipated velocity of 3.2 fps. This proposed lining would be acceptable.

Next, a native grass mixture is analyzed for adequacy using the shear stress method. Since this seed mixture has a "B" retardance, the allowable shear stress is 2.10 lb/ft^2. This time it is determined that the anticipated shear stress for a channel, 1.6' deep, with a 2' bottom width is 2.00 lb/ft^2, and less than the allowable shear stress of 2.10 lb/ft^2. Therefore, the proposed lining is acceptable.

Since the channel will be seeded, rather than sodded, a temporary liner is required to prevent erosion within the channel until the vegetation becomes established. A curled wood mat is proposed and checked for adequacy. The value of Manning's "n" taken from Table 8 is 0.035 (since the anticipated flow depth is between 0.5' and 2.0'). The maximum permissible shear stress for this product is 1.55 lb/ft^2. Since the anticipated shear stress (1.25 lb/ft^2) is less than the maximum permissible, this temporary lining is acceptable.

Due to the steep bed slope (0.10 ft/ft) of Section B, a riprap lining is proposed and must be checked using the shear stress method. Through trial and error it is determined that a channel, 0.8' deep, with a 4.0 ft wide bottom width, and R-7 riprap lining would be required to provide sufficient capacity with adequate protection (see Channel DC-1B on Worksheet 21). Since this channel discharges directly into a stream channel, outlet protection should be provided. See Outlet Protection section of this manual.

4. **Freeboard** - Since the flow depth in Section A, at which the required capacity is provided, is greater for the native grass vegetated condition than for the temporary liner, the minimum total channel depth for Section A should be 1.6' + 0.5', the freeboard, or 2.1'. The temporary liner should extend to the full constructed depth of the channel. Stable flow conditions exist in both Sections A and B, and the anticipated flow depths are less than 24", so the required freeboard is 0.5' for both sections. Thus the minimum total depth of Section A is 2.1' (1.6' + 0.5'), and that for Section B is 1.3' (0.8' + 0.5').

Construction - Temporary and permanent channels should be constructed to the dimensions shown on the E & S Control plan drawings. **(NOTE: Channels having riprap, Reno mattress, or gabion linings must be sufficiently over-excavated so that the design dimensions will be provided after placement of the protective lining.)**

Maintenance - Channels should be maintained to ensure that the specified design dimensions and protective linings are available at all times. Damaged channel linings should be repaired or replaced immediately

Channel #1 (Diversion Channel) on
STANDARD WORKSHEET #21
CHANNEL DESIGN DATA

PROJECT NAME: ____________________
LOCATION: ____________________
PREPARED BY: ____________________ DATE: ____________________
CHECKED BY: ____________________ DATE: ____________________

CHANNEL OR CHANNEL SECTION	DC-1A	DC-1A	DC-1A	DC-1A	DC-1A
PROTECTIVE LINING **	Unlined	KY Bluegrass	Birdsfoot Tr	Nat Gr	Curled Wd
CHANNEL TOP WIDTH (FT)@ D	6.8	8.8	8.8	10.4	8.0
CHANNEL TOP WIDTH (FT)@ d	4.8	6.8	6.8	8.4	6
CHANNEL SIDE SLOPES (H:V)	2	2	2	2	2
CHANNEL BOTTOM WIDTH (FT)	2.0	2.0	2.0	2.0	2.0
d (FLOW DEPTH IN FT)	0.7	1.2	1.2	1.6	1.0
BOTTOM WIDTH:DEPTH RATIO (12:1 MAX)	2.9	1.7	1.7	1.2	2.0
A (AREA IN SQ. FT.)	2.38	5.28	5.28	8.32	4.0
R (HYDRAULIC RADIUS)	0.46	0.72	0.72	0.91	0.62
S (BED SLOPE, FT/FT)*	0.02	0.02	0.02	0.02	0.02
VEGETATIVE LINING RETARDANCE	N/A	C	C	B	N/A
n (MANNING'S COEFFICIENT)**	0.020	0.053	0.053	0.109	0.035
V (AT FLOW DEPTH d, CFS)	6.3	3.2	3.2	1.8	4.4
Q (AT FLOW DEPTH d, CFS)	15.0	16.8	16.8	15.0	17.4
Q_r (REQUIRED CAPACITY) CFS	15.0	15.0	15.0	15.0	15.0
S_c (CRITICAL SLOPE)	0.008	0.049	0.049	0.195	0.023
$.7S_c$	0.006	0.034	0.034	0.14	0.016
$1.3S_c$	0.010	0.064	0.064	0.25	0.029
STABLE FLOW? (Y/N)	Y	Y	Y	Y	N
FREEBOARD BASED ON UNSTABLE FLOW FT	N/A	N/A	N/A	N/A	0.3
FREEBOARD BASED ON STABLE FLOW FT	0.2	0.3	0.3	0.4	N/A
MINIMUM REQUIRED FREEBOARD FT***	0.5	0.5	0.5	0.5	0.5
D (TOTAL DEPTH) FT	1.2	1.7	1.7	2.1	1.5
d_{50} STONE SIZE (IN)	N/A	N/A	N/A	N/A	N/A
DESIGN METHOD FOR PROTECTIVE LINING ** PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)**	S	V	V	S	S
V_a (ALLOWABLE VELOCITY) FPS	N/A	5	4	N/A	N/A
τ_d (SHEAR STRESS AT FLOW DEPTH d) LB/FT^2	0.87	N/A	N/A	2.00	1.25
τ_a (MAX ALLOWABLE SHEAR STRESS) LB/FT^2	0.03	N/A	N/A	2.1	1.55

* Slopes may not be averaged.
** For vegetated channels, provide data for temporary linings and vegetated conditions in separate columns.
*** Minimum Freeboard, F, is 0.5 ft.
**** Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is recommended for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

Channel #1 (Diversion Channel) on
STANDARD WORKSHEET #21
CHANNEL DESIGN DATA

PROJECT NAME: ______________________________

LOCATION: ______________________________

PREPARED BY: ____________________ DATE: ____________

CHECKED BY: ____________________ DATE: ____________

CHANNEL OR CHANNEL SECTION	DC-1B	DC-1B	DC-1B	DC-1B	DC-1B
PROTECTIVE LINING **	R-3	R-4	R-5	R-6	R-7
CHANNEL TOP WIDTH (FT)@ D	7.4	7.8	8.2	8.6	9.2
CHANNEL TOP WIDTH (FT)@ d	5.4	5.8	6.2	6.6	7.2
CHANNEL SIDE SLOPES (H:V)	2	2	2	2	2
CHANNEL BOTTOM WIDTH (FT)	3.0	3.0	3.0	3.0	4.0
d (FLOW DEPTH IN FT)	0.6	0.7	0.8	0.9	0.8
BOTTOM WIDTH:DEPTH RATIO (12:1 MAX)	5.0	4.3	3.8	3.3	5.0
A (AREA IN SQ. FT.)	2.5	3.1	3.7	4.3	4.5
R (HYDRAULIC RADIUS)	0.44	0.50	0.56	0.61	0.59
S (BED SLOPE, FT/FT)*	0.1	0.1	0.1	0.1	0.1
VEGETATIVE LINING RETARDANCE	N/A	N/A	N/A	N/A	N/A
n (MANNING'S COEFFICIENT)**	0.041	0.055	0.066	0.075	0.098
V (AT FLOW DEPTH d, CFS)	6.7	5.4	4.8	4.5	3.4
Q (AT FLOW DEPTH d, CFS)	16.8	16.6	17.8	19.4	15.3
Q_r (REQUIRED CAPACITY) CFS	15.0	15.0	15.0	15.0	15.0
S_c (CRITICAL SLOPE)	0.034	0.059	0.082	0.103	0.175
$.7S_c$	0.024	0.041	0.057	0.072	0.123
$1.3S_c$	0.044	0.076	0.106	0.133	0.228
STABLE FLOW? (Y/N)	Y	Y	N	N	Y
FREEBOARD BASED ON UNSTABLE FLOW FT	N/A	N/A	0.3	0.3	N/A
FREEBOARD BASED ON STABLE FLOW FT	0.2	0.2	N/A	N/A	0.2
MINIMUM REQUIRED FREEBOARD FT***	0.5	0.5	0.5	0.5	0.5
D (TOTAL DEPTH) FT	1.1	1.2	1.3	1.4	1.3
d_{50} STONE SIZE (IN)	3	6	9	12	15
DESIGN METHOD FOR PROTECTIVE LINING **** PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)	S	S	S	S	S
V_a (ALLOWABLE VELOCITY) FPS	N/A	N/A	N/A	N/A	N/A
τ_d (SHEAR STRESS AT FLOW DEPTH d) LB/FT^2	3.74	4.37	4.99	5.62	4.99
τ_a (MAX ALLOWABLE SHEAR STRESS) LB/FT^2	1.00	2.00	3.00	4.00	5.00

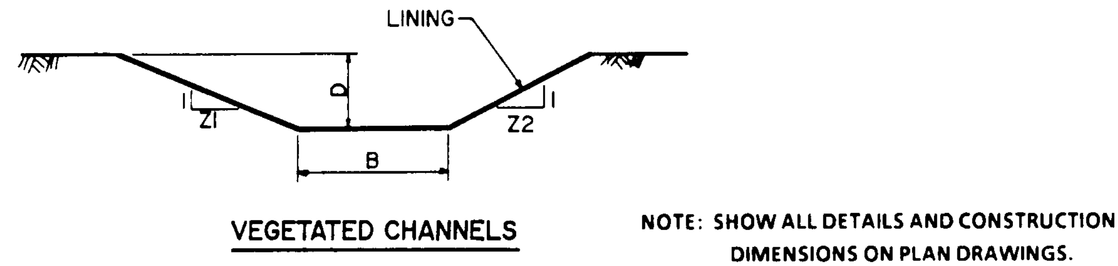
* Slopes may not be averaged.

** For vegetated channels, provide data for temporary linings and vegetated conditions in separate columns.

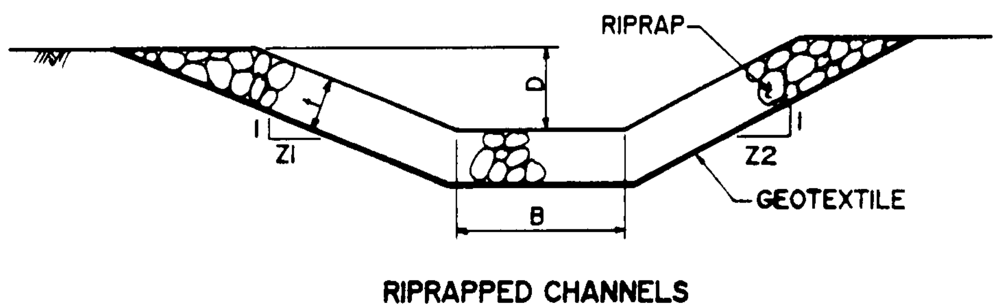
*** Minimum Freeboard, F, is 0.5 ft.

**** Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is recommended for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

Channel #1 Segments "A" and "B"
on Standard Worksheet #22

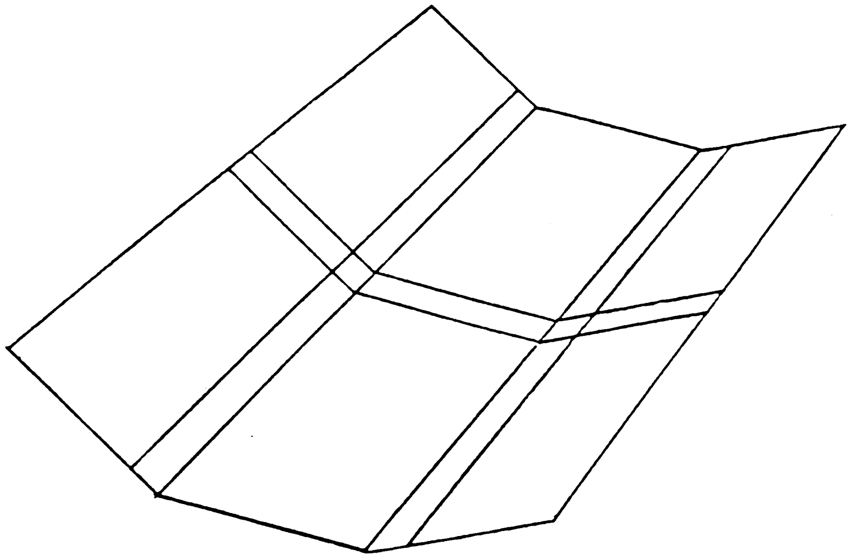


Channel	Stations	B	D	Z1	Z2	Lining
DC-1A	Entire	2.0	2.1	2.0	2.0	Grass/Curled Wood Mat

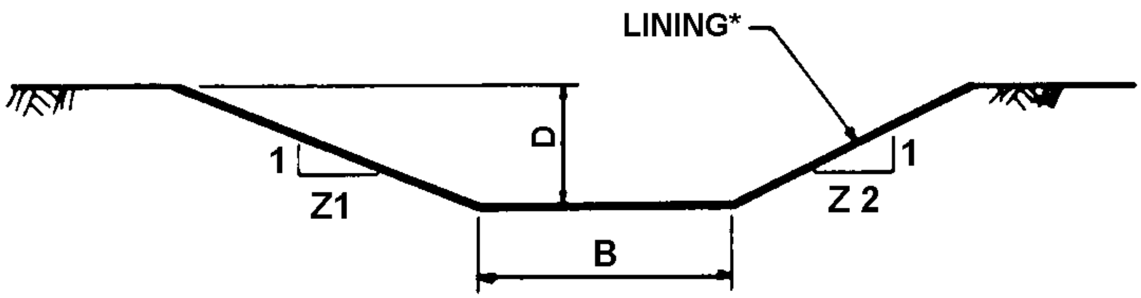


Channel	Stations	B	D	Z1	Z2	Riprap Gradation	t
DC-1B	Entire	4.0	1.3	2	2	R-7	30"

STANDARD CONSTRUCTION DETAIL #1
Vegetated Channels



LINING INSTALLATION

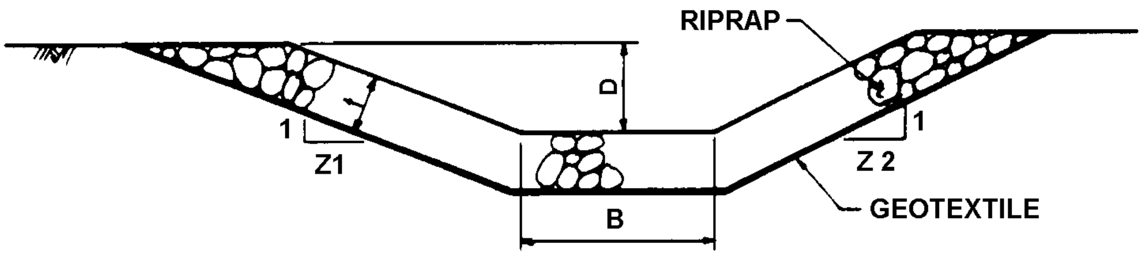


CHANNEL CROSS-SECTION

CHANNEL NO.	STATIONS	BOTTOM WIDTH B (FT)	DEPTH D (FT)	Z1 (FT)	Z2 (FT)	LINING*

* See Manufacturer's Lining Installation Detail for Staple Patterns, and Vegetative Stabilization Specifications for Soil Amendments, Seed Mixtures, and Mulching information.

STANDARD CONSTRUCTION DETAIL #2
RIPRAP CHANNELS



CHANNEL CROSS-SECTION

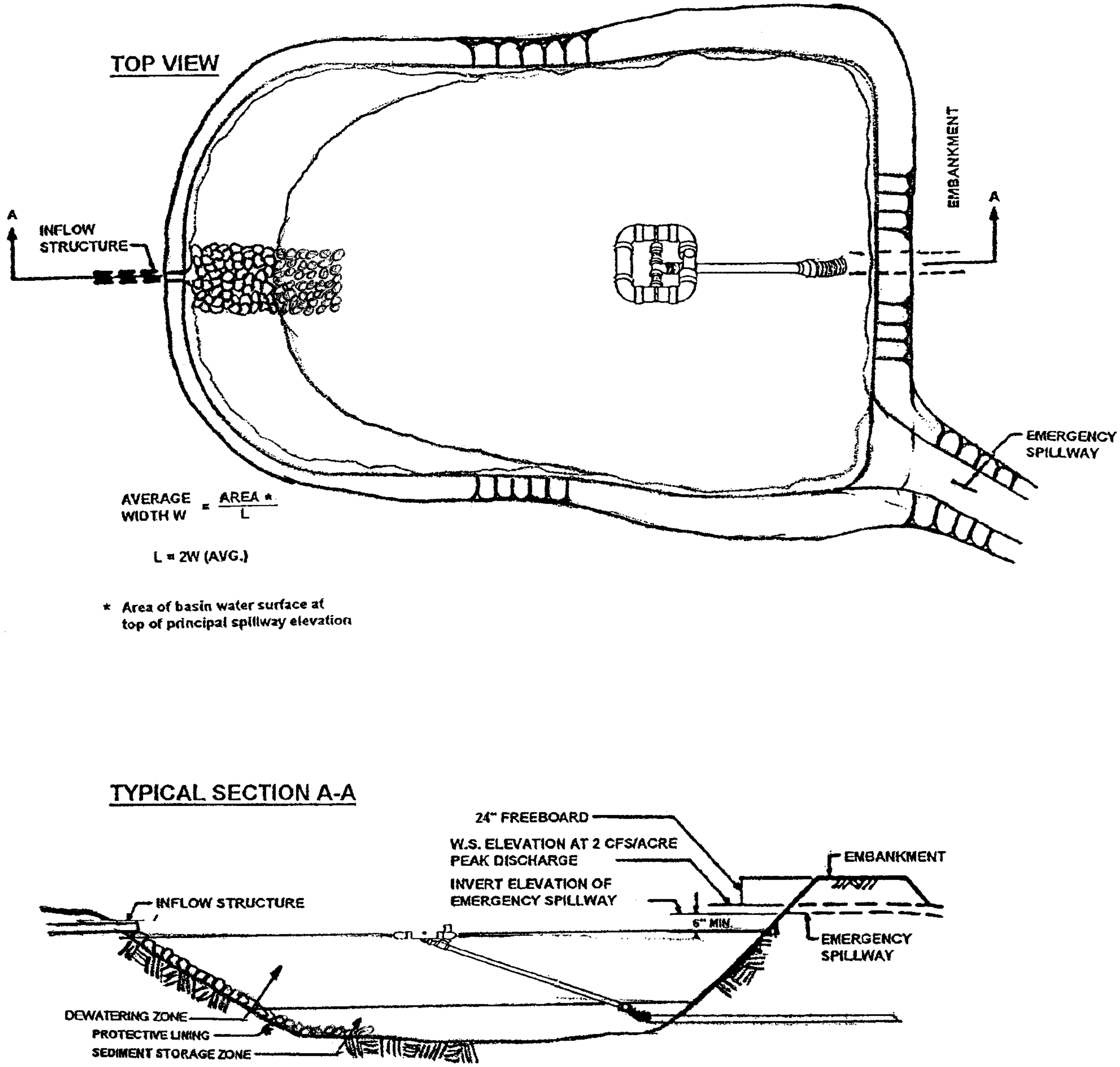
CHANNEL NO.	STATIONS	BOTTOM WIDTH B (FT)	DEPTH D (FT)	Z1 (FT)	Z2 (FT)	RIPRAP	
						SIZE (R-__)	THICK. t (IN)

SEDIMENT BASINS

DESIGN CRITERIA SUMMARY

1. A sediment storage zone of 1,000 cubic feet per disturbed acre within the watershed of the basin is required.
2. A dewatering zone of 5,000 cubic feet for each acre tributary to the basin is to be provided. Reductions in the dewatering zone are allowed unless the basins is in a HQ or EV watershed, however the minimum required dewatering zone is at least 3,600 cubic feet per acre.
3. Sediment basins must have a flow length to width ratio of at least 2:1.
4. Sediment basins must dewater in a period ranging from 2 to 7 days. Skimmers are the preferred dewatering device, however perforated risers are also acceptable.
5. Every sediment basin should be provided with an emergency spillway with a minimum bottom width of 8'.
6. The elevation of the emergency spillway crest must be at least 6” above that of the principal spillway(top of dewatering zone).
7. Sediment basin spillways must be able to discharge 2 cfs/acre from the entire contributing watershed.
8. A minimum of 24 inches of freeboard is required above the elevation of the 2 cfs/acre. If the emergency spillway is being used to provide part of the 2 cfs/acre discharge, the freeboard must be provided above the design flow elevation in the emergency spillway.
9. When a perforated riser is selected as the means to dewater the basin, the diameter of the riser should be at least 1.25 times that of the outlet barrel. The minimum riser diameter is 15”. The minimum barrel diameter is 12”.
10. In some instances a sediment basin may be later used for a stormwater management pond. In those cases it may be necessary to use a temporary riser while the basin is performing as a sediment basin. An acceptable means of using a temporary riser in conjunction with a permanent riser is shown by Standard Construction Detail # 6.

FIGURE 5
Sediment Basin



Guide stakes should be installed to prevent the skimmer from moving from side to side. A device (concrete block or equivalent) to prevent the skimmer from settling below the top of sediment storage zone should also be installed.

DESIGN CRITERIA

A sediment storage zone of 1,000 cubic feet per disturbed acre within the watershed of the basin is required. The elevation at which the required capacity is provided should be marked on a clean-out stake located near the center of the basin. Accumulated sediment shall be removed from the basin whenever it reaches that elevation on the clean-out stake.

A dewatering zone of 5,000 cubic feet for each acre tributary to the basin is to be provided. Reductions in the dewatering zone are allowed for the factors listed below, however the minimum required dewatering zone is at least 3,600 cubic feet per acre. The dewatering zone is in addition to the sediment storage zone. No reduction in dewatering zone will be permitted in basins located in Special Protection watersheds; such basins shall also use principal spillways that dewater from the top 6 inches of the dewatering zone or shall have permanent pools greater or equal to 18 inches deep.

(1) A reduction of 700 cubic feet per acre for basins with principal spillways that dewater from the top 6 inches of the dewatering zone.

(2) A reduction of 700 cubic feet per acre for basins with permanent pools greater or equal to 18 inches average depth. The sediment storage zone may be a part of the permanent pool.

(3) A reduction of 350 cubic feet per acre for basins with basin length to width ratios of 4:1 or greater.

(4) A reduction of 350 cubic feet per acre for basins with dewatering times ranging from 4 to 7 days. Calculations to support the extended dewatering time must be supplied.

Determine the Storage and Discharge Capacities.
Standard Worksheet #12 is recommended for this purpose.

1. The drainage area used is the maximum during construction area that will be tributary to the basin. Since watersheds often change during grading operations, roadway construction, installation of sewer lines, and construction of buildings and parking lots, the Maximum During Construction Drainage Area is not necessarily the pre- or post-construction drainage area. The watershed areas used to size basins should be delineated on the E & SPC plan maps. If this is not possible or undesirable due to clutter, a legible copy of the work map used to size the basins should be provided.

2. The disturbed area includes all areas that will be disturbed during the life of the basin whether they are all disturbed at the same time or not.

Develop a Stage Storage Curve.
Standard Worksheet #14 is recommended for this purpose.

1. Determine the surface area of the basin at each contour line within the proposed basin.

2. Calculate the volume between the contours.

3. Record the data in a table.

Determine the Sediment Storage Elevation.

1. Using the sediment storage volume (S_d) from standard worksheet #12, find the elevation on the stage storage curve that corresponds to that volume.

2. The bottom row of perforations on the principal spillway riser should be located at this elevation.

Determine the Elevation at which the Total Storage Volume is provided.

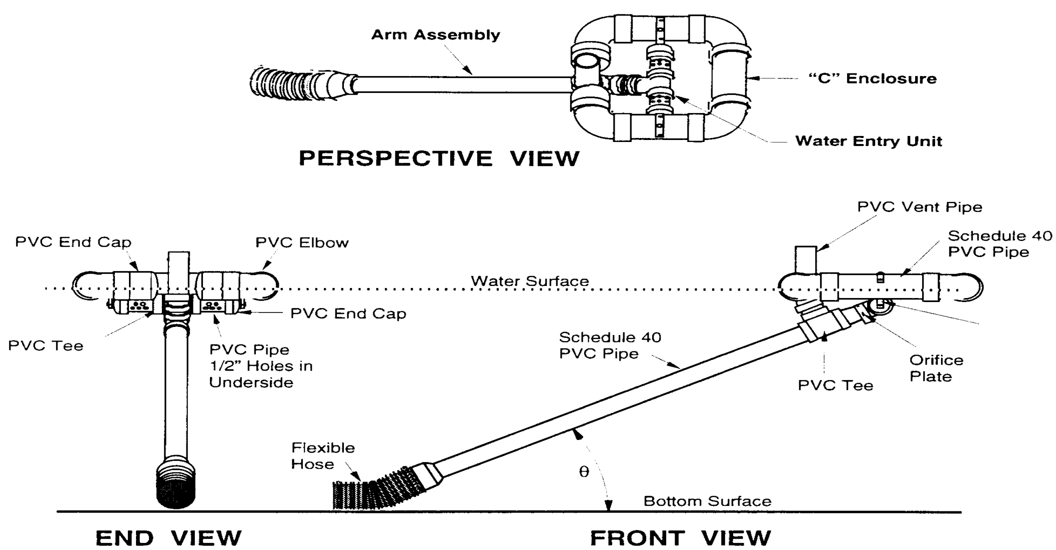
1. Using the total storage volume (S_t) from Standard Worksheet #12, find the elevation on the stage storage curve that corresponds to that volume.

2. This elevation is the minimum elevation for the crest of the principal spillway riser.

Except for activities in Special Protection Watersheds, the minimum dewatering time for sediment basins is 48 hours. The maximum dewatering time should not exceed 7 days. Sediment basins in Special Protection watersheds shall be designed to dewater in no less than 4 days and no more than 7 days when at full capacity. The lower limit of dewatering is the top of the sediment storage zone, or the top of the permanent pool if a permanent pool is used. The upper limit is the top of the dewatering zone.

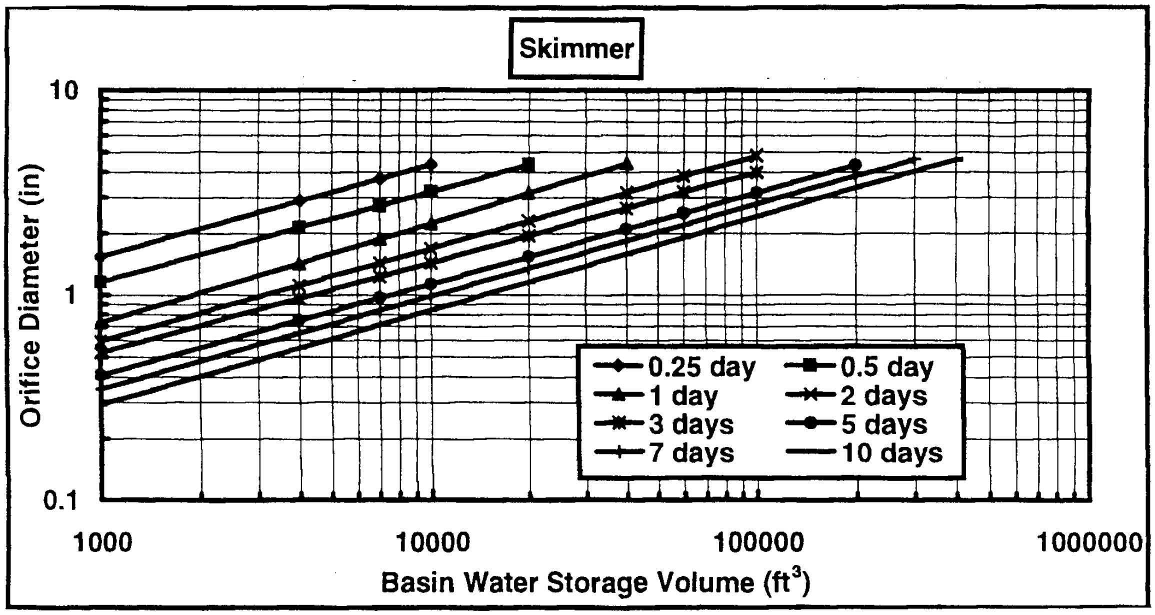
Sediment basins may be dewatered using a temporary perforated riser, or preferably using a device commonly known as a skimmer to discharge water from the top of the dewatering zone. The following Figures 6 & 7, taken from Penn State Agricultural and Biological Engineering fact Sheet F-253, may be used to size the skimmer dewatering device.

FIGURE 6
Skimmer



θ should be 45° or less when the water surface is at the maximum pool elevation - the elevation of the 2 cfs/acre discharge.

FIGURE 7
Skimmer Orifice Design Chart



Skimmer Orifice design Example:

Find the vertical line representing the basin's dewatering zone volume. At the intersection of the vertical line with the desired dewatering time, read horizontally to the left to find the required skimmer orifice diameter. For example, for a basin volume of 40,000 cubic feet and a desired dewatering time of two days, the required skimmer orifice diameter is 3.2 inches. There should be at least 16 -½ " diameter holes (0.2 sq. in. per hole) in the underside of the water entry unit of the skimmer to allow water into the skimmer orifice. The outlet pipe or barrel must be capable of discharging at the rate permitted by the skimmer. Anti-seep collars are recommended for the barrel.

When highly erodible soils will be disturbed in the drainage area of a sediment basin, longer settling times will result in a higher percentage of suspended soilids removal. Therefore, settling times of 4 to 7 days are recommended in such situations.

Perforated Riser Dewatering

For sediment basins with perforated risers, designers may use the following Rule of Thumb. Provide 1 square inch of opening per acre of drainage area with all perforations one inch in diameter and equally spaced vertically along the riser. The lowest row of perforations is at the sediment storage zone elevation (i.e. sediment clean-out elevation). The number of perforations needed may be determined by dividing the total number of acres tributary to the basin by 0.785. No further computation of dewatering time is required if the Rule of Thumb is used correctly. The rule of thumb may not be used in Special Protection or High Quality watersheds where longer dewatering time is required.

Wherever total dewatering of the basin is necessary, and perforations are located below the sediment storage zone level, the rule of thumb may not be used. The discharge through the perforations in the sediment storage zone as well as perforations in the dewatering zone must be considered when computing dewatering time.

The Rule of Thumb is not a precise procedure. If a very accurate dewatering time is desired, Standard Worksheets #15 and 16 are recommended for this purpose.

Determine the principal spillway discharge capacity.

The combined capacities of the principal and emergency spillways must be at least 2 cfs/acre for the entire watershed of the basin.

The principal spillway is analyzed for three possible limiting flow types: Weir flow, Orifice flow, and Pipe flow. The principal spillway discharge capacity is the smallest of these three flow rates. Discharges through riser perforations or through a skimmer should be disregarded during this computation. Weir flow/orifice flow may be determined from Figure 8 or by the following equations:

1. Orifice Flow: $\mathbf{Q = CA\,(2gH)^{0.5}}$

Where: Q = discharge in cubic feet per second (cfs)
C = orifice coefficient, use C = 0.6 for corrugated metal pipe risers.
A = cross-sectional area of the riser pipe in square feet
g = acceleration due to gravity, 32.2 ft/sec^2
H = head above riser crest in feet

2. Weir Flow: $\mathbf{Q = CLH^{1.5}}$

Where: Q = discharge in cubic feet per second (cfs)
C = weir coefficient, use 3.1 for corrugated metal pipe risers.
L = circumference of the riser in feet
H = head above riser crest in feet

3. Pipe Flow: $\mathbf{Q = a\,[\,(2gh) / (1 + K_m + K_p L)\,]^{0.5}}$

Where: Q = discharge in cubic feet per second (cfs)
a = cross-sectional area of the barrel in square feet
g = acceleration due to gravity, 32.2 ft/sec^2
h = head above the centerline of the outlet end of the barrel
K_m = coefficient of minor losses, can be assumed to be 1.0 for most principal spillway systems
K_p = pipe friction coefficient = $(5087\,n^2) / di^{4/3}$ (See Table 14 for K_p values for common sizes of pipe.)

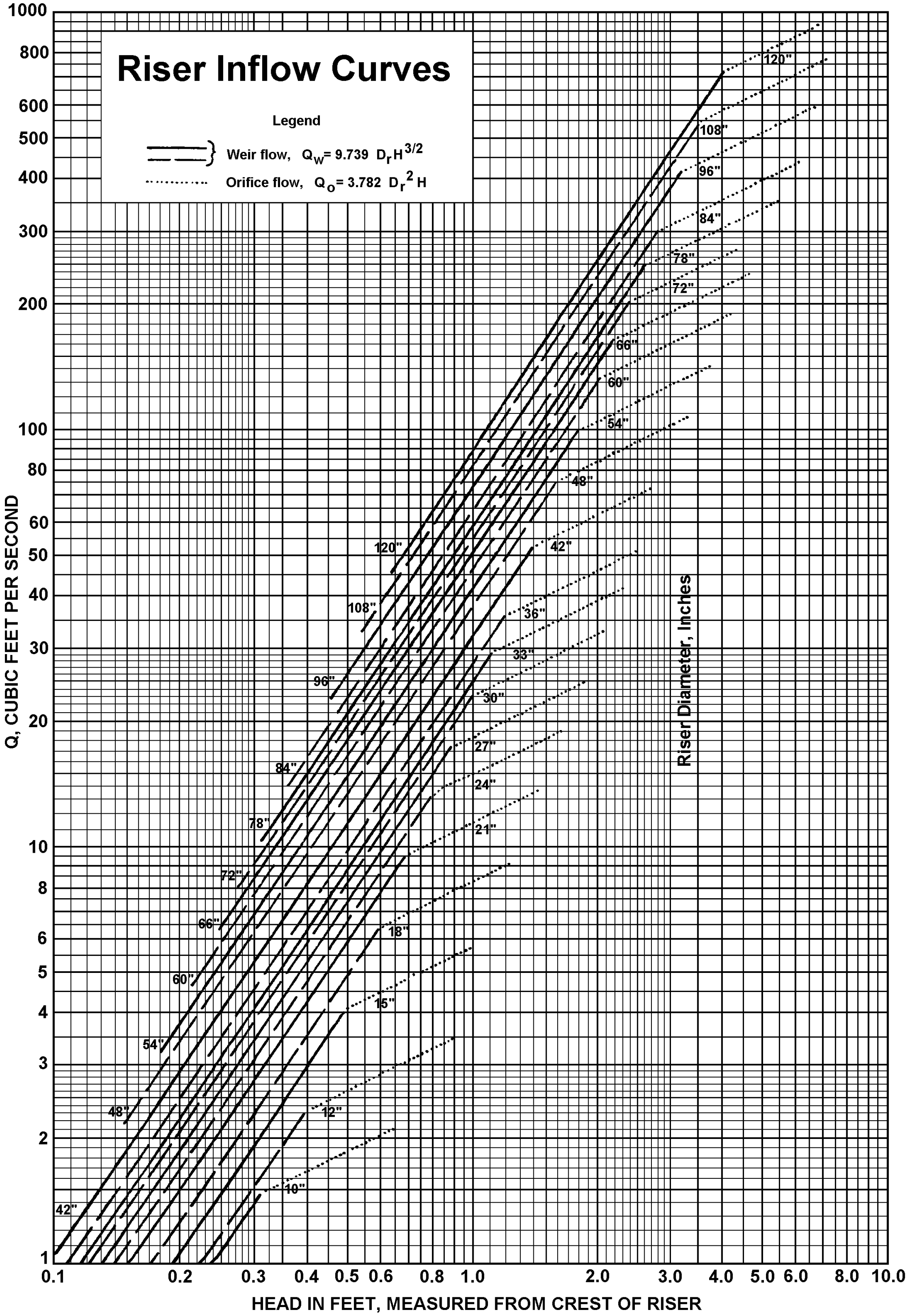
Where: n = Manning's coefficient of roughness,
use n = 0.025 for corrugated metal pipe
n = 0.015 for reinforced concrete pipe.
di = inside diameter of the barrel in inches

L = barrel length in feet

TABLE 14
K_p Values for Common Sizes of Pipe

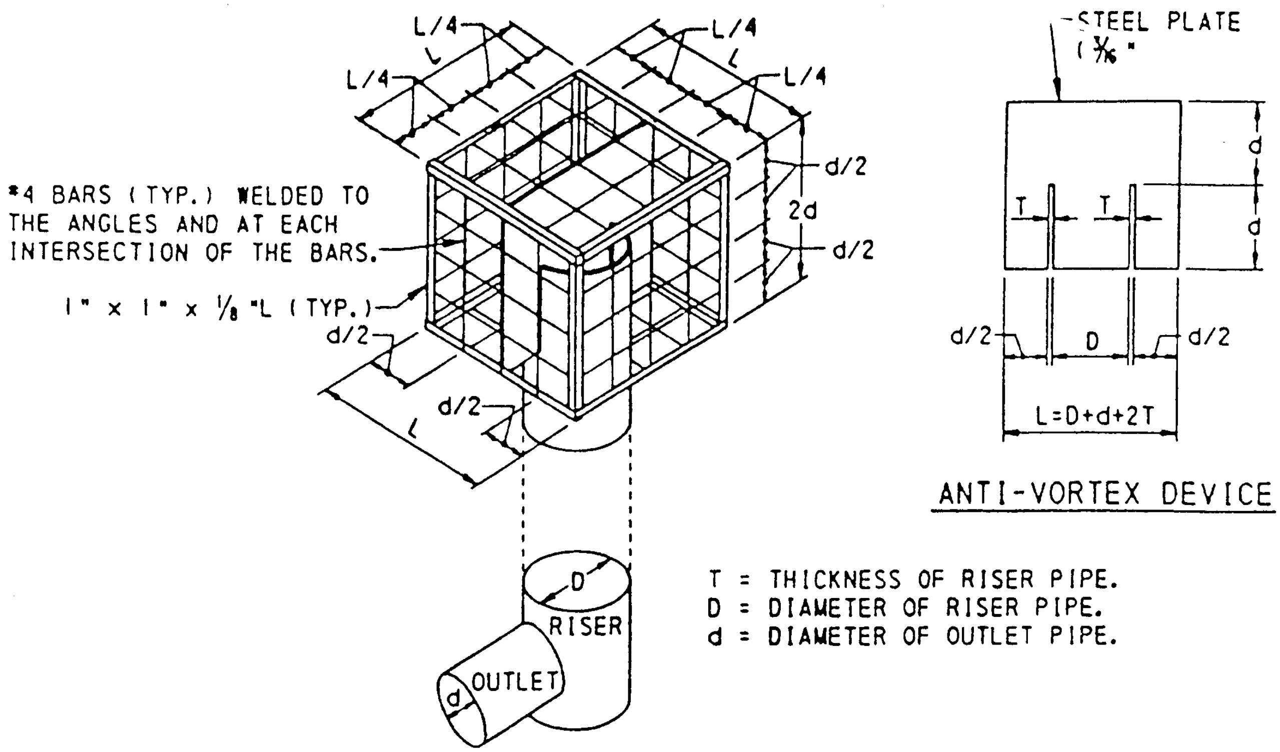
Pipe Diameter (inches)	Flow Area (sq ft)	Manning's Coefficient	
		0.015	0.025
6	0.196	0.1050	0.2916
8	0.349	0.0715	0.1987
10	0.545	0.0531	0.1476
12	0.785	0.0417	0.1157
14	1.069	0.0339	0.0942
15	1.23	0.0309	0.0859
16	1.40	0.0284	0.0789
18	1.77	0.0243	0.0674
21	2.41	0.0198	0.0549
24	3.14	0.0165	0.0459
27	3.98	0.0141	0.0393
30	4.91	0.0123	0.0341
36	7.07	0.0096	0.0267
42	9.62	0.0078	0.0218
48	12.57	0.0066	0.0182
54	15.90	0.0056	0.0156
60	19.64	0.0049	0.0135

FIGURE 8
Riser In flow Curves



The principal spillway riser should have a trash rack and an anti-vortex device.

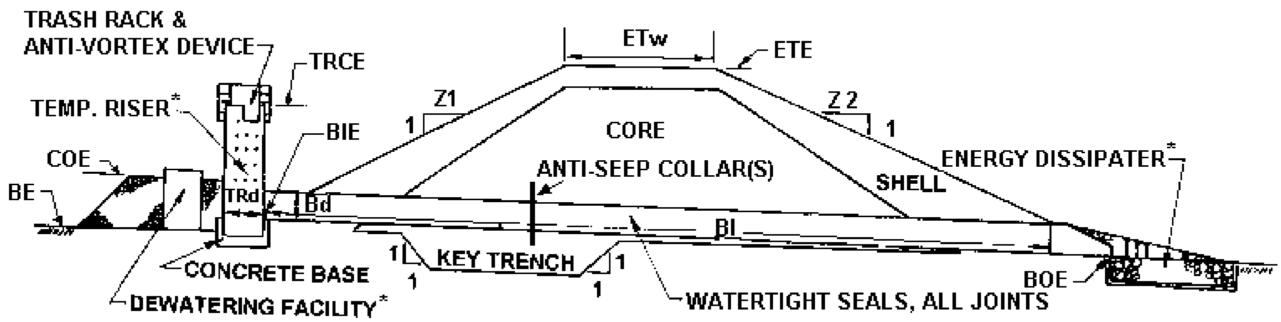
FIGURE 9
Typical Trash Rack and Anti-vortex Device



TRASH RACK AND ANTI-VORTEX DEVICE

The principal spillway riser must be securely anchored and attached to the outlet barrel with a water-tight seal (see Figure 10).

STANDARD CONSTRUCTION DETAIL #3
Sediment Basins



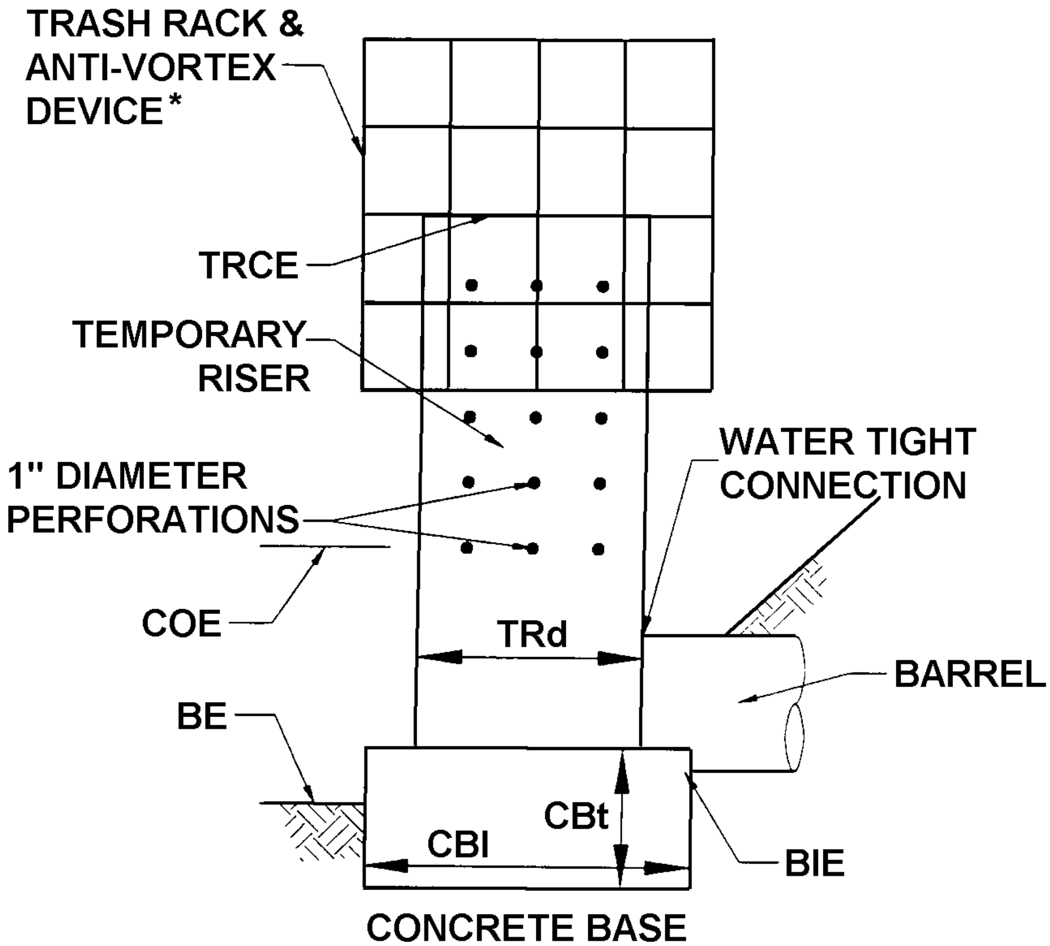
EMBANKMENT SECTION ALONG PRINCIPAL SPILLWAY*

BASIN NO.	Z1 (FT)	Z2 (FT)	TEMPORARY RISER DIA TRd (IN)	TEMPORARY RISER CREST ELEV TRCE (FT)	TEMPORARY RISER MAT'L	BARREL DIA Bd (IN)	BARREL INLET ELEV BIE (FT)	BARREL MAT'L	BARREL LENGTH BI (FT)	BARREL OUTLET ELEV BOE (FT)	EMBANKMENT TOP ELEV ETE (FT)	EMBANKMENT TOP WIDTH ETw (FT)	CLEAN OUT ELEV COE (FT)	BOTTOM ELEV BE (FT)

* Also refer to Sediment Basin Temporary Riser, Emergency Spillway, Energy Dissipater, Trash Rack & Anti-vortex Device, and Sediment Storage Dewatering Facility Details.

A clean out stake shall be placed near the center of each basin. Accumulated sediment shall be removed when it has reached the clean out elevation on the stake.

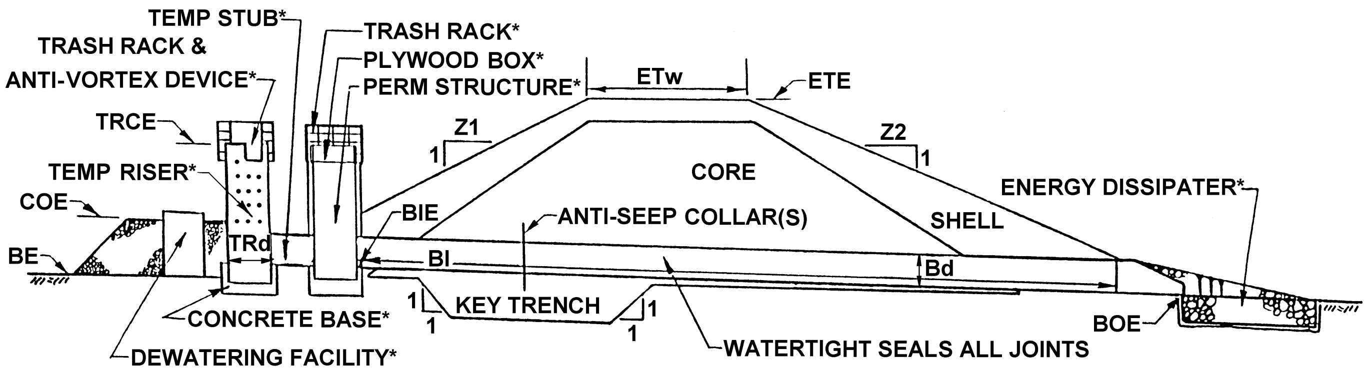
STANDARD CONSTRUCTION DETAIL #4
Sediment Basin Temporary Risers*



BASIN NO.	TEMPORARY RISER DIA TRd (IN)	CREST ELEV TRCE (FT)	MAT'L	PERFORATIONS NO. HOLES PER ROW	VERTICAL SPACING OF ROWS (FT)	CONCRETE BASE LENGTH CBI (IN)	WIDTH CBw (IN)	THICK. CBt (IN)	BARREL INLET ELEV BIE (FT)

* See Trash Rack & Anti-vortex Device Detail

STANDARD CONSTRUCTION DETAIL # 5
Sediment Basins With Permanent Storm Water Structures*



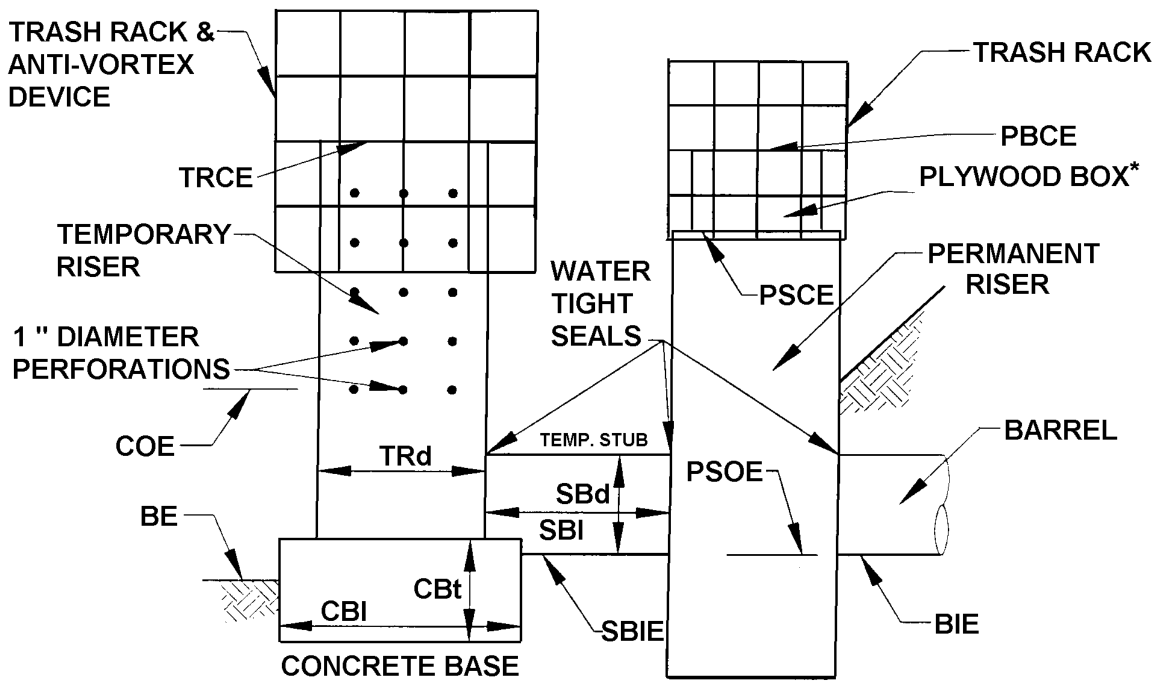
EMBANKMENT SECTION ALONG PRINCIPAL SPILLWAY*

			TEMPORARY RISER			BARREL					EMBANKMENT		CLEAN	
BASIN NO.	Z1 (FT)	Z2 (FT)	DIA TRd (IN)	CREST ELEV TRCE (FT)	MAT'L	DIA Bd (IN)	INLET ELEV BIE (FT)	MAT'L	LENGTH BI (FT)	OUTLET ELEV BOE (FT)	TOP ELEV ETE (FT)	TOP WIDTH ETw (FT)	OUT ELEV COE (FT)	BOTTOM ELEV BE (FT)

* See Sediment Basin Temporary Riser & Permanent Structure, Emergency Spillway, Trash Rack & Anti-vortex Device, Energy Dissipater, and Sediment Storage Dewatering Facility details.

A Clean out Stake shall be placed near the center of each basin. Accumulated sediment shall be removed when it has reached the clean out level marked on the stake.

STANDARD CONSTRUCTION DETAIL #6
Sediment Basin Temporary Riser & Permanent Structure*

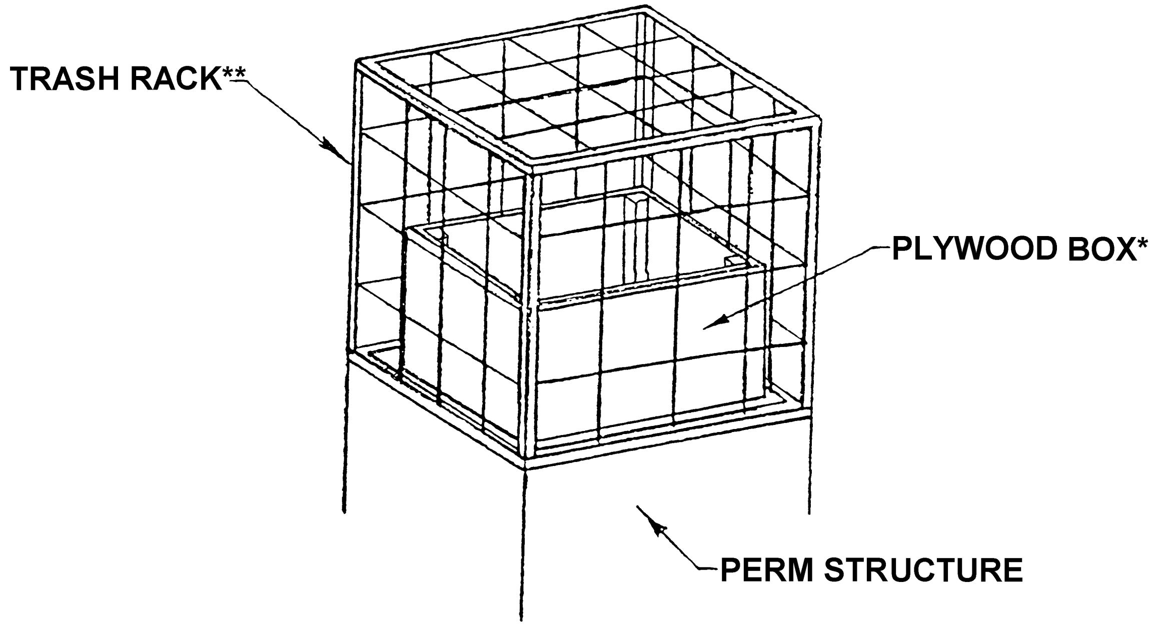


BASIN NO.	TEMPORARY RISER			PERFORATIONS		CONCRETE BASE			BARREL
	DIA TRd (IN)	CREST ELEV TRCE (FT)	MAT'L	NO. HOLES PER ROW	VERTICAL SPACING OF ROWS (FT)	LENGTH CBI (IN)	WIDTH CBw (IN)	THICK. CBt (IN)	INLET ELEV BIE (FT)

BASIN NO.	TEMPORARY STUB				PERMANENT STRUCTURE			
	DIA SBd (IN)	INVERT ELEV SBIE (FT)	MAT'L	LENGTH SBI (FT)	CREST ELEV PSCE (FT)	OPENING LENGTH PSOI (IN)	OPENING WIDTH PSOw (IN)	OUTLET ELEV PSOE (FT)

* See Trash Rack & Anti-vortex Device and Plywood Box Details.

STANDARD CONSTRUCTION DETAIL #7
Plywood Boxes And Trash Racks For Permanent Structures



* ¾” Marine grade plywood box with 2” × 2” pressure treated corner supports, set into 1 ½” grate offsets, caulk all seams to form watertight seals.

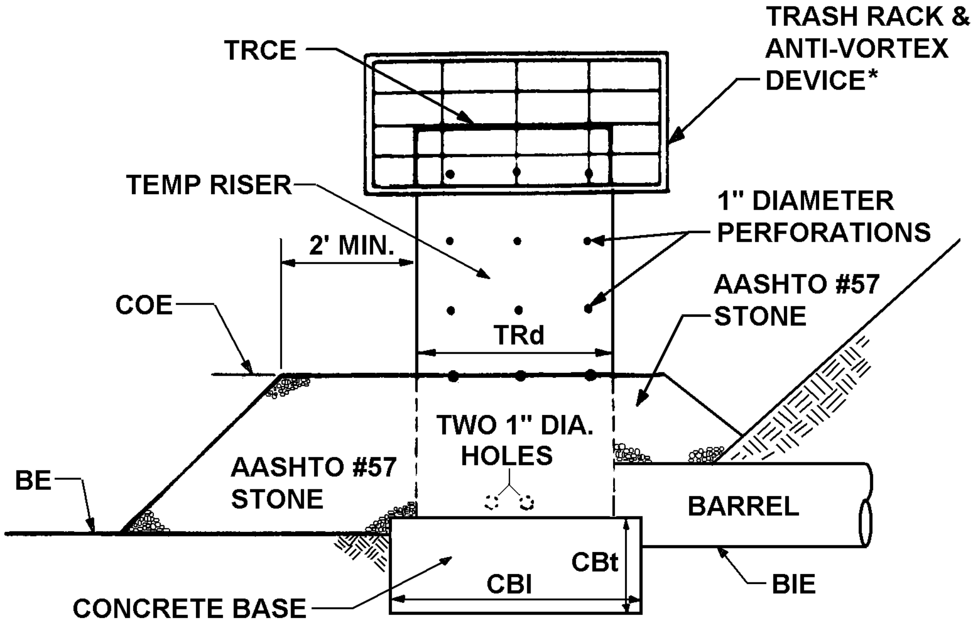
** Trash rack composed of 1” × 1” × 1/8” L (Typ.) and #4 Bars (Typ.) welded to the angles and at each intersection of the bars; #4 Bars spaced @ ½ the diameter of the barrel max.

Plywood box must be bolted or strapped to the permanent riser.

Top of plywood box must be at least as high as temporary riser.

Wherever total basin dewatering is required, two 1” diameter holes should be located at the bottom of the riser and a 2’ thick layer of AASHTO #57 stone placed around the riser up to the sediment storage zone (or cleanout) elevation. Filter cloth wrapped around the riser is not an acceptable alternative. (See Figure 10).

FIGURE 10
Dry Sediment Basin Temporary Riser*



BASIN NO.	TEMPORARY RISER			PERFORATIONS			CONCRETE BASE		BARREL
	DIA TRd (IN)	CREST ELEV TRCE (FT)	MAT'L	NO. HOLES PER ROW	VERTICAL SPACING (FT)	BOTTOM ROW ELEV COE (FT)	LENGTH & WIDTH CBI (IN)	THICK. CBt (IN)	INLET ELEV BIE (FT)

* See Trash Rack & Anti-vortex Device Detail

A minimum of 24 inches of freeboard is required above the elevation of the 2 cubic feet per second per acre discharge. Assuming the emergency spillway is being used to discharge part of the 2 cfs/acre discharge, the freeboard must be provided above the design flow elevation in the emergency spillway.

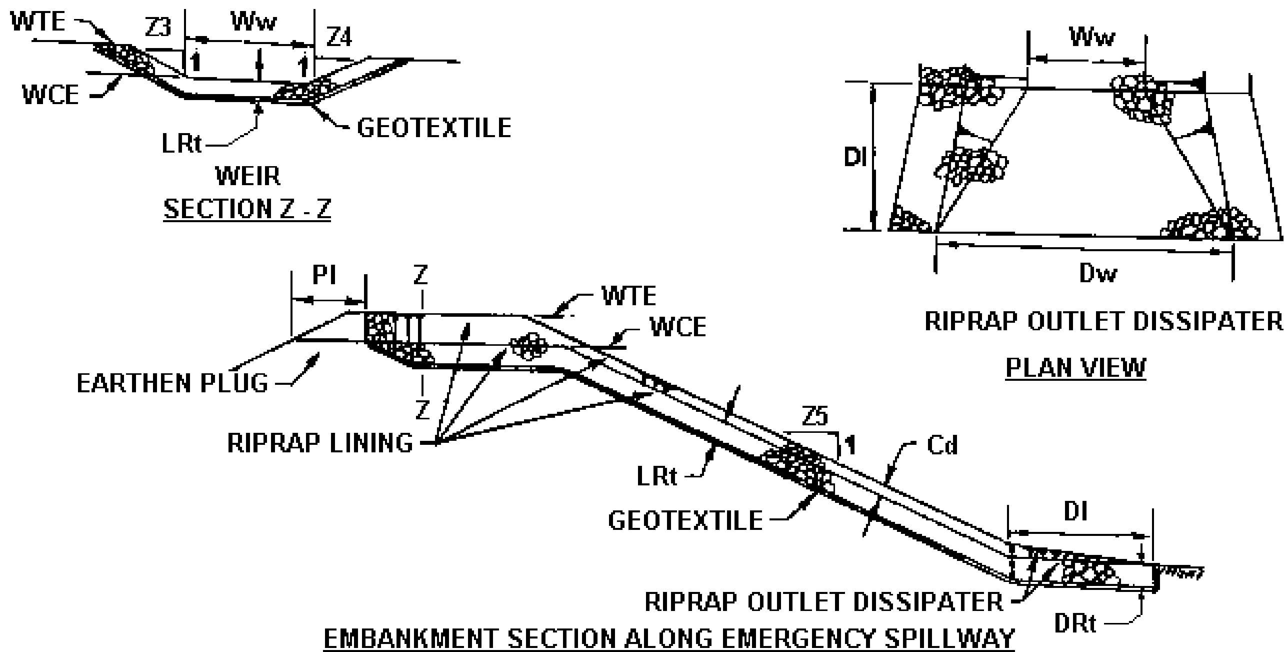
Every sediment basin should be provided with an emergency spillway.

The elevation of the emergency spillway crest must be at least 6” above that of the principal spillway.

Wherever an emergency spillway is located on a constructed embankment it must have a riprap or other stable permanent lining which extends to the receiving waterway, channel or other non-erosive outlet .

Wherever riprap is used as a protective liner in an emergency spillway, a compacted and stabilized earthen plug should be left in place (on the inner side of the spillway) to prevent water from discharging through the emergency spillway until the design water elevation is reached (see Standard Construction Detail #8).

STANDARD CONSTRUCTION DETAIL #8
Sediment Basin Emergency Spillways



BASIN NO.	WEIR Z3 (FT)	Z4 (FT)	TOP ELEV WTE (FT)	CREST ELEV WCE (FT)	WIDTH Ww (FT)	LINING RIPRAP SIZE (R-__)	RIPRAP THICK. LRt (IN)	CHANNEL Z5 (FT)	DEPTH Cd (FT)	DISSIPATER LENGTH Dl (FT)	WIDTH Dw (FT)	RIPRAP SIZE (R-___)	RIPRAP THICK. DRt (IN)

Dimension Pl should be 5' minimum.

Check the capacity of the emergency spillway.

1. Tables provided in Chapter 11 of the NRCS' Engineering Field Manual are recommended for determining emergency spillway capacity.

2. An acceptable alternative is the use of the weir equation:

$$Q = CLH^{1.5}$$

   Where this option is used, the maximum value of C should be 2.8. L is the bottom width of the spillway at the crest, and H is the depth of flow above the spillway crest. Note: Manning's channel equation should not be used to size the spillway crest. However, it should be used to design the outlet channel below the spillway crest.

3. The total of the emergency and principal spillway capacities must equal or exceed the required 2 cfs/acre discharge capacity.

4. Once the depth of flow through the emergency spillway has been determined, the elevation of the top of the embankment can be computed. This elevation must be at least 2 feet (24”) above the water surface elevation at which the required 2 cfs/acre discharge capacity is provided.

The discharge from a sediment basin must be to waters of the Commonwealth or other approved alternative, and shall be designed, operated, and maintained without causing accelerated erosion or sedimentation. Approved alternatives include stable constructed channels, storm sewers, and similar facilities that can accept the discharge with no erosion occurring.

Provide a suitable protective lining for each collection channel or other device that discharges to the basin; the lining should extend to the bottom of the basin and at least 10' along the basin bottom to dissipate excess energy.

Stabilize all interior slopes of the basin above the sediment storage zone (or permanent pool) elevation and the interior and exterior slopes of the embankment immediately upon completion of the basin.

DO NOT LOCATE SEDIMENT BASINS IN STREAM CHANNELS, WATERWAYS, OR IN WETLANDS.

The minimum flow length to width ratio is 2:1. The following formula may be used to determine if this criteria is met:

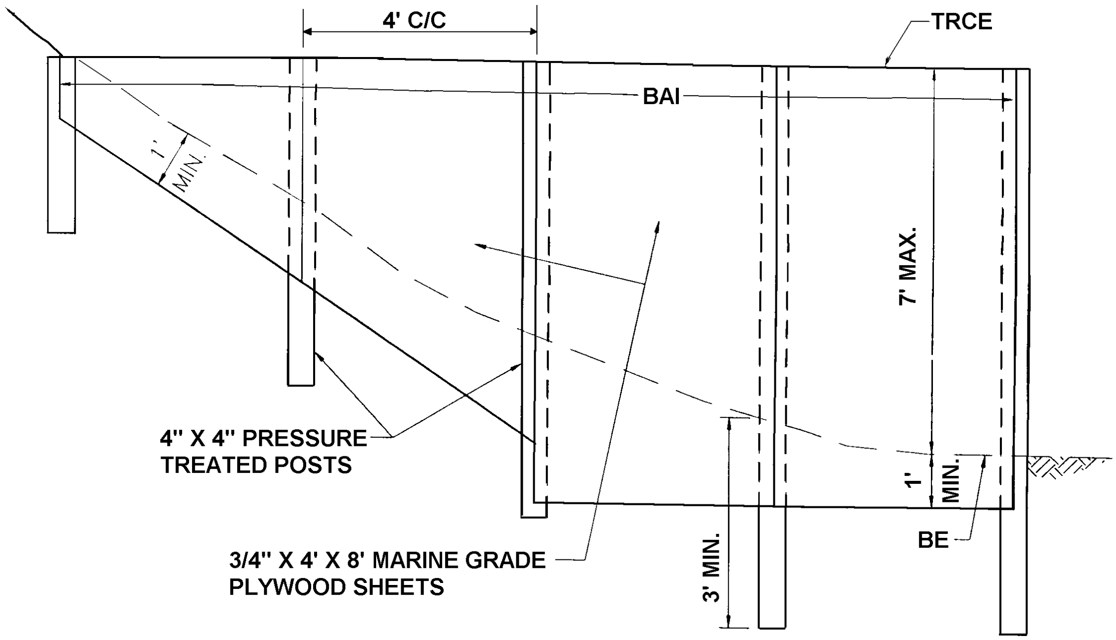
$$\mathbf{L_{(min)} = 1.41 \ (SA_3)^{0.5}}$$

Where: $L_{(min)}$ = Minimum Flow Length
SA_3 = Surface Area at the top of the dewatering volume

If the flow length from the outlet of an collector channel or inflow pipe to the principal spillway is not $\geq L_{(min)}$, either the collector alignment should be revised (e.g. moved so that the inlet to the basin is farther away from the principal spillway), or one or more baffles should be used to increase the flow length within the basin (see Figure 11 and Standard Construction Detail #9). Flow length is to be measured at the elevation of the top of the dewatering zone.

Where runoff from disturbed areas enters basins from different directions, it is better to combine flows from the various areas into a single inlet to the basin rather than have multiple inlets to the basin. If a designer chooses to reduce the settling volume of a basin by increasing the flow length to width ratio to 4:1, the flow length to width ratio for all inlets must be at least 4:1.

STANDARD CONSTRUCTION DETAIL #9
Baffles

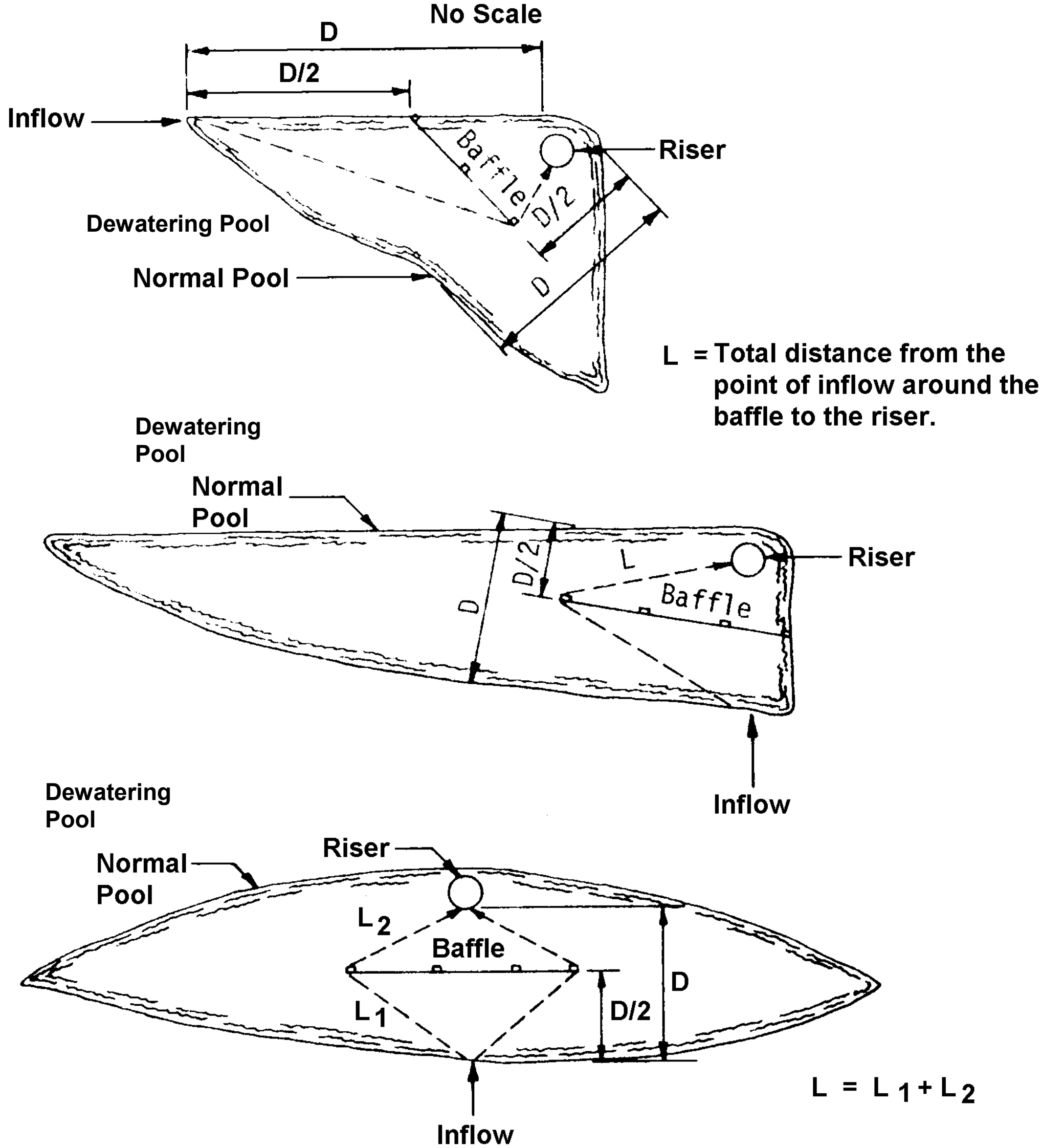


In pools with depths exceeding 7', the top of the plywood baffle does not need to extend to the temporary riser crest.

BASIN NO.	BAFFLE LENGTH BAI (FT)	BAFFLE HEIGHT	TEMPORARY RISER CREST ELEV TRCE (FT)	BOTTOM BOTTOM ELEV BE (FT)

FIGURE 11
Use of Baffles in Sediment Basins

EXAMPLE PLAN VIEWS OF BAFFLE LOCATIONS IN SEDIMENT BASINS



Outlet barrels should be installed early in the construction of the embankment (not after the embankment is completed), and shall drain to a stable receiving watercourse. Basins should not be constructed in locations where subsequent trenching for sewer lines and utilities will disturb the embankment.

Wherever soils susceptible to piping are encountered, either anti-seep collars or gravel packs should be installed with the outlet barrel.

The following procedure provides the dimensions of anti-seep collars required for *temporary sediment basins only*. It will provide an increase to the seepage length of 10 percent for various pipe (barrel) slopes, embankment side slopes, and principal spillway riser heights. It does not apply to permanent basins, which require an increase in the seepage length of at least 15 percent.

(1) Determine the length of pipe in the saturated zone (L_S). See Figure 13.

$$L_s = y\,(z + 4)\left[1 + \frac{\text{pipe slope (ft / ft)}}{0.25 - \text{pipe slope}}\right]$$

where: L_S = Length of pipe in saturated zone (ft)
y = Distance from upstream invert of principal spillway riser to top of dewatering volume.
z = Horizontal component of upstream embankment slope (ft)

To determine L_S graphically, refer to Figure 13

Example: y = 8 ft., embankment inside slope = 2.5:1, pipe slope = 10%

L_S = 87 feet

(2) Determine number and spacing of anti-seep collars.

(3) Enter Figure 14 from the left at the location corresponding to L_S as calculated above. Draw a horizontal line to the point where it intersects with the line that matches the desired number of collars. Draw a vertical line from that point to the line in the upper chart that corresponds to the diameter of the pipe (barrel). From that point, draw a horizontal line to the right to read the required size of the collar(s). If this is too large, the number of collars should be increased.

(4) The maximum spacing between collars should be 14 × V (from Figure 12).

(5) Anti-seep Collars and their connections to the pipe (barrel) must be watertight.

(6) Anti-seep Collars should be located below the phreatic line in the embankment and should be evenly spaced.

(7) They should not be located closer than 2 feet to a pipe joint.

(8) There must be sufficient distance between collars for hauling and compacting equipment.

FIGURE 12
Anti-seep Collar Design

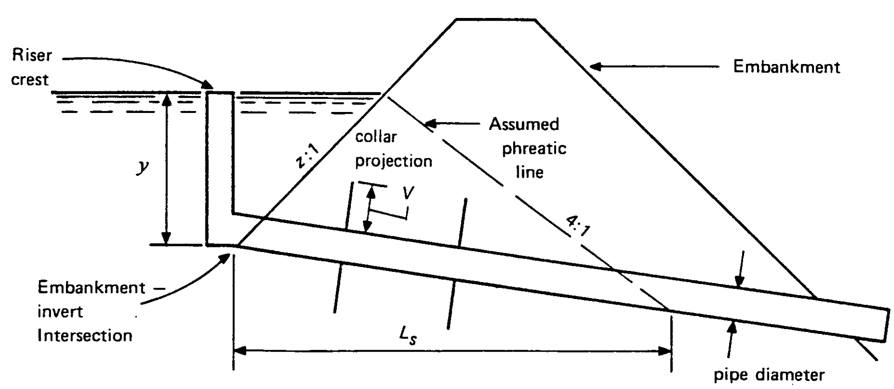


FIGURE 13
Graphical Determination of Length of Pipe in the Saturated Zone (L_s)

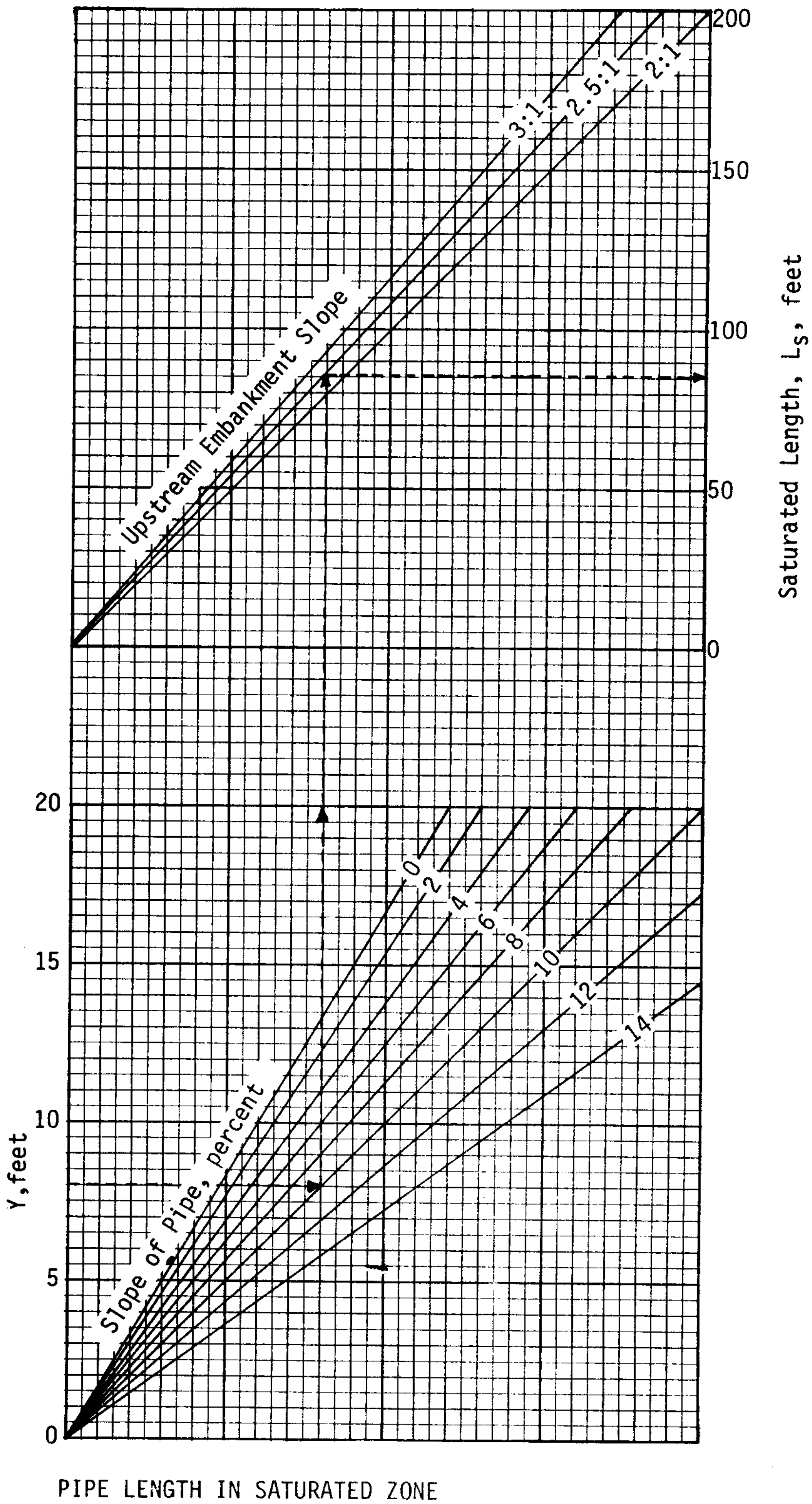
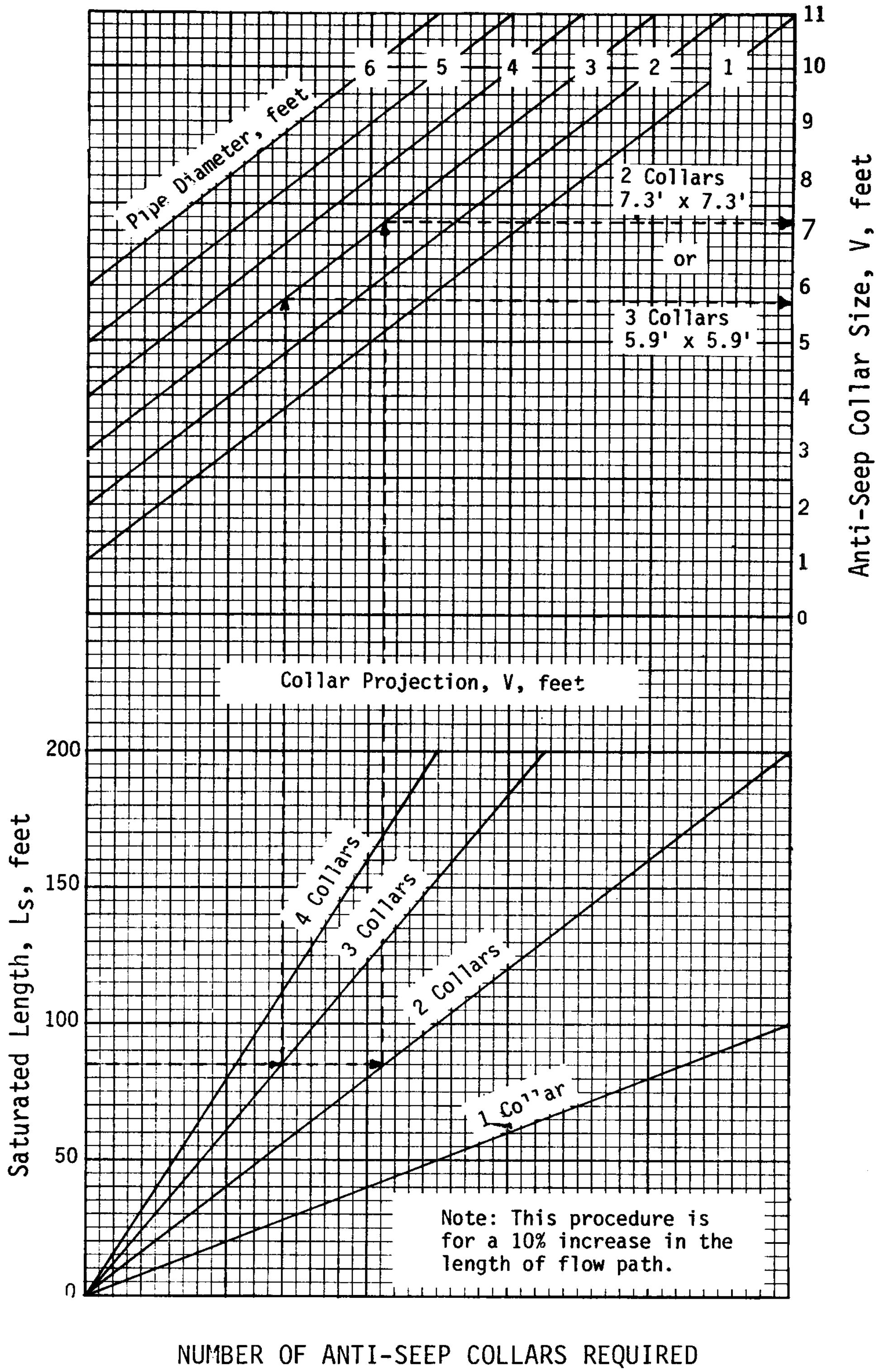
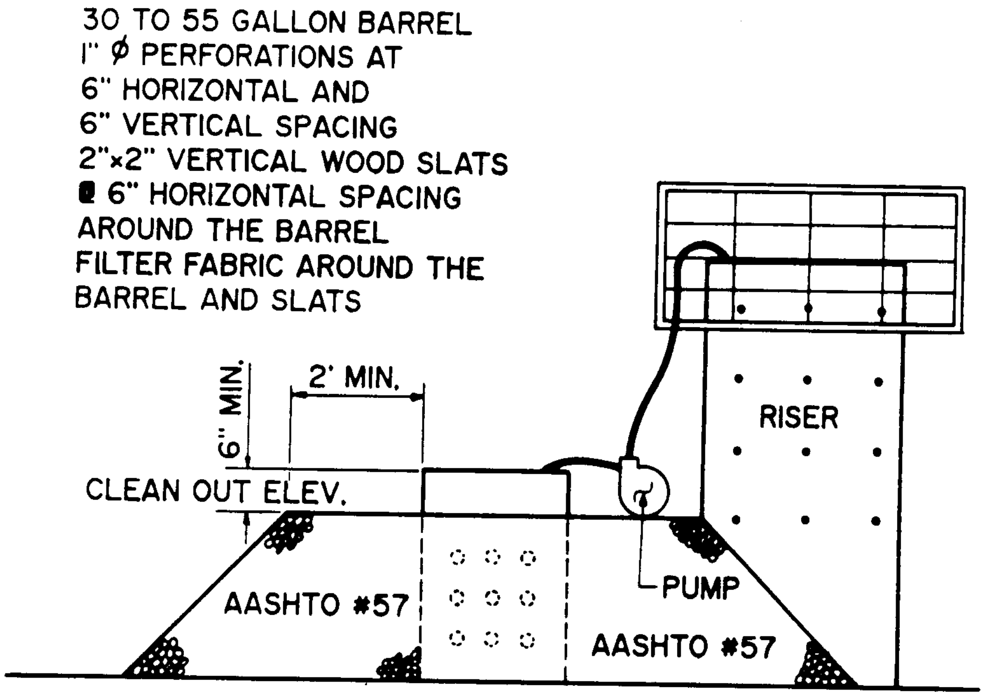


FIGURE 14
Graphical Determination of Anti-seep Collar Size



STANDARD CONSTRUCTION DETAIL #10
Sediment Basin or Sediment trap Sediment Storage Dewatering Facility



Provide construction details for each proposed sediment basin on the erosion and sediment control plans. The plan view should indicate the principal and emergency spillway locations, the Inlets from all pipes and Interceptor Channels, and any proposed Outlet Protection. Also provide a construction detail of the principal and emergency spillways showing all critical dimensions and elevations. A summary table showing all critical dimensions and elevations for each basin is also recommended.

Include construction specifications, such as:

Sediment basins, including all appurtenant works, shall be constructed to the detail and dimensions shown on the E & SPC Plan Drawings.

Fill material for the embankments shall be free of roots, or other woody vegetation, organic material, large stones, and other objectionable materials. The embankment shall be compacted in layered lifts.

Upon completion, the embankment shall be seeded and mulched or otherwise stabilized according to the specifications of the E & SPC Plan Drawings.

Include maintenance requirements, such as:

Inspect all sediment basins on at least a weekly basis and after each runoff event.

Provide access for sediment removal and other required maintenance activities.

Remove sediment and restore the basin to its original dimensions when the sediment has accumulated to the level shown on the sediment clean-out stake located near the center of the basin. Dispose of materials removed from the basin in the manner described in the E & SPC plan.

Repair clogged or damaged spillways immediately.

Remove trash and other debris from the basin and riser.

Check basin embankments, spillways, and outlets for erosion, piping and settlement. Make necessary repairs immediately.

Replace displaced riprap within the outlet energy dissipater immediately after it is displaced and especially after major storm discharge events.

Remove accumulated sediment and stabilize disturbed areas inside the basin before any sediment basin may be converted to a stormwater management facility. To assist in removing sediment, which is usually saturated, a device such as is shown in Standard Construction Detail #10 may be used to dewater the sediment prior to it's removal. Add rock filters as necessary.

SEDIMENT TRAPS

GENERAL CONSIDERATIONS

Sediment Traps may be designed to function as Temporary Facilities, or be incorporated into the Stormwater Management System upon completion of the project. In the latter case, the trap must be dewatered, cleaned, and stabilized prior to its conversion to a detention pond. Standard Construction Detail #10, found in the section on Sediment Basins, is a detail of a recommended “Sediment Basin or Sediment Trap Sediment Storage Dewatering Facility,” which may be used for this purpose.

Sediment Traps must have a length to width ratio of at least 2:1. Field conditions, ease of construction, and trapping efficiency should be considered in choosing the configuration. There are, however, certain design requirements that must be satisfied for all sediment traps. Standard Worksheets #8 through 11 are recommended for organizing and submitting sediment trap data.

Wherever possible, Sediment Traps should be located below all proposed areas of disturbance. Locating traps within proposed grading areas typically results in a major portion of the earthmoving taking place without benefit of the control facility being in place that was designed to handle runoff from the disturbed areas. Collection channels should enter the trap on the upslope side so that they will not adversely affect the storage capacity of the basin.

Consideration should be given to how the location of any proposed trap will be accessed. If a proposed location is not easily accessible, special attention must be given to any access roads that will be constructed.

Intersection of a trap by proposed or existing sewer lines, utility lines, roadways, or other structures should be avoided wherever possible. Wherever this is not possible, the plan should address how the integrity/capacity of the trap will be maintained.

Location of traps on steep slopes or on unstable soils should be avoided wherever possible. Where this is not possible, the plan should address how failure of the trap will be avoided.

Sediment traps should not be located within live stream channels (unless the channel will be eliminated by the proposed construction) or in wetlands.

DESIGN CRITERIA

1. The maximum permissible drainage area is 5.0 acres

2. Sediment traps must have a minimum storage volume of 2,000 cubic feet for each acre of contributing drainage area (disturbed and undisturbed). 700 cubic feet/acre shall be considered sediment storage. 1,300 cubic feet/acre shall be considered settling volume. Supporting computations must be provided for irregularly shaped traps (Standard Worksheet #14 is recommended for this purpose).

3. Minimum Length (L) of Flow Through Trap is 10 ft.*

4. Sediment traps must discharge to stable, erosion resistant areas and not create offsite stormwater problems. Wherever a trap must discharge down a long or steep slope, consideration should be given to using a barrel/riser type spillway in conjunction with a temporary slope pipe. Suitable outlet protection must be provided at the pipe outfall.

   * These specifications may be waived for traps constructed around an inlet structure.

See Figure 11 and Standard Construction Detail #9 in the section on Sediment Basins for details about baffles.

5. Minimum trap storage depth is 2.0 ft. (Minimum 1' for sediment; minimum 1' for dewatering zone)

6. Traps must be able to dewater the settling volume completely. Wherever total dewatering is desired, adequate filtering must be provided.

7. Maximum Constructed Embankment Height is 5.0' unless berm is construced as a permanent stormwater management basin.

8. Minimum embankment top width is 5.0'

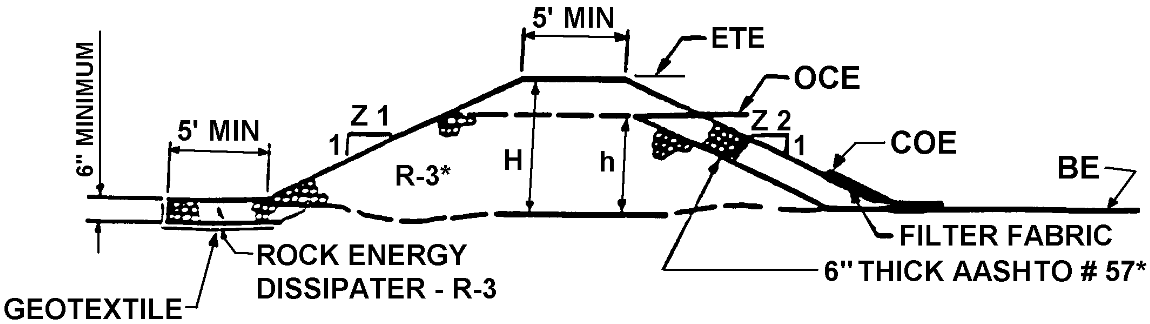
9. Maximum Embankment Side Slopes is 2:1 (H:V)

10. Minimum Freeboard above Maximum Design Water Level is 12".

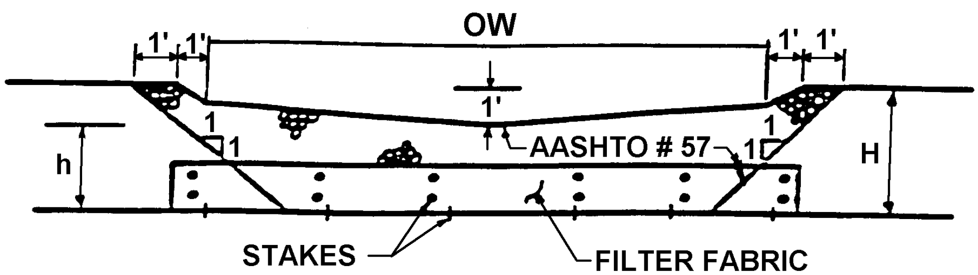
11. Outlets shall be designed as follows:

For traps with Embankment Spillways, the minimum embankment spillway width (in feet) is 2 times the number of acres of contributing drainage area, or 2 times the height of the spillway crest, which ever is greater. The minimum spillway crest elevation is the elevation at which the required 2,000 cubic feet per contributing drainage acre storage capacity is provided. The maximum spillway side slope is 2:1 (H:V). The minimum rock size for construction of spillway is R-3. (NOTE: The entire spillway should be constructed with rock; see Standard Construction Detail #11). The inside face of the spillway should be covered with a 6" (minimum) thick layer of filter stone (maximum size = AASHTO #57). Filter fabric should be securely staked on top of the filter stone up to the Sediment Storage Elevation. Any excess fabric should be staked to the bottom of the trap.

STANDARD CONSTRUCTION DETAIL #11
Embankment Sediment Traps



SECTION THROUGH SPILLWAY*



INSIDE FACE

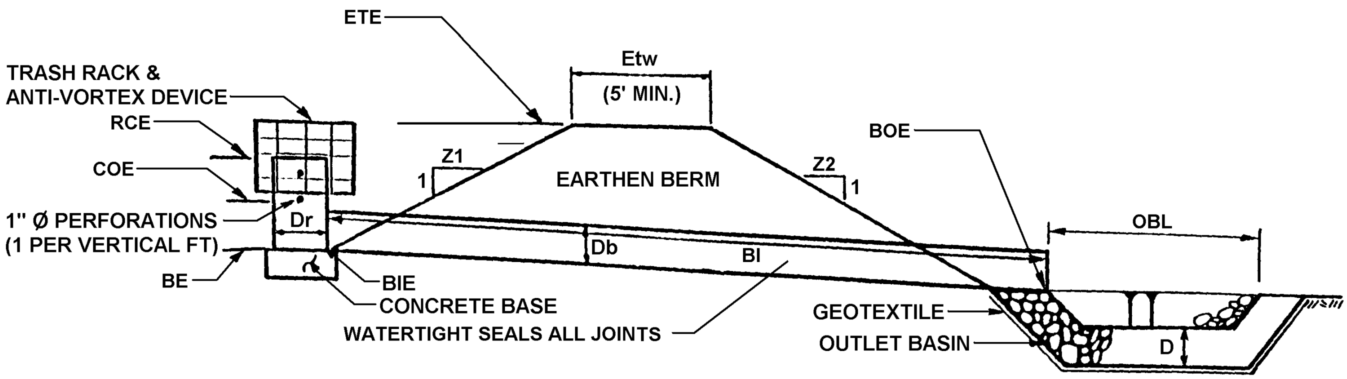
TRAP NO.	Z1 (FT)	H (FT)	h (FT)	Z2 (FT)	EMBANK. TOP ELEV. ETE (FT)	OUTLET CREST ELEV. OCE (FT)	CLEAN OUT ELEV. COE (FT)	BOTTOM ELEV. BE (FT)	OUTLET WIDTH OW (FT)

* Embankment outlet composed entirely of rock; main body R-3 or larger, inside face AASHTO # 57 stone or smaller.

Clean out stake shall be placed near center of each trap. Accumulated sediment shall be removed when it reaches the clean out elevation marked on the stake.

For traps with barrel/riser spillways, the crest of the riser should be set at the elevation at which the required 2,000 cubic feet/acre storage capacity is provided. The riser and outlet barrel should be sized to provide 1.5 cfs/acre (minimum) discharge capacity. Supporting calculations must be provided. The embankment must provide at least 12” of Freeboard above the maximum design water elevation (the elevation at which the 1.5 cfs/acre discharge capacity is provided). Perforations in the riser to dewater the trap should be limited to one 1” diameter hole per vertical foot of riser with the lowest perforation at the sediment storage elevation (see Standard Construction Detail #12).

STANDARD CONSTRUCTION DETAIL #12
Barrel/Riser Sediment Traps



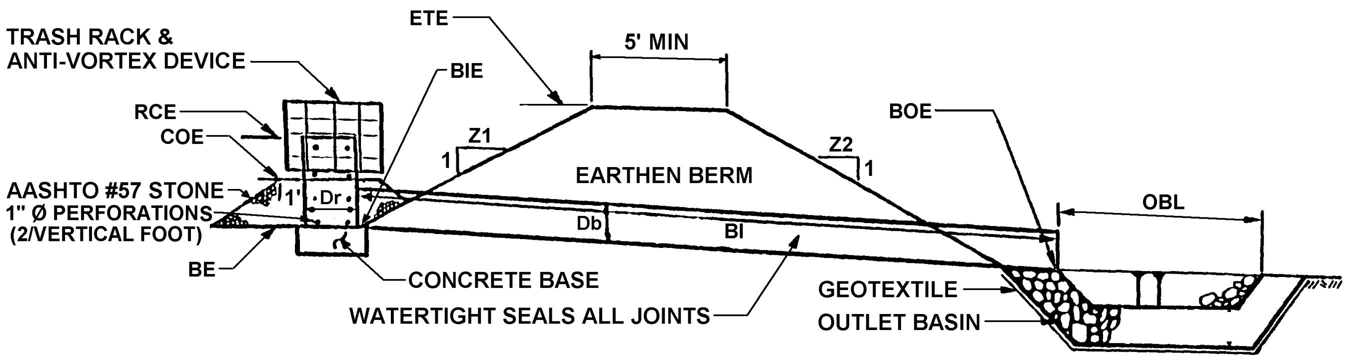
BASIN NO.	Z1 (FT)	Z2 (FT)	RISER MAT'L	RISER DIA Dr (IN)	RISER CREST ELEV RCE (FT)	RISER BOT. PERF. ELEV (FT)	BARREL MAT'L	BARREL DIA Db (IN)	BARREL INLET ELEV BIE (FT)	BARREL LENGTH Bl (FT)	BARREL OUTLET ELEV BOE (FT)	EMBANKMENT TOP ELEV ETE (FT)	EMBANKMENT TOP WIDTH Etw (FT)	CLEAN OUT ELEV COE (FT)	BOTTOM ELEV BE (FT)

TRAP NO.	CONCRETE BASE LENGTH CBl (IN)	CONCRETE BASE WIDTH CBw (IN)	CONCRETE BASE THICKNESS CBt (IN)	OUTLET BASIN RIPRAP SIZE (R-___)	OUTLET BASIN DEPTH D (IN)	OUTLET BASIN WIDTH OBW (FT)	OUTLET BASIN LENGTH OBL (FT)

Clean out stakes shall be placed near center of trap. Accumulated sediment shall be removed when it reaches the clean out mark on the stake.

Wherever it is necessary to totally dewater a barrel/riser type trap, the riser should be designed according to the specifications shown in Standard Construction Detail #13.

STANDARD CONSTRUCTION DETAIL #13
Dry Barrel / Riser Sediment Traps



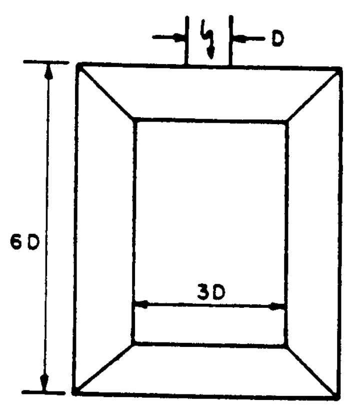
TRAP NO.	Z1 (FT)	Z2 (FT)	RISER MAT'L	RISER DIA Dr (IN)	RISER CREST ELEV RCE (FT)	RISER BOT. PERF. ELEV (FT)	BARREL MAT'L	BARREL DIA Db (IN)	BARREL INLET ELEV BIE (FT)	BARREL LENGTH BI (FT)	BARREL OUTLET ELEV BOE (FT)	EMBANK TOP ELEV ETE (FT)	CLEAN OUT ELEV COE (FT)	BOTT'M ELEV BE (FT)

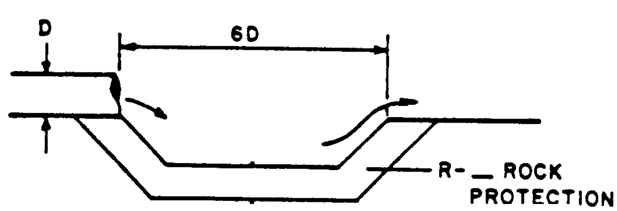
TRAP NO.	CONCRETE BASE LENGTH CBI (IN)	CONCRETE BASE WIDTH CBw (IN)	CONCRETE BASE THICKNESS CBt (IN)	OUTLET BASIN RIPRAP SIZE (R-___)	OUTLET BASIN DEPTH D (IN)	OUTLET BASIN WIDTH OBW (FT)	OUTLET BASIN LENGTH OBL (FT)

Clean out stakes shall be placed near center of trap. Accumulated sediment shall be removed when it reaches the clean out mark on the stake.

At a minimum, outlet protection should consist of a Rock Outlet Basin with dimensions conforming to those shown in Figure 15.

FIGURE 15
Sediment Trap Outlet Basin Details





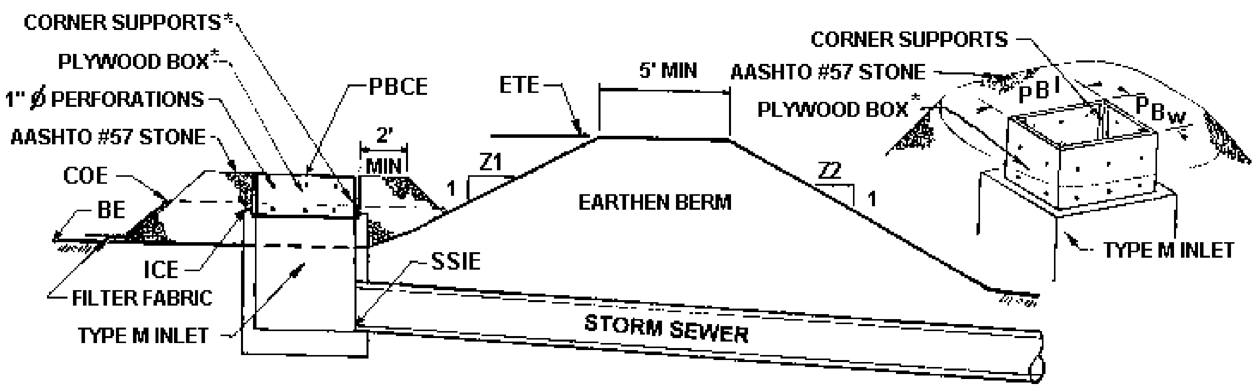
Note: Basin Depth = D
For Rock Protection Placement
Thickness, See Table 9.

A trash rack and anti-vortex device (see Figure 9) shall be provided for all barrel/riser type spillways.

Inlet Sediment Traps

Sediment Traps excavated or constructed around any type of inlet structure must satisfy items 1., 2., and 5. through 12. above. All inlet sediment traps shall conform to the specifications shown in Standard Construction Detail #14.

STANDARD CONSTRUCTION DETAIL #14
Type M Inlet Sediment Traps



TRAP NO.	Z1 (FT)	Z2 (FT)	PLYWOOD BOX LENGTH PBl (IN)	PLYWOOD BOX WIDTH PBw (IN)	PLYWOOD BOX CREST ELEV PBCE (FT)	PERFORATIONS NO. PER ROW	PERFORATIONS ROW ELEV (FT)	INLET CREST ELEV ICE (FT)	STORM SEWER INVERT ELEV SSIE (FT)	EMBANK TOP ELEV ETE (FT)	CLEAN OUT ELEV COE (FT)	BOTTOM ELEV BE (FT)
			48 1/4	27		10						

*3/4" Marine grade plywood box with 2" × 2" pressure treated corner supports, set into Type M Inlet 1 ½" grate offsets, caulk all seams to form watertight seals.

Clean out stakes shall be placed near center of trap. Accumulated sediment shall be removed when it reaches the clean out mark on the stake.

MAINTENANCE

At a minimum, sediment traps shall be inspected on a weekly basis <u>and</u> after each runoff event. Sediment must be removed from the trap when the storage volume has been reduced to 1,300 cubic feet per acre of contributing drainage area. This elevation should be clearly marked on a stake near the center of the trap.

Clogged or damaged spillways shall be immediately restored to the design specifications.

Other required maintenance shall be completed within 5 working days of the inspection.

STABILIZATION METHODS AND STANDARDS

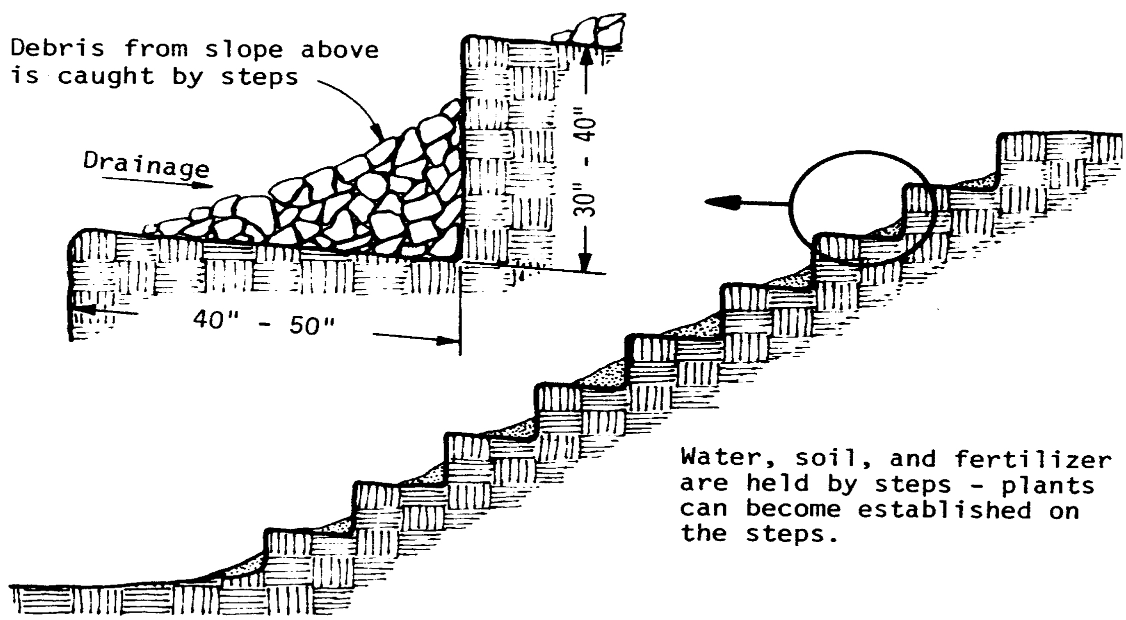
GENERAL - As soon as slopes, channels, ditches, and other disturbed areas reach final grade they must be stabilized. Upon completion or temporary cessation of the earth disturbance activity, or any stage thereof in Special Protection watersheds, the project site shall be immediately stabilized. This chapter is intended to provide specifications for stabilization and information that is useful in achieving stabilization in the least amount of time.

SITE PREPARATION On slopes that are 3:1 or steeper, and more than 40' high, benches at 30' vertical intervals are recommended.

<u>SURFACE ROUGHENING</u> is the practice of providing a rough soil surface with horizontal depressions for the purpose of reducing runoff velocity, increasing infiltration, aiding the establishment of vegetation, and reducing erosion. Surface roughening and erosion control blankets should be applied to all slopes steeper than 3:1 unless a stable rock face is provided. Details for Stair Stepping, Grooving, and Tracking are provided below. Details for benches are found in Table 20 and Standard Construction Detail #24.

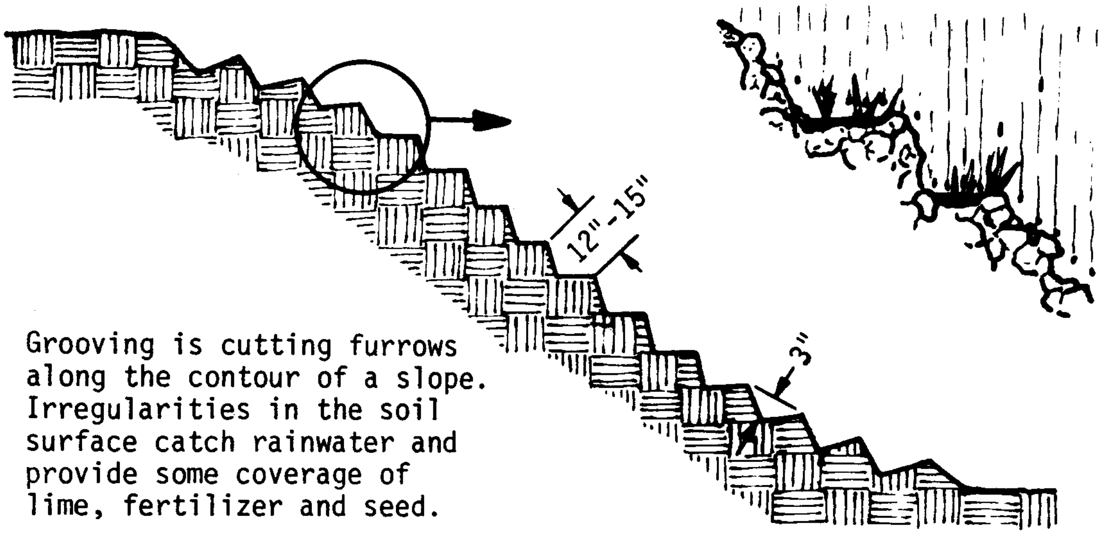
<u>STAIR STEP</u> grading (see Figure 16) may be conducted on slopes having bedrock soft enough to be ripped by a bulldozer. Wherever stair step grading is used the size of the horizontal cut should exceed that of the vertical cut by at least 10". Individual vertical cuts should not exceed 30 inches in soft materials or 40" in harder rock. The horizontal cut should be graded toward the vertical cut (i.e. into the cut).

FIGURE 16
Stair Step Grading of Cut Slopes



GROOVING slopes (see Figure 17) consists of using machinery to create depressions parallel to contour along the slope. In softer materials and on slopes gentler than 3:1, this may be done with discs, tillers, or harrows; the teeth of a front end loader may be used for harder materials. Grooves should be at least 3” deep and no more than 15” apart.

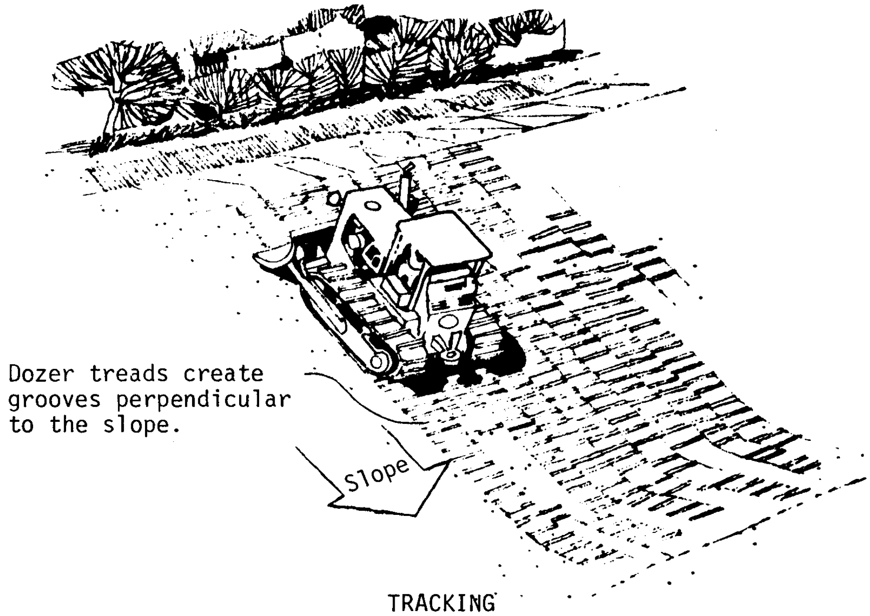
Figure 17
Grooved Slope Details



Grooving (as described above) may be used on fill slopes gentler than 3:1.

TRACKING SLOPES (see Figure 18) is done by running tracked machinery up and down the slope, leaving tread marks parallel to the contour. (Note: If a bulldozer is used, the blade should be up.) Care should be exercised on soils having a high clay content to avoid over-compaction.

FIGURE 18
Tracking a Fill Slope



SEEDING

The Department recommends the use of the **Penn State <u>Erosion Control & Conservation Plantings on Noncropland</u>** Manual as a reference to use for selection of species, seed specifications, mixtures, liming and fertilizing, time of seeding, and seeding methods. The publication is available from county Cooperative Extension Service offices. Specifications for these items may also be obtained from Penn DOT's Publication # 408, Section 804 or by contacting the applicable county conservation district. Upon selection of a reference, that reference must be used to provide all specifications for seeding, mulching, and soil amendments. Indicate the reference being used in the plan submittal.

Seeding rates are stated as pounds per acre (lb/A) of pure live seed (PLS). Pure Live Seed is the product of the percentage of pure seed times the percentage of germination divided by 100 (e.g. [85% pure seed $\times$ 72% germination] $\div$ 100 = 61% PLS).

Actual Seeding Rates may be determined by dividing the PLS seeding rate by the %PLS shown on the seed tag, or calculated as shown above (e.g. for a PLS seeding rate of 12 lb/A from a seedlot with a PLS of 35%, the actual seeding rate is equal to 12 $\div$ 0.35 = 34.3 lb/A). If More Than One Species is used, indicate the application rate for each species.

The Department also recommends that soil testing be done prior to seeding and mulching to determine the proper soil amendments and application rates for the proposed seed mixture(s). Soil test kits are inexpensive and may be obtained from the county Cooperative Extension Service offices. When done properly, soil tests can actually save money that would otherwise be lost on improper soil amendments, unsuccessful seeding, and damage caused by erosion of unstabilized areas. In the absence of a soil test, soil amendments should be added at the rates specified by the selected seeding reference.

Site conditions such as soil limitations, steepness of slope, and proposed land use should be considered in selecting seed mixtures.

Tables contained in the county <u>Soil Surveys</u> published by the USDA Natural Resources Conservation Service provide valuable information regarding soil use limitations. Soils designated as "infertile", "wet", "droughty", "acid", etc. should be given special attention when selecting seed mixtures. Table 15 identifies plant species which are tolerant and intolerant of these soil conditions.

Wherever seeding is to be done on steep slopes ($\geq$ 3:1), seed mixtures should be selected that are appropriate for steep slopes. <u>Table 4</u> in the **<u>Erosion Control & Conservation Plantings on Noncropland</u>** and <u>Table A</u> (Section 804.2(b)) in Penn DOT's publication 408 identify seed mixtures suitable for steep slope conditions.

Fill slopes should be seeded and mulched at regular vertical increments (15' max.) as the fill is being constructed. This will allow the bottom of the fill to move toward stabilization while work continues on the upper portion, making final stabilization easier to achieve and providing some vegetative buffering at the bottom of the slope.

In critical areas (e.g. adjacent to or within 50' of streams, ponds, or wetlands) consideration should be given to providing a protective blanket for seeded areas. Mulch with netting or protective blankets should be provided for seeded areas on slopes steeper than 3:1.

<u>Table 4</u> in the **<u>Erosion Control & Conservation Plantings on Noncropland</u>** Manual as well as PennDOT's publication 408 provide information regarding seed selection for various proposed land uses.

When wetland areas are temporarily disturbed, isolate and stockpile topsoil for replacement after grading is completed. If temporary vegetative stabilization is necessary, apply annual ryegrass at the rate of 48# PLS/acre. Mulch using clean straw at the rate of 3T /acre. No soil amendments are recommended.

Show all seeding, mulching, and soil amendment specifications on a detail sheet. References to a standard seed mixture are not acceptable.

The beginning and ending of the germination season for each of the proposed seed mixtures should be provided as well as directions for temporary stabilization of disturbed areas that achieve finished grade during non-germinating seasons.

Vegetated areas shall be considered permanently stabilized when a uniform 70% vegetative cover of erosion resistant perennial species has been achieved, or the disturbed area is covered with an acceptable BMP which permanently minimizes accelerated erosion and sedimentation. Until such time as this standard is achieved, interim stabilization measures and temporary erosion and sediment control BMPs that are used to treat project runoff may not be removed.

TABLE 15
Plant Tolerances of Soil Limitation Factors

Species	Growth Habit[1]	Tolerates: Wet Soil	Dry Site	Low Fertility	Acid Soil (pH 5-5.5)[2]	Minimum Seed Specifications[3]: Purity (%)	Ready Germ (%)	Hard Seed (%)	Total Germ (%)	Seeds/lb (1,000s)
Warm-Season Grasses										
Deertongue	bunch	yes	yes	yes	yes	95	75		75	250
Weeping lovegrass	bunch	no	yes	yes	yes	97	75		75	1,500
Switchgrass[4]	bunch	yes	yes	yes	yes	(60 PLS)				390
Big bluestem	bunch	no	yes	yes	yes	(60 PLS)				150
Cool-Season Grasses										
Tall Fescue	bunch	yes	no	yes	no	95	80		80	227
Redtop	sod	yes	yes	yes	yes	92	80		80	5,000
Fine fescues	sod	no	no	yes	no	95	80		80	400
Perennial ryegrass	bunch	yes	no	no	no	95	85		85	227
Annual ryegrass	bunch	yes	no	yes	no	95	85		85	227
Kentucky bluegrass	sod	no	no	no	no	85	75		75	2,200
Reed canarygrass	sod	yes	yes	yes	no	95	70		70	520
Orchardgrass	bunch	yes	yes	yes	yes	95	80		80	654
Timothy	bunch	yes	no	yes	yes	95	80		80	1,230
Smooth bromegrass	sod	no	yes	yes	no	95	80		80	136
Legumes[5]										
Crownvetch	sod	no	yes	yes	no	98	40	30	65	120
Birdsfoot trefoil[6]	bunch	yes	no	yes	yes	98	60	20	80	400
Flatpea	sod	no	no	yes	yes	98	55	20	75	10
Serecia lespedeza	bunch	no	yes	yes	yes	98	60	20	80	335
Cereals										
Winter wheat	bunch	no	no	no	no	98	85		85	15
Winter rye	bunch	no	no	yes	yes	98	85		85	18
Spring oats	bunch	no	no	no	no	98	85		85	13
Sundangrass	bunch	no	yes	no	no	98	85		85	55
Japanese millet	bunch	yes	no	yes	yes	98	80		80	155

1 Growth habit refers to the ability of the species to either form a dense sod by vegetative means (stolons, rhizomes, or roots) or remain in a bunch or single plant form. If seeded heavily enough, even bunch formers can produce a very dense stand. This is sometimes called a sod, but not in the sense of a sod formed by vegetative means.

2 Once established, plants may grow at a somewhat lower pH, but cover generally is only adequate at pH 6.0 or above.

3 *Minimum seedlots are truly minimum, and seedlots to be used for revegetation purposes should equal or exceed these standards.* Thus, deertongue grass should germinate 75% or better. Crownvetch should have at least 40% readily germinable seed and 30% hard seed. Commonly, seedlots are available that equal or exceed minimum specifications. Remember that disturbed sites are adverse for plant establishment. Ready germination refers to seed that germinates during the period of the germination test and that would be expected, if conditions are favorable, to germinate rapidly when planted. The opposite of ready germination is dormant seed, of which hard seed is one type.

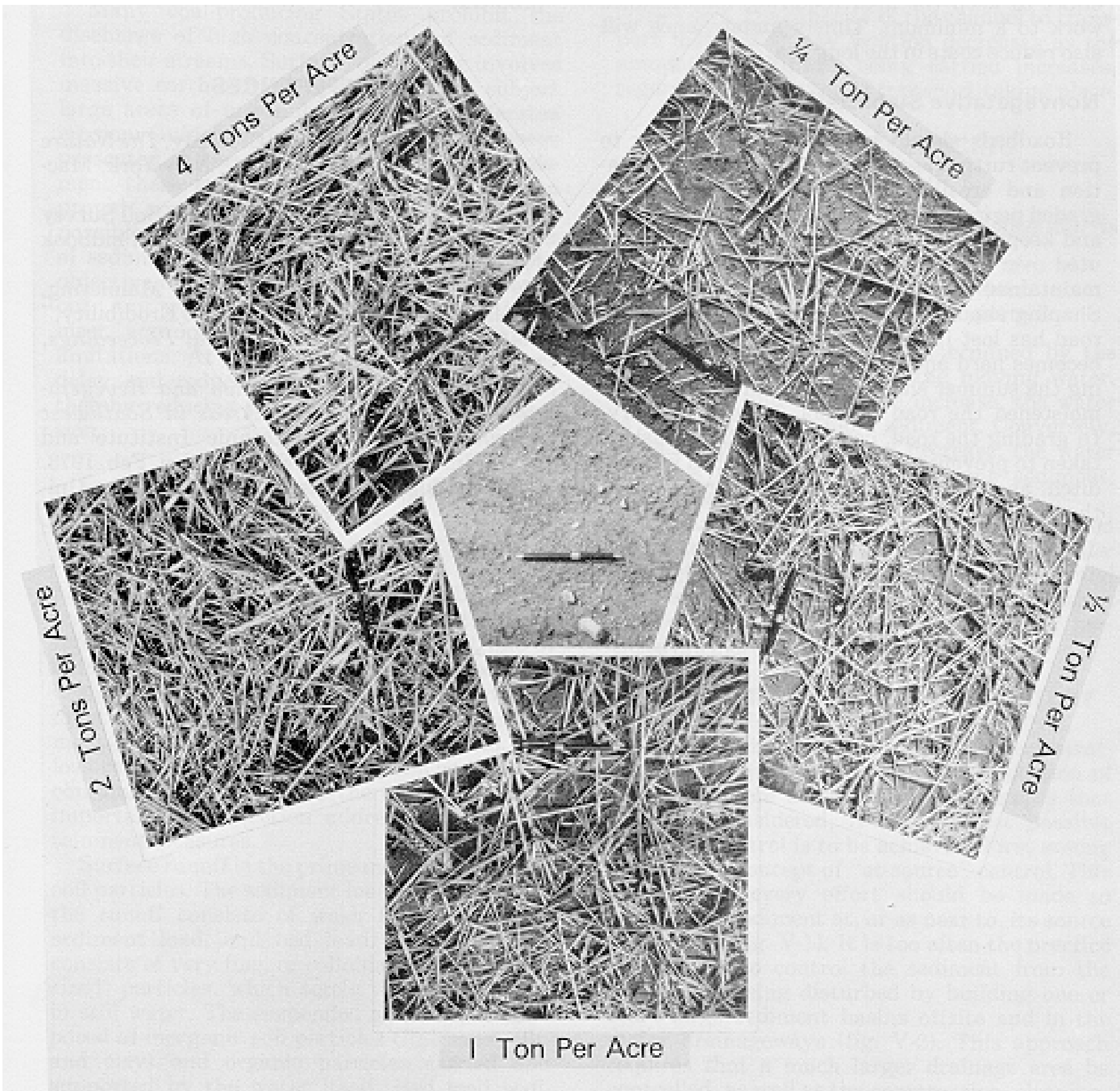
4 Switchgrass seed is sold only on the basis of pure live seed (PLS).

5 Need specific legume inoculant. Inoculant suitable for garden peas and sweetpeas usually is satisfactory for flatpea.

6 Birdsfoot trefoil is adapted over the entire state, except in the extreme southeast where crown and root rots may injure stands.

MULCHING - Mulches absorb rainfall impact, increase the rate of infiltration, reduce soil moisture loss due to evaporation, moderate soil temperatures, provide a suitable environment for germination, and protect the seedling from intense sunlight. All seeded areas should be mulched to minimize the potential for failure to establish an adequate vegetative cover. Mulching may also be used as a temporary stabilization of disturbed areas in non-germinating seasons.

FIGURE 19
Straw Mulch At Various Rates Of Application



Apply mulches at the rates shown in **Table 16**

Straw and hay mulch should be anchored immediately after application to prevent being windblown. A tractor-drawn implement may be used to “crimp” the straw or hay into the soil. This method is limited to slopes no steeper than 3:1. The machinery should be operated on the contour. (Note: Crimping of hay or straw by running over it with tracked machinery is not recommended.)

Asphalt, either emulsified or cut-back, containing no solvents or other diluting agents toxic to plant or animal life, uniformly applied at the rate of 31 gallons per 1000 sq. yd. may be used to tack mulch.

Synthetic Binders (chemical binders) may be used as recommended by the manufacturer to anchor mulch provided sufficient documentation is provided to show they are non-toxic to native plant and animal species.

Lightweight plastic, fiber, or paper nets may be stapled over the mulch according to manufacturer's recommendations.

TABLE 16
Mulch Application Rates

Mulch Type	Application Rate (Min.)			Notes
	Per Acre	Per 1,000 sq. ft.	Per 1,000 sq. yd.	
Straw	3 tons	140 lb.	1,240 lb.	Either wheat or oat straw, free of weeds, not chopped or finely broken
Hay	3 tons	140 lb.	1,240 lb.	Timothy, mixed clover and timothy or other native forage grasses
Wood Cellulose	1,500 lb.	35 lb.	310 lb.	Do not use alone in winter, during hot and dry weather or on steep slopes (≥ 3:1)
Wood	1,000 lb. Cellulose	25 lb.	210 lb.	When used over straw or hay
Wood Chips	4 - 6 tons	185 - 275 lb.	1,650 - 2,500 lb.	May prevent germination of grasses and legumes

EROSION CONTROL BLANKETS - There are many varieties of Erosion Control Blankets on the market. They range from rolls of natural and artificial materials, which must be installed by hand, to liquid, spray-on, materials which make use of a bonding agent to hold natural or artificial fibers in place until vegetation becomes established. Use erosion control blankets on all slopes that are steeper than 3:1.

Consideration should be given to using a suitable erosion control blanket wherever earth disturbance occurs in close proximity (within 50') to waters of the Commonwealth (e.g. stream crossings, wetlands, ponds, storm sewer inlets etc.), especially if site conditions make use of conventional erosion and sediment control BMPs difficult. (Note: The E & S Control plan must address how runoff from disturbed areas will be handled prior to the erosion control blanket being installed.) Erosion control blankets should also be considered where soil conditions (e.g. low fertility, droughty conditions, erodibility, etc.) make revegetation difficult. When properly installed, erosion control blankets can help hold soil particles in place and retain soil moisture, promoting seed germination. The blanket also provides the seedlings protection from intense sunlight during early stages of growth. A temporary blanket is necessary where vegetation is proposed as the protective lining for waterways.

Erosion control blankets are NOT effective in preventing slumping. Wherever slope stability problems are anticipated or encountered, appropriate measures such as reducing steepness of slope, diverting upslope runoff, reducing soil moisture, loading the toe, or buttressing the slope should be considered.

Wherever erosion control blankets are specified, they should be installed/applied according to the manufacturer's recommendations.

A copy of the installation/application procedure should be included in the E & S Control plan on a detail sheet. If the specific product that will be used cannot be identified in the E & S Control plan, the minimum standards for the product that will be used must be provided.

MISCELLANEOUS BEST MANAGEMENT PRACTICES

GENERAL - In this chapter, specifications are provided for the design, installation, and maintenance of the most commonly used erosion and sediment pollution BMPs not covered elsewhere in Department documents or guidelines. Wherever BMPs not covered by this manual are proposed, it is the responsibility of the plan preparer to provide sufficient design and installation detail as well as supporting calculations, test results, etc. to show that the proposed BMP will be effective in minimizing erosion and/or preventing sediment pollution to waters of the Commonwealth when installed and maintained in the proposed manner. New or innovative BMPs will be reviewed on a case by case basis. In all such cases, an alternative BMP for which standards are provided in this manual should be proposed for use should the initial BMP(s) prove to be ineffective.

ROCK CONSTRUCTION ENTRANCE WITH WASH RACK - Rock construction entrances with wash racks should be considered wherever soil and/or traffic conditions on site require washing the construction vehicle wheels prior to exiting the site to avoid excessive tracking of mud onto a highway.

Rock construction entrances with wash racks should be constructed to the minimum length, width, and thickness dimensions shown on Standard Construction Detail #15. A metal wash rack is an acceptable alternative to the reinforced concrete one shown.

Approaches to the wash rack should be lined with AASHTO #1 or R-3 rock a minimum of 25’ on both sides.

The wash rack should discharge to a sediment removal facility, such as a vegetated filter strip or into a channel leading to a sediment removal device.

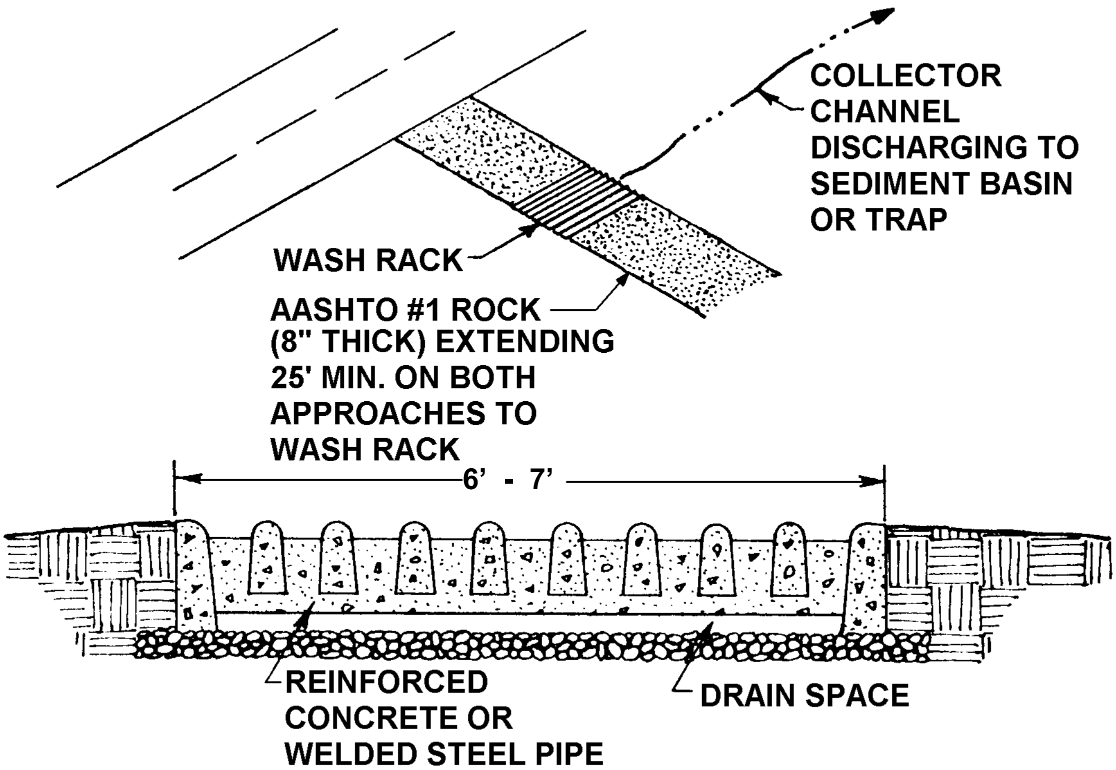
Rock construction entrances with wash racks should be maintained to the specified dimensions by adding rock when necessary at the end of each work day. A stockpile of rock material should be maintained on site for this purpose.

Sediment deposited on paved roadways shall be removed and returned to the construction site. **NOTE: Washing the roadway or sweeping the deposits into roadway ditches, sewers, culverts, or other drainageways is not acceptable.**

Damaged wash racks should be repaired as necessary to maintain their effectiveness.

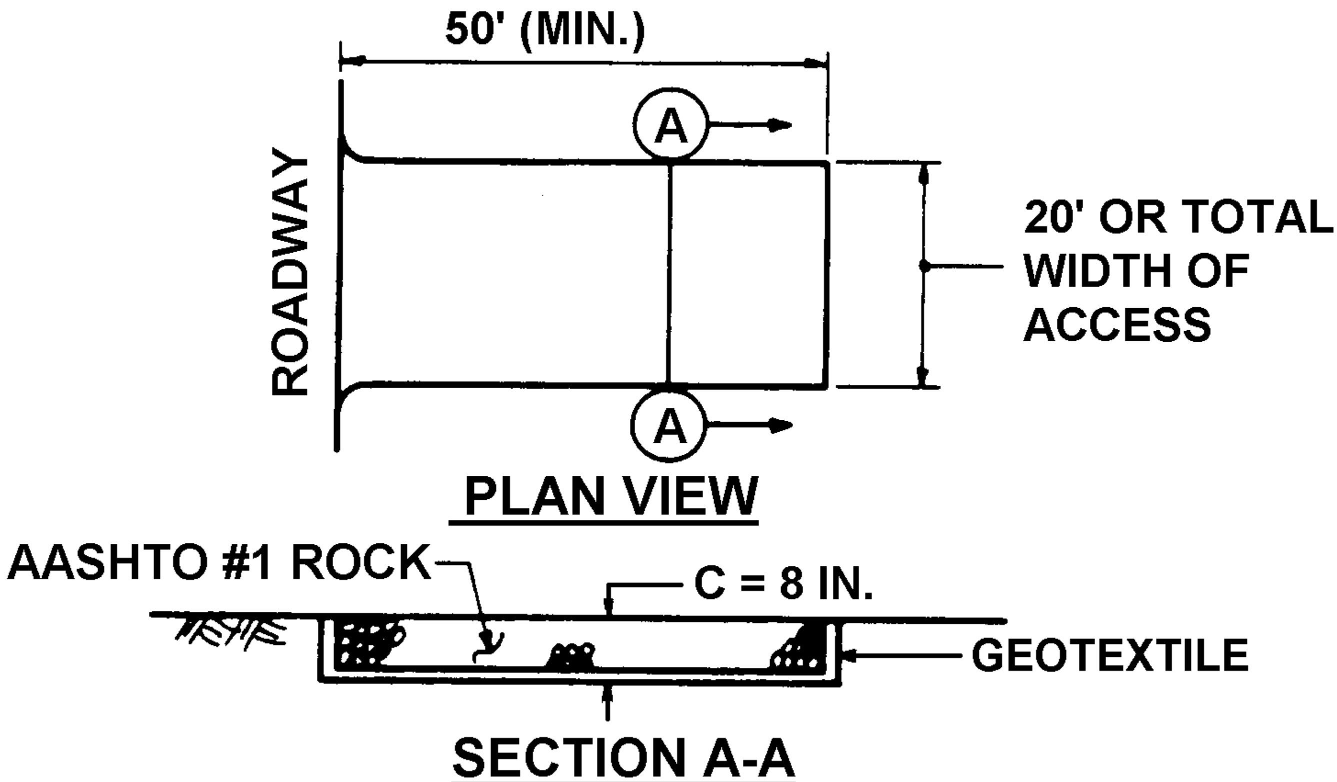
A rock construction entrance without a wash rack is shown on Standard Construction Detail #16.

STANDARD CONSTRUCTION DETAIL #15
Rock Construction Entrance With Wash Rack



MAINTENANCE: Rock Construction Entrance thickness shall be constantly maintained to the specified dimensions by adding rock. A stockpile of rock material shall be maintained on site for this purpose. Drain space under wash rack shall be kept open at all times. Damage to the wash rack shall be repaired prior to further use of the rack. At the end of each construction day, all sediment deposited on paved roadways shall be removed and returned to the construction site.

STANDARD CONSTRUCTION DETAIL #16
Rock Construction Entrance



MAINTENANCE: Rock Construction Entrance thickness shall be constantly maintained to the specified dimensions by adding rock. A stockpile shall be maintained on site for this purpose. At the end of each construction day, all sediment deposited on paved roadways shall be removed and returned to the construction site.

VEGETATIVE FILTER STRIP - A vegetative filter strip consists of a well-vegetated, grassy area below a disturbed area that can be used to remove sediment from runoff prior to its reaching waters of the Commonwealth. To be effective, runoff must be in the form of sheet flow, and the vegetative cover must be established prior to the disturbance. Due to the time required to establish vegetation and the need to control runoff from the areas disturbed while constructing filter strips, constructed vegetative filter strips are not recommended. The suitability of natural vegetative filter strips must be field verified prior to their approval.

Vegetative filter strips may be used to remove sediment from project runoff that is directed to the strip as sheet flow. The maximum slope length that can be considered sheet flow should be determined from Table 17.

Vegetation must be an existing, well-established, perennial grass. Wooded and brushy areas are not acceptable.

Minimum width of the filter strip shall be:

$$\mathbf{W_{min} = 2S + 25\ ft\ \ (50\ ft\ Min.)}$$

Where: W_{min} = Minimum filter width in feet
S = Average slope (in percent) of the filter strip

If at any time, the width of the vegetative filter strip has been reduced by sediment deposition to ½ its original width, suitable alternative BMPs should be installed immediately.

STRAW BALE BARRIERS - Straw bale barriers may be used to control runoff from small disturbed areas provided that runoff is in the form of sheet flow. Since straw bales tend to deteriorate within a 3 month period, they should be considered as short-term control measures.

Straw bale barriers should not be used in areas of concentrated flows (e.g. channels, swales, erosion gullies, across pipe outfalls, as inlet protection, etc.).

The maximum slope length above any straw bale barrier should not exceed that shown in Table 17. The slope length shown is the distance from the barrier to the drainage divide or the nearest upslope channel. **NOTE: Slope length may not be increased by use of multiple rows of barriers!** For non-uniform slopes use the method described following Table 18 to determine the slope length.

TABLE 17
Maximum Slope Length for Straw Bale Barriers

Slope - Percent	Maximum Slope Length (ft) Above Barrier
2 (or less)	150
5	100
10	50
15	35
20	25
25	20
30	15
35	15
40	15
45	10
50	10

Straw bale barriers should not be used in areas where rock prevents full and uniform anchoring of the bales.

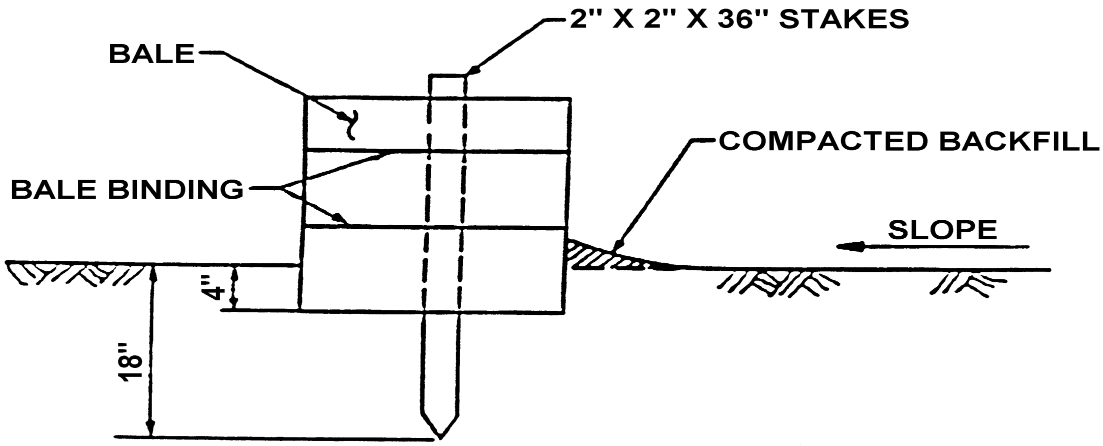
Straw bale barriers should be installed according to Standard Construction Detail #17.

Bales should be installed in an anchoring trench.

Two support stakes should be driven through each bale to the depth 18” below the ground surface.

The excavated soil should be backfilled and compacted on the upslope side of the bales.

STANDARD CONSTRUCTION DETAIL #17
Straw Bale Barriers

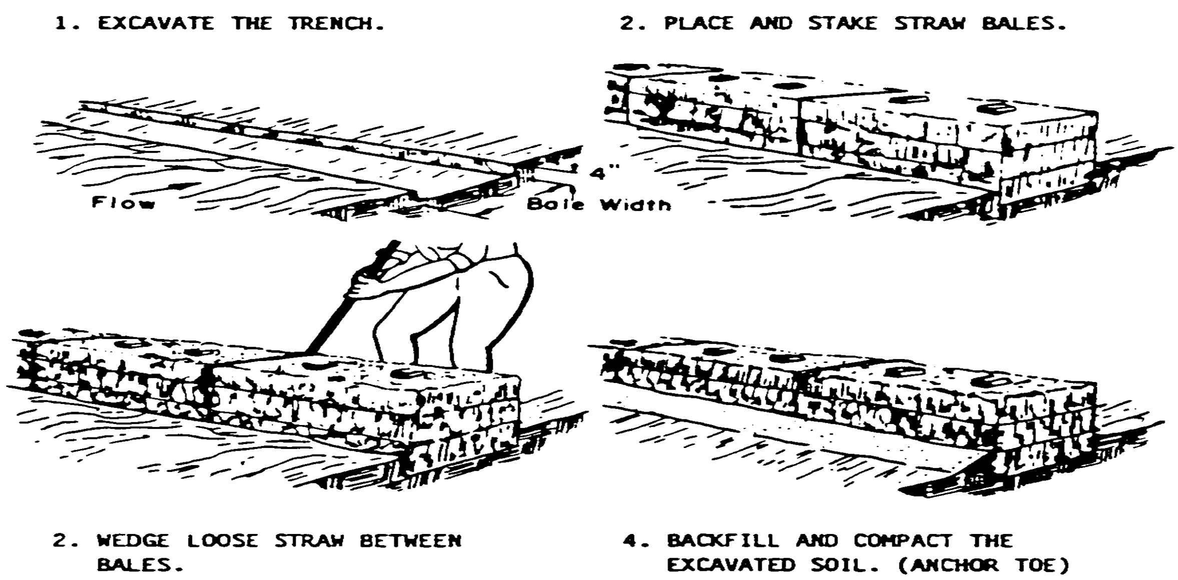


Straw Bale Barriers should not be used for more than 3 months.

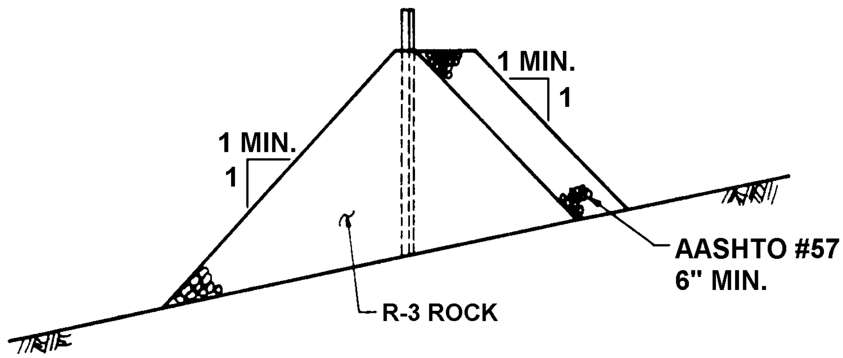
Straw Bale Barriers shall be placed at existing level grade. Both ends of the barrier shall be extended at least 8 feet up slope at 45 degrees to the main barrier alignment.

Sediment shall be removed when accumulations reach 1/3 the above ground height of the barrier.

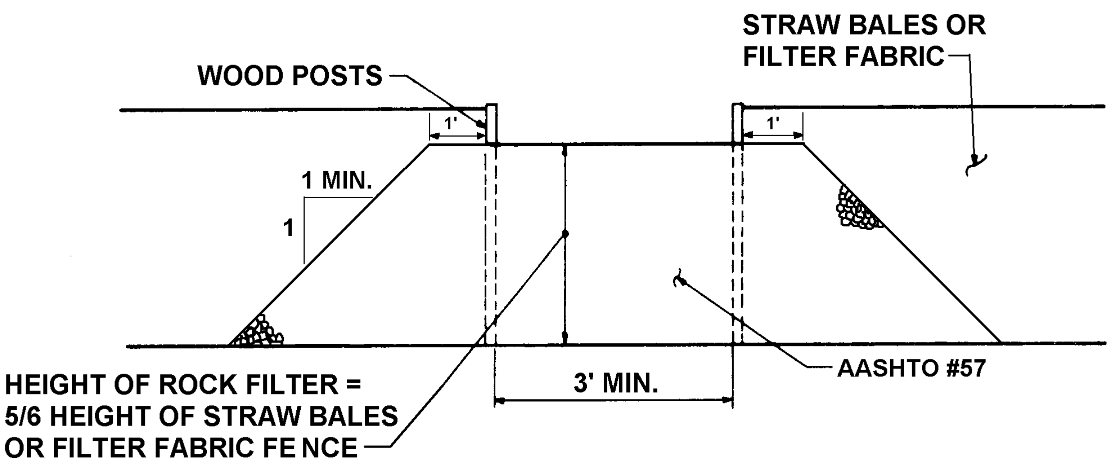
Any section of Straw Bale Barrier which has been undermined or topped shall be immediately replaced with a Rock Filter Outlet. See Standard Construction Detail #18.



STANDARD CONSTRUCTION DETAIL #18
Rock Filter Outlets



OUTLET CROSS-SECTION



UP-SLOPE FACE

Sediment must be removed when accumulations reach 1/3 the height of the outlet.

FILTER FABRIC FENCE (SILT FENCE) - Filter fabric fence may be used to control runoff from small disturbed areas when it is in the form of sheet flow, and the discharge is to a stable area. Only those fabric types specified for such use by the manufacturer should be used.

Do not use filter fabric fence in areas of concentrated flows (e.g. channels, swales, erosion gullies, across pipe outfalls, as inlet protection, etc.). **It should not be wrapped around the principal spillway risers of sediment basins.**

Filter fabric fence should not be used in areas where rock or rocky soils prevent the full and uniform anchoring of the fence.

Filter fabric fence should not be installed on uncompacted fills or in extremely loose soils (e.g. sandy loam), since this will likely result in undermining of the fence.

Filter fabric fence should be installed at level grade. Both ends of each fence section should be extended at least 8 feet upslope at 45 degrees to the main fence alignment to allow for pooling of water.

A 6” deep trench should be excavated, minimizing the disturbance on the downslope side. The bottom of the trench should be at level grade. maximum deviation from level grade should be 1%, and not extend for more than 25 ft.

Support stakes should be driven 18” below the existing ground surface at 8 foot (max.) intervals.

Filter fabric should be stretched and fastened to the upslope side of the support stakes. Wherever reinforced fabric fence is installed, the reinforcement mesh should be fastened to the stakes prior to the fabric.

At fabric ends, both ends should be wrapped around the support stake and stapled. If the fabric comes already attached to the stakes, the end stakes should be held together while the fabric is wrapped around the stakes at least one revolution prior to driving the stakes.

The bottom of the fence should be anchored by placing the fabric in the bottom of the trench, and backfilling and compacting the fill material in the trench.

Guy wires should be attached to reinforced fabric fence (see Standard Construction Detail #20). An acceptable alternative is to stake straw bales on the downslope side of the fence (see Standard Construction Detail #21).

Filter fabric fence should be inspected weekly and after each runoff event. Needed repairs should be initiated immediately after the inspection.

Straw bales generally need to be replaced every three months.

Filter fabric fence alignment should be at least 8’ from the toe of fill slopes.

The maximum slope length above 18" or 30" filter fabric fence should not exceed that shown in Table 18. The slope length shown is the distance from the fence to the drainage divide or the nearest upslope channel. **NOTE: Multiple rows of Filter Fabric Fence may not be used on a continuous slope.**

TABLE 18
Maximum Slope Lengths for Filter Fabric Fence

Slope - Percent	Maximum Slope Length (ft) Above Fence	
	18" High Fence	30" High Fence*
2 (or less)	150	500
5	100	250
10	50	150
15	35	100
20	25	70
25	20	55
30	15	45
35	15	40
40	15	35
45	10	30
50	10	25

*Reinforced 30" high fence. See Standard Construction Details #20 or #21.

Wherever there is a break or change in slope above the silt fence, the Maximum Allowable Slope Length should be determined by the following method:

(a) Determine the length and percent of the slope segment immediately above the fence.

(b) Subtract the length of this segment from the allowable slope length for that percent slope shown in Table 18. If the result is positive, find the percentage of the allowable slope length that has been used (slope length ÷ allowable slope length).

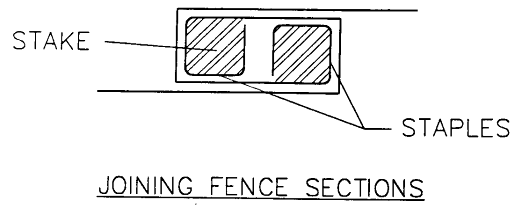
(c) Subtract the result from 1.00 to determine the unused percentage of allowable slope length.

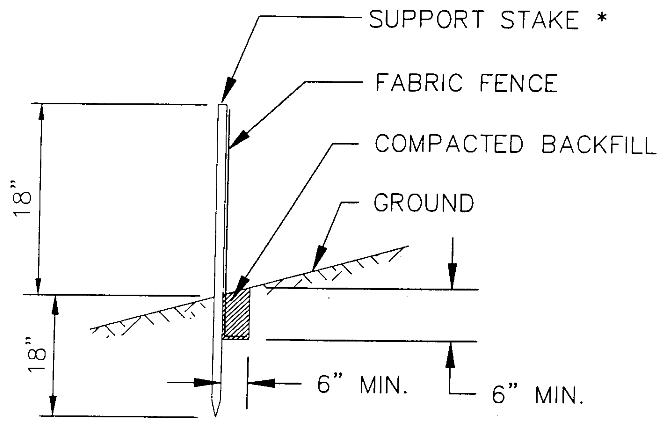
(d) Determine the maximum allowable slope length for the percent slope of the remaining segment from Table 18.

(e) Multiply this allowable slope length by the remainder from step (c) above.

(f) Add the result from step (b) to that from step (e). This is the maximum allowable slope length for the entire slope.

STANDARD CONSTRUCTION DETAIL #19
Standard Filter Fabric Fence (18” High)





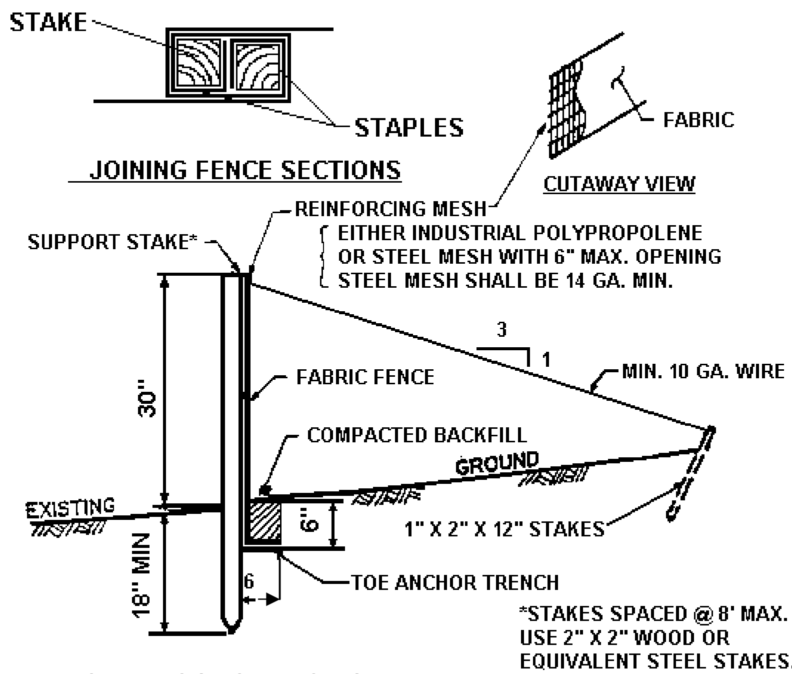
*Stakes spaced @ 8’ maximum. Use 2"x 2" wood or equivalent steel stakes.

Filter Fabric Fence must be placed at level existing grade. Both ends of the barrier must be extended at least 8 feet up slope at 45 degrees to the main barrier alignment.

Sediment must be removed when accumulations reach 1/2 the above ground height of the fence.

Any section of Filter fabric fence which has been undermined or topped must be immediately replaced with a Rock Filter Outlet. See Standard Construction Detail # 18.

STANDARD CONSTRUCTION DETAIL # 20
Reinforced Filter Fabric Fence (30" High)



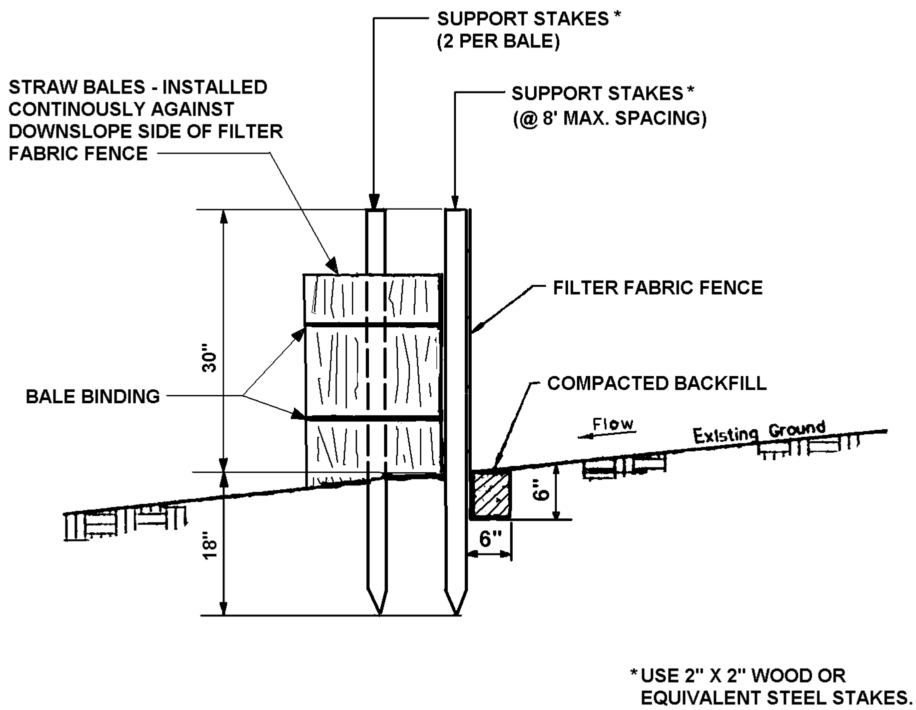
NOTE: SHOW ALL DETAILS AND CONSTRUCTION DIMENSIONS ON PLAN DRAWINGS.

Filter fabric fence must be installed at existing level grade. Both ends of each fence section must be extended at least 8 feet upslope at 45 degrees to the main fence alignment.

Sediment must be removed where accumulations reach 1/ 2 the above ground height of the fence.

Any fence section which has been undermined or topped must be immediately replaced with a rock filter outlet. See Standard Construction Detail # 18.

STANDARD CONSTRUCTION DETAIL #21
Filter Fabric Fence Reinforced by Staked Straw Bales



Filter fabric fence must be installed at existing level grade. Both ends of each fence section must be extended at least 8 feet upslope at 45 degrees to the main fence alignment.

Sediment must be removed where accumulations reach 1/ 2 the above ground height of the fence.

Any fence section which has been undermined or topped must be immediately replaced with a rock filter outlet. See Standard Construction Detail # 18.

SUPER SILT FENCE - Super silt fence may be used to control runoff from some small disturbed areas where the maximum slope lengths for reinforced filter fabric fence cannot be met and sufficient room for construction of sediment traps or basins does not exist.

Only those fabric types specified for use as silt fence by the manufacturer should be used.

The maximum slope length above any super silt fence should not exceed that shown in Table 19. The slope length shown is the distance from the fence to the drainage divide or the nearest upslope channel. **NOTE: Slope length may not be increased by use of multiple rows of Super Silt Fence!**

Super silt fence should not be used in areas where rock or rocky soils prevent the full and uniform anchoring of the fence or proper installation of the fence posts. It should be used only where access exists or can be made for the construction equipment required to install and remove the chain link fencing.

TABLE 19
Maximum Slope Lengths for Super Silt Fence

Slope Percent	Maximum Slope Length (ft)
2 (or less)	1,000
5	500
10	300
20	200
30	100
40	75
50	50

Super silt fence should be installed at level grade. Both ends of each fence section should be extended at least 8 feet upslope at 45 degrees to the main fence alignment to allow for pooling of water.

Super silt fence should be installed according to the details shown in Standard Construction Detail #22.

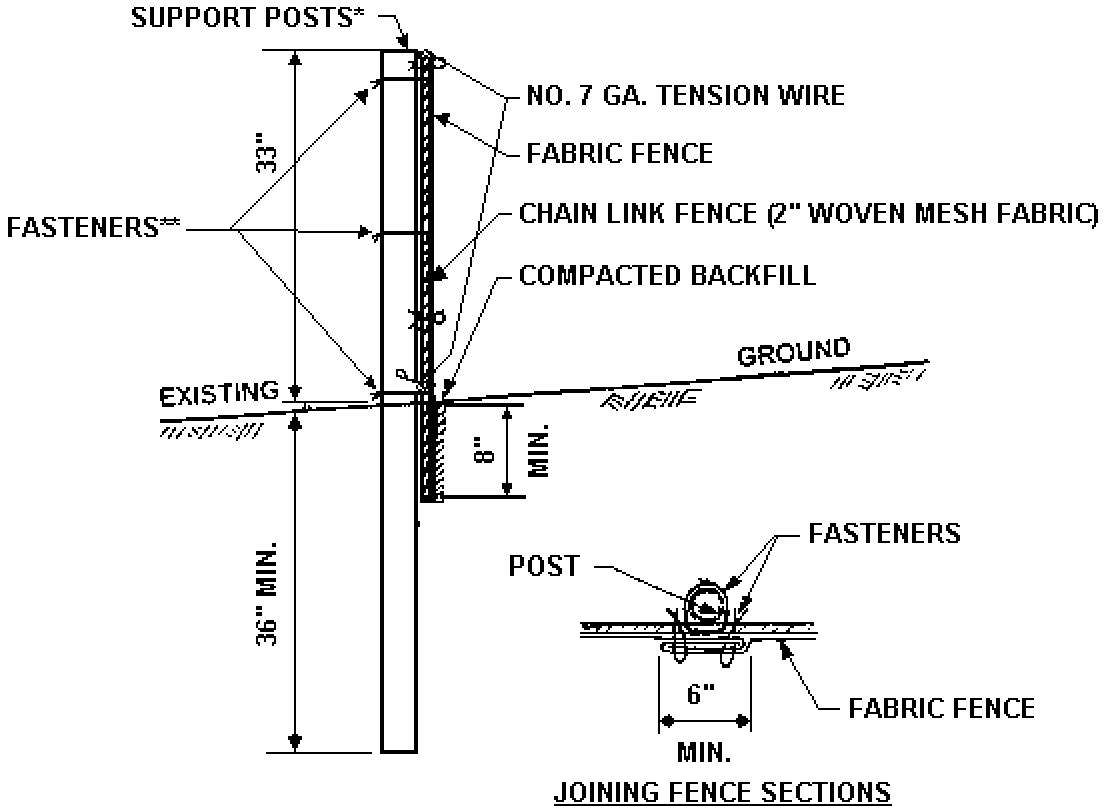
An 8" deep trench should be excavated, minimizing the disturbance on the downslope side. The bottom of the trench should be at level grade. Maximum deviation from level grade should be 5%, and not extend for more than 50 ft.

A chain link fence should be installed in the downslope side of the trench with the fence on the upslope side of the poles. Poles should be 2 ½" diameter galvanized or aluminum posts set at 10' maximum spacing. Poles should be driven a minimum 36" below the ground surface and extend a minimum of 33" above the ground surface. Poles do not need to be set in concrete.

Filter fabric should be stretched and securely fastened to the fence with wire fasteners, staples, or preformed clips. It should extend a minimum of 33" above the ground surface.

At fabric ends, both ends should be overlapped a minimum of 6", folded, and secured to the fence (see Standard Construction Detail #22). The fabric toe should be placed in the bottom of the trench, backfilled, and compacted.

STANDARD CONSTRUCTION DETAIL # 22
Super Filter Fabric Fence



* Posts spaced @ 10' max. Use 2 1/2" dia. galvanized or aluminum posts.

** Chain Link To Post Fasteners spaced @ 14" max. Use No. 6 Ga. aluminum wire or No. 9 galvanized steel pre-formed clips. Chain Link To Tension Wire Fasteners spaced @ 60" max. Use No. 10 Ga. galvanized steel wire. Fabric To Chain Fasteners spaced @ 24" max. C to C.

No. 7 Ga. Tension Wire installed horizontally at top and bottom of chain-link fence.

Filter Fabric Fence must be placed at existing level grade. Both ends of the barrier must be extended at least 8 feet upslope at 45 degrees to main barrier alignment.

Sediment must be removed when accumulations reach 1/ 2 the above ground height of the fence.

ROCK FILTERS - Rock filters may be used to control runoff within constructed channels until the protective lining is installed. They may also be used below construction work within an existing stream channel while flow is being diverted past the work area. In such cases, the filter should be located between the work area and the discharge from the bypass system. Rock filters may not be used in lieu of sediment basins.

Rock filters may be used to control sediment originating within a channel, either during construction of the channel (before the channel is stabilized) or during a temporary disturbance within the channel. Rock filters may not be used in collector channels in lieu of sediment basins.

Rock filters should not be used in lieu of appropriate channel linings. This practice often results in overtopping of the channel during storm events, scouring of the channel bottom below the filter, or erosion of the channel side slopes as sediment deposits build up behind the filter.

Rock filters should not be used in lieu of an adequate protective lining in sediment basin emergency spillways. This can reduce the effective discharge capacity of the spillway and, in doing so, increase the possibility of embankment failure.

Rock filters should be constructed according to the specifications shown in Standard Construction Detail #23.

Rock filters should be constructed with Riprap sized as follows:

For channels with Total Depth > 3 feet, use R-4.
For channels with Total Depth between 2 and 3 feet, use R-3.
For channels with Total Depth between 1 and 2 feet, use R-2.

Rock filters should not be used in channels of less than 1 foot total depth.

The filter should be equal in height to ½ the total depth of the channel with a 6" depression in the center.

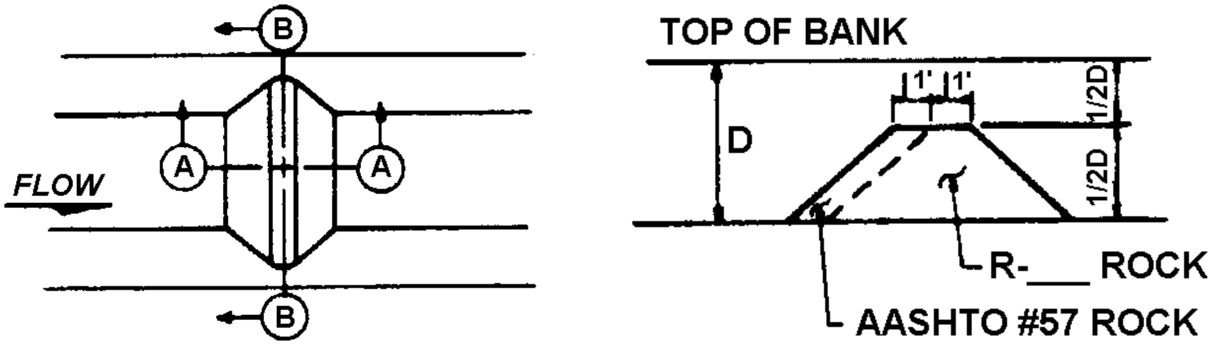
A one foot thick layer of AASHTO #57 stone should be placed on the upstream side of the filter.
NOTE: Filter fabric and straw bales should not be used in rock filters!

Rock filters should be inspected weekly and after each runoff event.

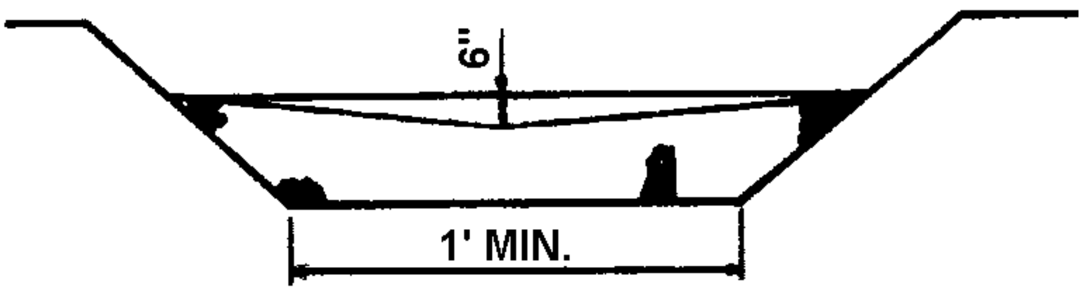
Clogged filter stone (AASHTO # 57) should be replaced.

Needed repairs should be initiated immediately after the inspection.

STANDARD CONSTRUCTION DETAIL # 23
Rock Filters



SECTION A-A



SECTION B-B

FOR 3' ≤ D USE R-4
FOR 2' ≤ D < 3' USE R-3
FOR 1' ≤ D < 2' USE R-2

ROCK FILTER NO.	LOCATION	D (FT.)	RIPRAP SIZE

Sediment must be removed when accumulations reach 1/ 2 the height of the filters.
Immediately upon stabilization of each channel, remove accumulated sediment, remove Rock Filter, and stabilize disturbed areas.

BENCHES - Benches may be used to break up long fill or cut slopes and convey runoff to one or both sides.

Benches should be constructed to the minimum dimensions shown in Standard Construction Detail #24.

Benches should have a minimum longitudinal drainage slope of 2% and a maximum slope of 5%.

Benches should be constructed so as to not exceed 800 feet of flow in one direction.

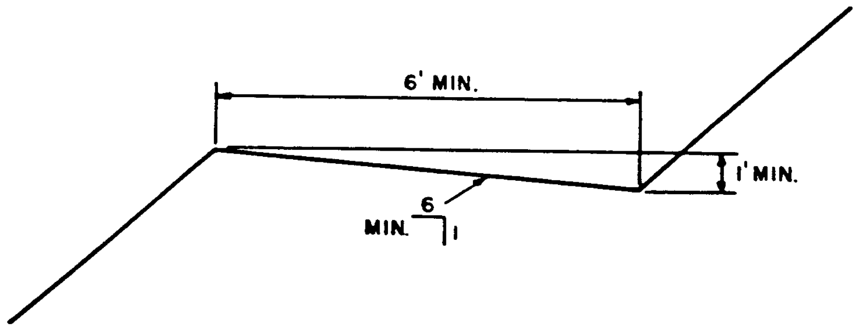
Benches should be installed to the maximum vertical spacing shown in Table 20.

TABLE 20
Bench Spacing

Slope (H:V)	Maximum Vertical Spacing Between Benches (Ft.)
2:1	20
3:1	30
4:1	40

Benches must discharge to adequately sized and protected conveyance facilities (e.g. storm sewers, groin ditches, etc.).

STANDARD CONSTRUCTION DETAIL #24
Bench Details



Benches must have adequate protection from erosion. Where equipment is likely to use the bench as a travelway (landfills for example), rock lining is recommended.

Benches should be inspected on a weekly basis and after each runoff event.

Benches should be maintained to design dimensions at all times.

Needed repairs should be initiated immediately after the inspection.

EARTHEN AND STRUCTURAL LEVEL SPREADERS

Earthen level spreaders are normally used where diversion ditches or dikes outlet onto areas of established vegetation. They are **not** to be used below sediment traps, sediment basins, or stormwater pipes. Structural level spreaders are usually individually designed to accommodate specific site conditions. These types of spreaders may be used below sediment traps, sediment basins, or stormwater pipes.

Earthen and structural level spreaders may be used where sediment-free storm runoff can be released in sheet flow down a stabilized slope without causing erosion. Where the downstream slope is stabilized with grass, a minimum cover of 90% is required. Wooded areas, with little or no grass cover, are not considered stabilized areas for this purpose. Earthen level spreaders should only be used where there will be no construction traffic over the level spreader.

The maximum discharge for earthen level spreaders is 1 cfs per foot of length based on the peak rate of flow from a ten year frequency rainfall event. Maximum drainage area to a earthen level spreader may not exceed 5 acres. An acceptable simplified method to determine the length, L, is that L is equal to five feet per acre of drainage area. In any case the minimum length equals 5 feet and the maximum length equals 25 feet.

The grade of the last 20 feet of the diversion channel that feeds the earthen level spreader must create a smooth transition from the channel grade to the earthen level spreader and, where possible, should be less than or equal to 1 percent. Construct the earthen level spreaders on zero percent grade to insure uniform spreading of sediment-free runoff. Minimum width of earthen level spreaders equals 6 feet. A transition section should be constructed between the diversion channel and the earthen level spreader if the widths are different.

To avoid reconcentrating flow downstream of the spreader, the maximum distance from the earthen level spreader to an existing or constructed defined drainage way is 100 feet with a 5% maximum slope unless very uniform and very stable site conditions exist.

Earthen level spreaders must be constructed on soil, not on fill.

Protect the lip of an earthen level spreader with an erosion-resistant material, such as a reinforced erosion control blanket, to prevent erosion and enable vegetation to become established. For design flows in excess of 4 cfs or for a permanent installation, a rigid lip of non-erodible material, such as pressure-treated timbers or concrete curbing, must be used.

For a vegetated lip, the erosion-control matting must be a minimum of 4 feet wide and extend 6 inches over the level lip. The upstream edge must be buried at least six inches deep in a vertical trench. The downstream edge should be securely held in place with closely spaced, heavy-duty staples, at least 12 inches long. A rigid level lip must be entrenched at least 2 inches below the ground surface and securely anchored to prevent displacement. Immediately after the earthen level spreader is constructed, the entire area of the spreader must be appropriately seeded and mulched.

Structural level spreaders are designed for site specific situations. Where the spreader is used as an outlet for a pipe spillway (sediment basin, sediment trap, stormwater management pond), the spreader must be designed to accommodate the maximum discharge from pipe spillway. The spreader must be sufficient size to reduce the velocity of water discharging from it to prevent erosion or scouring of the downslope area.

Structural level spreaders are often desirable where basins discharge to wetlands, to encourage sheet flow rather than channel flow to the wetlands. Other applications include sites where groundwater recharge is the objective. Because each site will be different, design criteria needs to be flexible;

however, the plan preparer must use sound engineering judgment, and provide documentation for the design criteria selected.

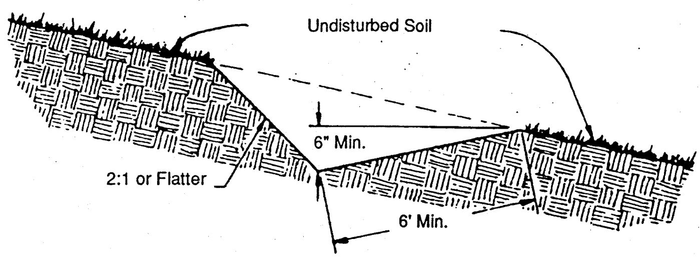
The grade of the spreader must be flat to ensure uniform spreading of storm runoff.

To avoid reconcentrating flow downstream of the spreader, the maximum distance from the structural level spreader to an existing or constructed defined drainage way is 100 feet with a 5% maximum slope unless very uniform and very stable site conditions exist.

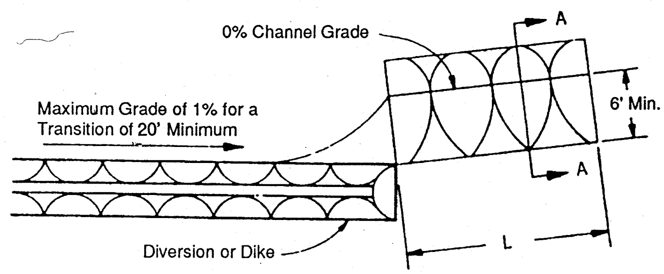
Because of the possibility of high prolonged discharge from structural level spreaders, special care must be taken to stabilize the area in the immediate vicinity of the discharge. Such stabilization is usually mechanical (stone, riprap, paving) as opposed to vegetation only.

Typical details of earthen level spreaders are shown on Standard Construction Detail #25. Because of the wide variations and types of structural level spreaders, no typical details are provided.

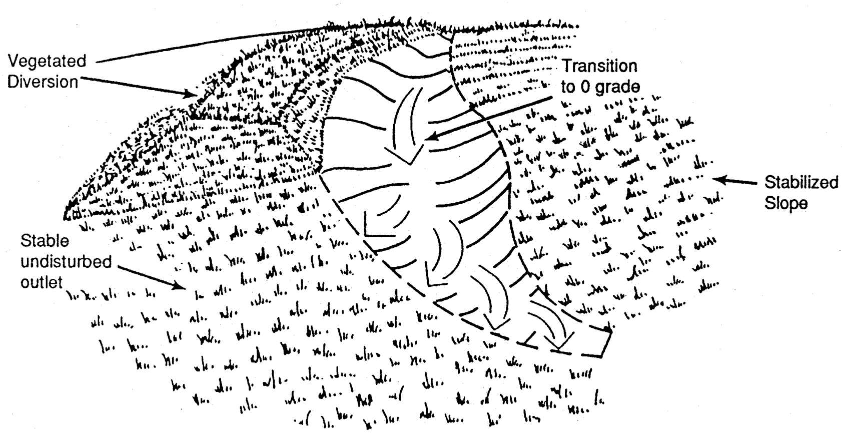
STANDARD CONSTRUCTION DETAIL #25
Earthen Level Spreader



SECTION A-A



PLAN



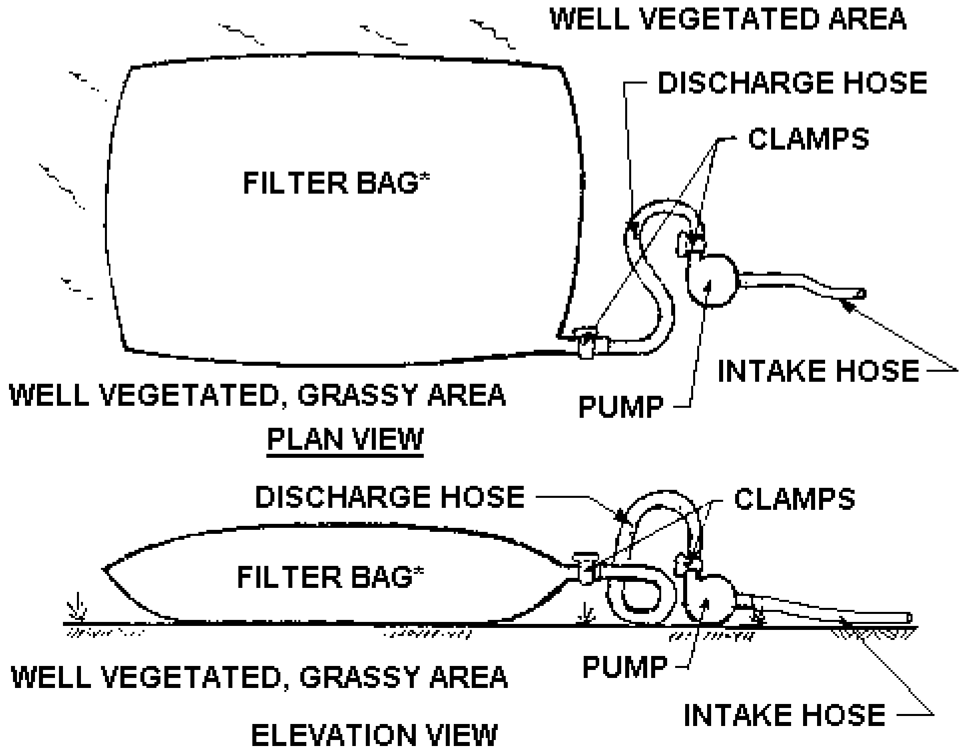
ISOMETRIC VIEW - (Not to Scale)

<u>PUMPED WATER FILTER BAGS</u> - Filter bags may be used to filter water pumped from disturbed areas prior to discharging to waters of the Commonwealth. They may also be used to filter water pumped from the sediment storage areas of sediment basins.

The pumping rate should be specified on the plan drawings next to the typical detail. Pumping rates will vary depending on the size of the filter bag, and the type and amount of sediment discharged to the bag.

Filter bags should be installed according to the details shown in Standard Construction Detail #26.

STANDARD CONSTRUCTION DETAIL #26
Pumped Water Filter Bag



Filter bags shall be made from non-woven geotextile material sewn with high strength, double stitched "J" type seams. They shall be capable of trapping particles larger than 150 microns.

A suitable means of accessing the bag with machinery required for disposal purposes must be provided. Filter bags shall be replaced when they become ½ full. Spare bags shall be kept available for replacement of those that have failed or are filled.

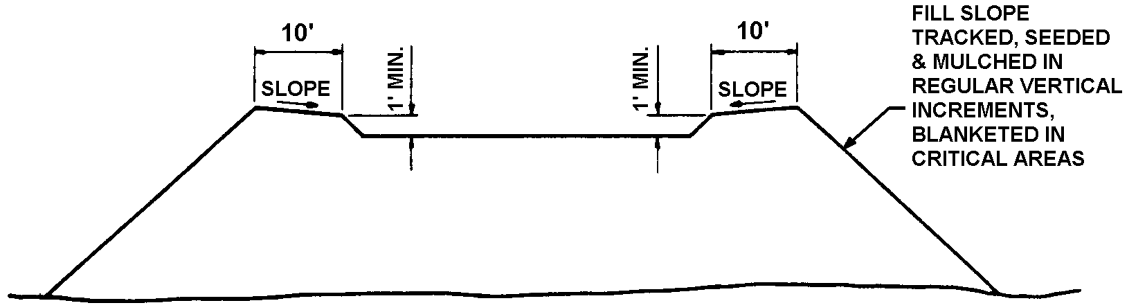
Bags shall be located in well-vegetated (grassy) area, and discharge onto stable, erosion resistant areas. Where this is not possible, a geotextile flow path shall be provided. Bags shall not be placed on slopes greater than 5%.

The pump discharge hose shall be inserted into the bags in the manner specified by the manufacturer and securely clamped.

The pumping rate shall be no greater than 750 gpm or ½ the maximum specified by the manufacturer, whichever is less. Pump intakes should be floating and screened.

Filter bags shall be inspected daily. If any problem is detected, pumping shall cease immediately and not resume until the problem is corrected.

STANDARD CONSTRUCTION DETAIL #27A
Top-Of-Slope Berms



TEMPORARY BERMS TO BE PLACED, MAINTAINED, AND ADJUSTED CONTINUOUSLY UNTIL 90% VEGETATIVE GROWTH IS ESTABLISHED ON THE EXTERIOR SLOPES WITH PERMANENT STORM DRAINAGE FACILITIES FUNCTIONING.

BERMS MUST OUTLET TO TEMPORARY SLOPE PIPES, PERMANENT SLOPE PIPES, TEMPORARY CHANNELS, OR PERMANENT CHANNELS.

TEMPORARY SLOPE PIPES - Temporary slope pipes may be used to convey runoff down steep slopes (existing or constructed). Wherever they are used to convey discharges from sediment basins, they should be connected to the principal spillway barrel outlet. When used to convey runoff from unstabilized areas, they must discharge to a sediment basin, trap, or collector channel.

Add outlet protection as needed to avoid erosion to downstream areas.

Temporary slope pipes should have sufficient capacity to convey the anticipated peak flow from the design storm. The minimum pipe diameter and minimum berm heights are given in Table 21.

The maximum tributary drainage area = 5 Acres

The entrance should have a flared end section with a 6" toe plate, which is firmly entrenched.

The pipe should consist of heavy duty flexible pipe or corrugated metal and shall be securely staked to the slope. The maximum distance between stakes should be 10 feet.

All connections should be watertight.

Temporary slope pipes should be installed according to the details shown in Standard Construction Detail #27.

Temporary slope pipes should be inspected on a weekly basis and after each runoff event.

Any accumulated sediment should be removed from the entrance.

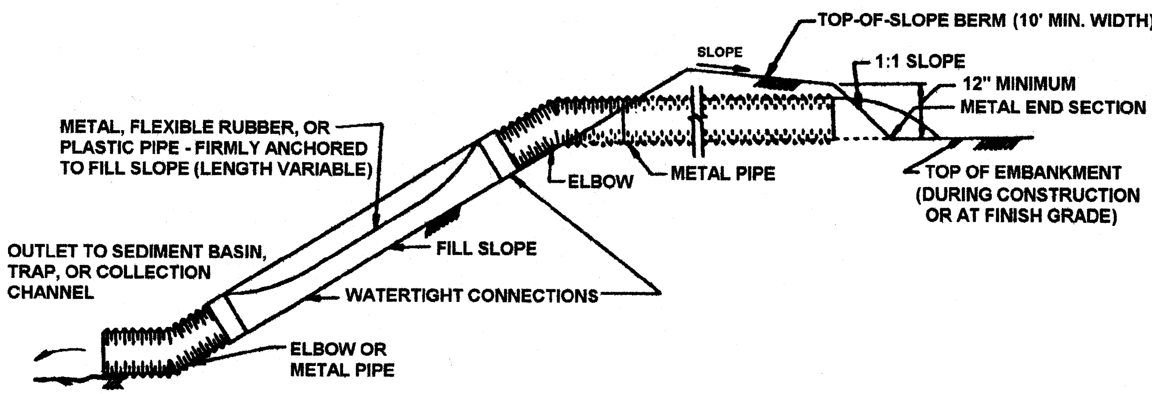
Damaged pipe should be repaired or replaced.

Needed repairs should be initiated immediately after the inspection.

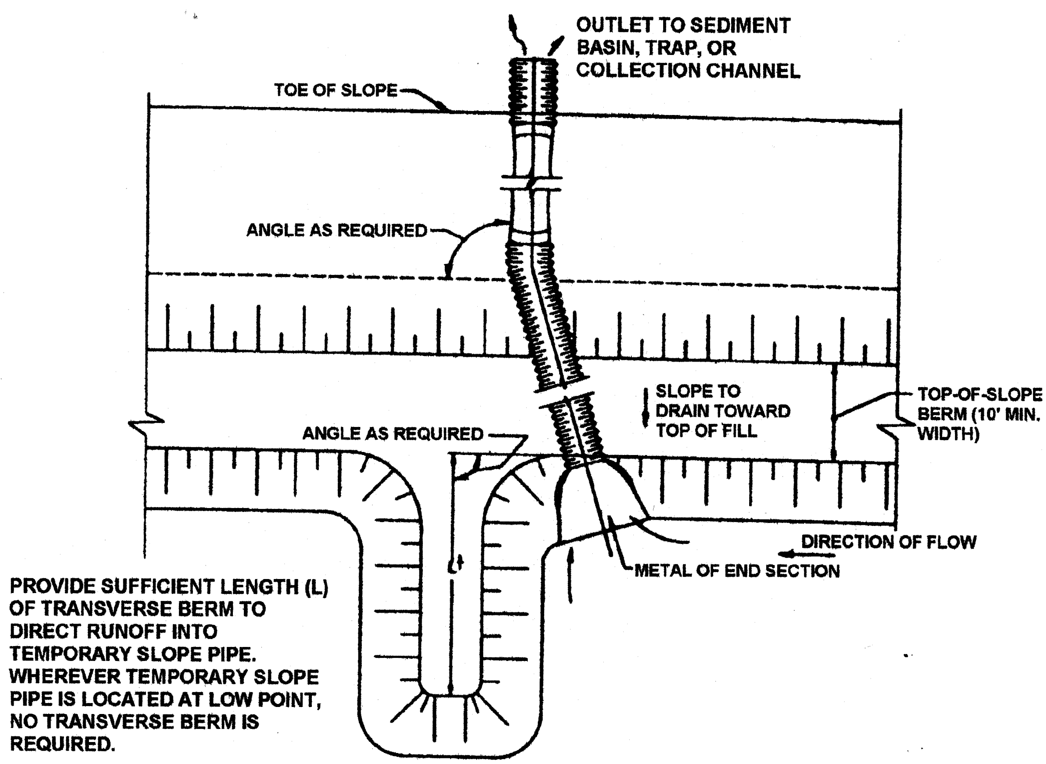
TABLE 21
Minimum Dimensions for Temporary Slope Pipes

Drainage Area (Acres)	Minimum Pipe Diameter (in.)	Minimum Berm Height (in.)
<2	12	24
2 - 4	15	27
4 - 5	18	30

STANDARD CONSTRUCTION DETAIL #27
Temporary Slope Pipe



SLOPE PIPE WITH TRANSVERSE BERM



PLAN

Transverse berm must be used whenever temporary slope pipe is not located at low point.

Any accumulated sediment should be removed from the inlet.

STORM INLET PROTECTION

Storm sewer Inlets should be protected from sediment pollution wherever the sewer system does not discharge into a functioning sediment basin. (NOTE: Since detention ponds do not effectively remove sediment prior to discharging, storm sewers discharging to detention ponds should be protected from sediment pollution.) Inlet protection may also be desirable in cases where it would be difficult or expensive to clean accumulated sediment from sewer lines, or where a temporary riser may have to be removed from a permanent basin prior to completion of all earthmoving. Inlet protection should be maintained until all earthwork within the tributary drainage area has been completed and stabilized.

Silt fence and straw bale barriers are not intended for use in areas of concentrated flow such as is common at storm sewer inlets. Typically, the fence or straw bales fail, allowing unfiltered water to enter the inlet. In those rare instances where the fence or bales do not fail, runoff usually either bypasses the inlet, causing erosion and/or capacity problems down gradient, or backs up to the point of creating flooding. This can create traffic hazards.

INLET FILTER BAGS

Filter bags should trap all particles larger than 150 Microns.

Wherever filter bags are used they should be installed according to the manufacturer's specifications. Typical installation details should be provided on the drawings. NOTE: Filter bags designed to fit over the inlet grate are not recommended for most storm sewer inlets. Use of such filter bags could result in a severe reduction of the inlet capacity resulting in flooding or runoff bypassing the inlet. Wherever such bags are used, they should be located at topographic low points and limited to 1 acre maximum drainage areas. Inlet filter bags are not generally recommended as the primary BMP to remove sediment from site runoff water.

Inlet filter bags should be inspected on a weekly basis and after each runoff event.

Filter bags should be cleaned and/or replaced when the bag is ½ full.

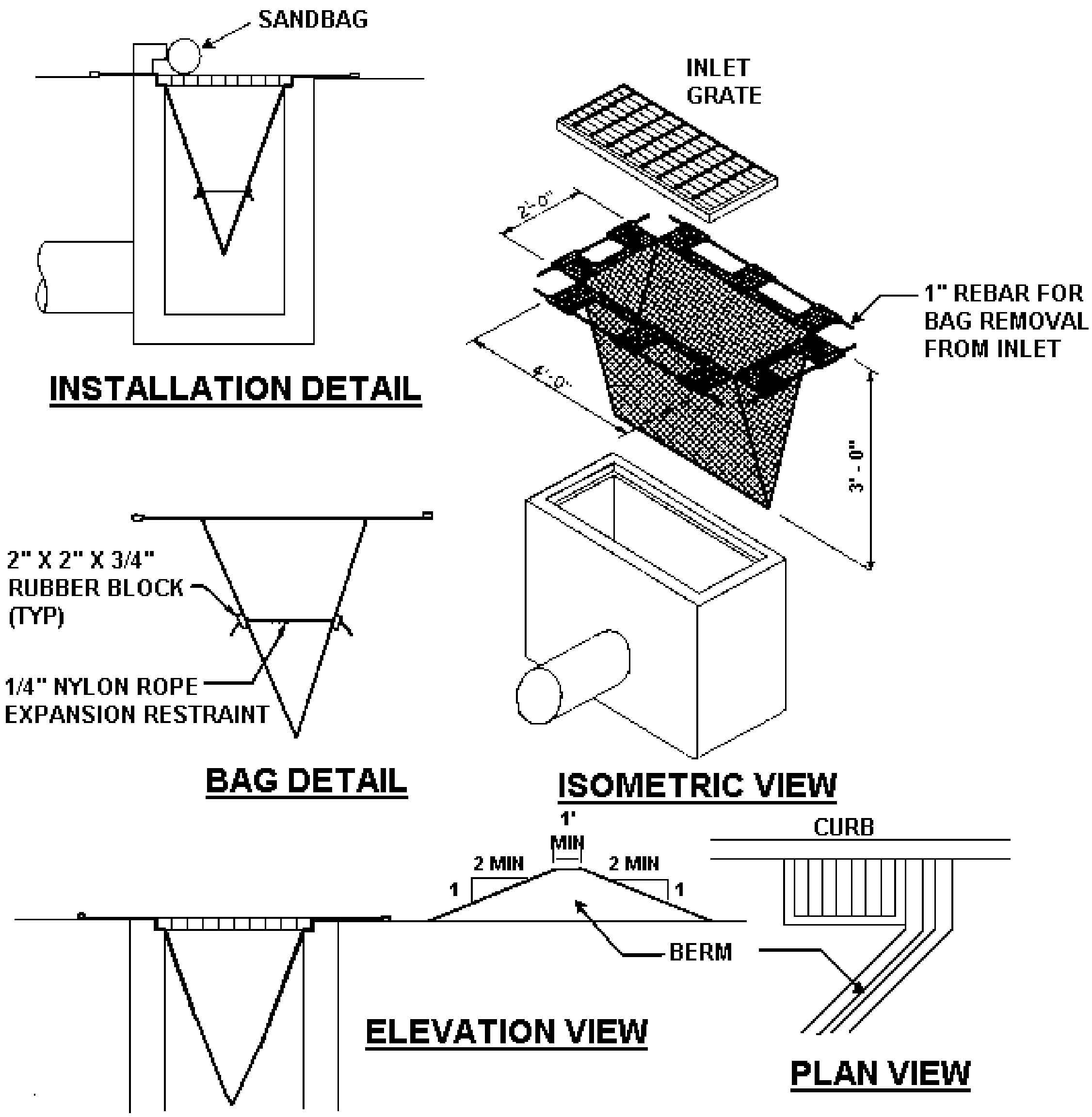
Damaged filter bags should be replaced.

Needed repairs should be initiated immediately after the inspection.

CONCRETE BLOCK/GRAVEL INLET PROTECTION

Wherever concrete block/gravel inlet protection is proposed, it should be installed according to the details shown in Standard Construction Details #29 or 30. This type of inlet protection should not be used where ponding of water would cause a traffic hazard.

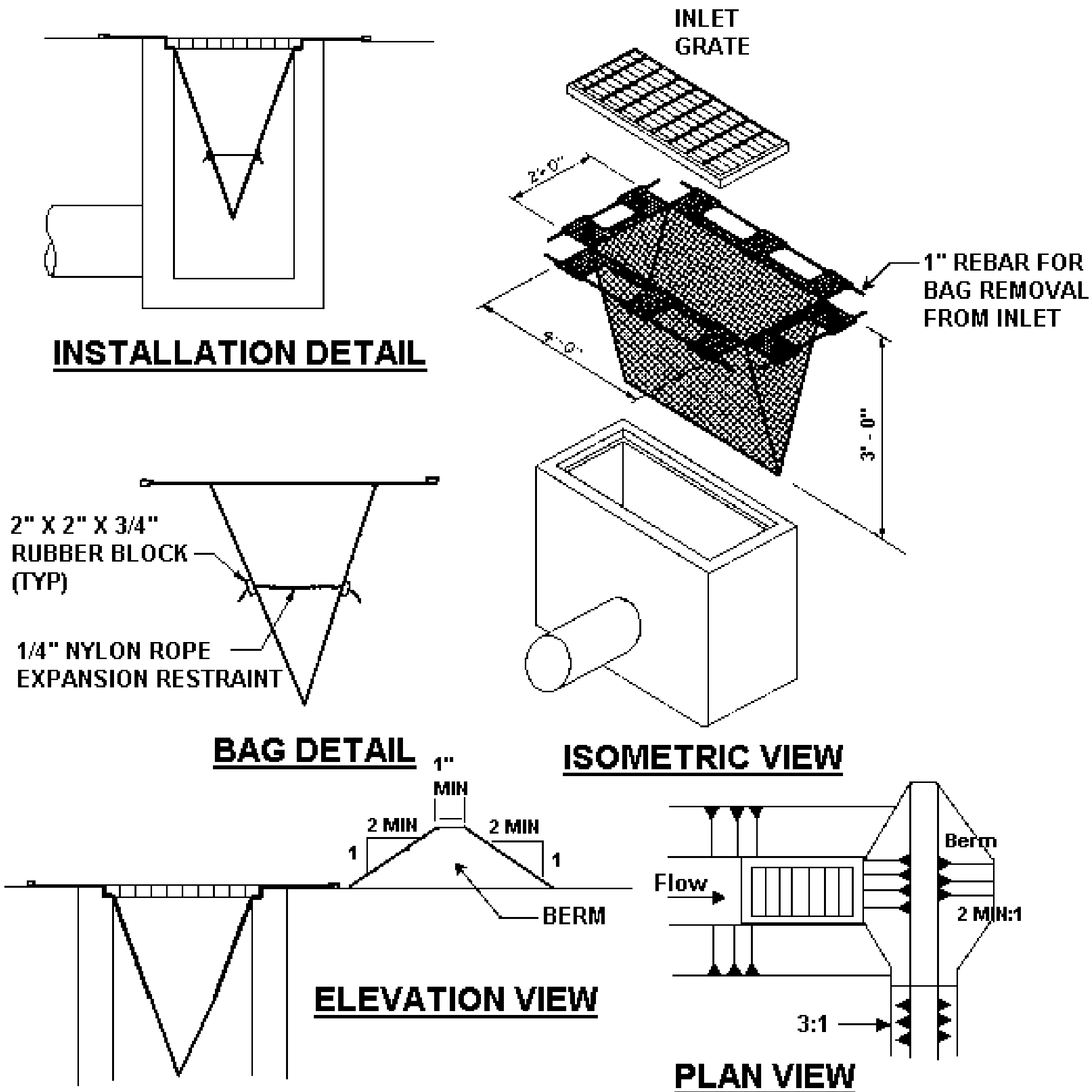
STANDARD CONSTRUCTION DETAIL #28
Filter Bag Inlet Protection
Curbed roadway



Maximum Drainage Area = ½ acre.
Inlet protection is not required for inlet tributary to sediment basin or trap. Berms required for all installations.
Earthen berm shall be maintained until roadway is stoned. Road subbase berm shall be maintained until roadway is paved.
Six inch minimum height asphalt berm shall be maintained until roadway surface receives final coat.

DO NOT USE ON MAJOR PAVED ROADWAYS WHERE PONDING MAY CAUSE TRAFFIC HAZARDS

STANDARD CONSTRUCTION DETAIL #28a
Filter Bag Inlet Protection
Channel or Roadside Swale



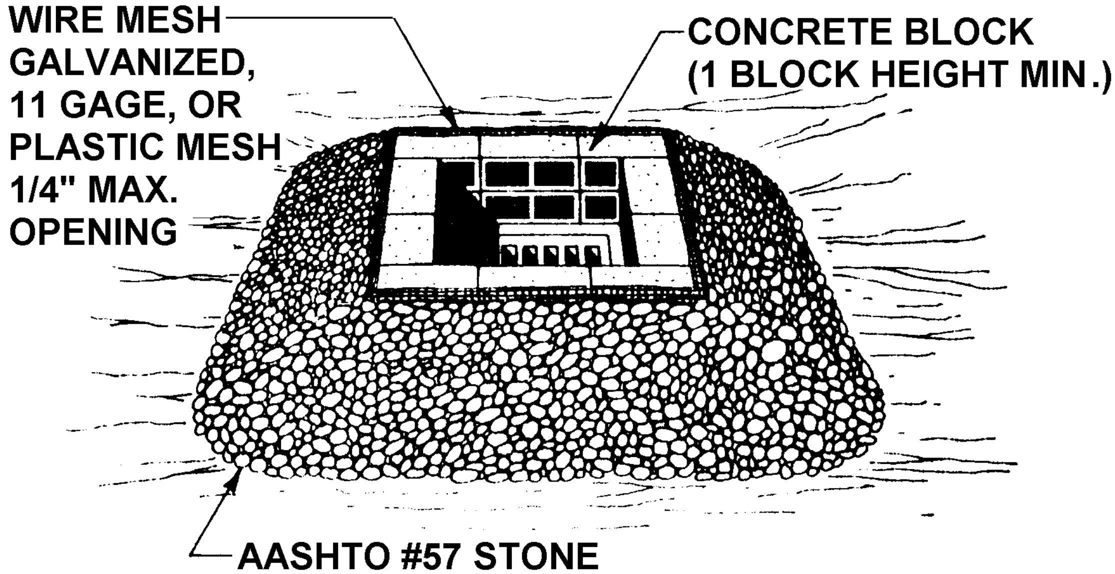
Maximum Drainage Area =½ acre.

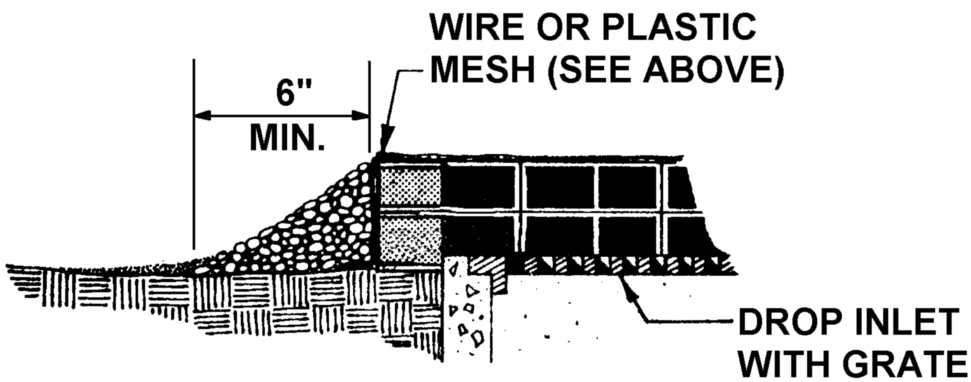
Inlet protection is not required for inlet tributary to sediment basin or trap. Berms required for all installations.

Earthen berm in roadway shall be maintained until roadway is stoned. Road subbase berm on roadway shall be maintained until roadway is paved. Earthen berm in channel shall be maintained until permanent stabilization is completed or to remain permanently.

DO NOT USE ON MAJOR PAVED ROADWAYS WHERE PONDING MAY CAUSE TRAFFIC HAZARDS

STANDARD CONSTRUCTION DETAIL #29
Stone & Concrete Block Inlet Protection
Channel or Roadside Swale





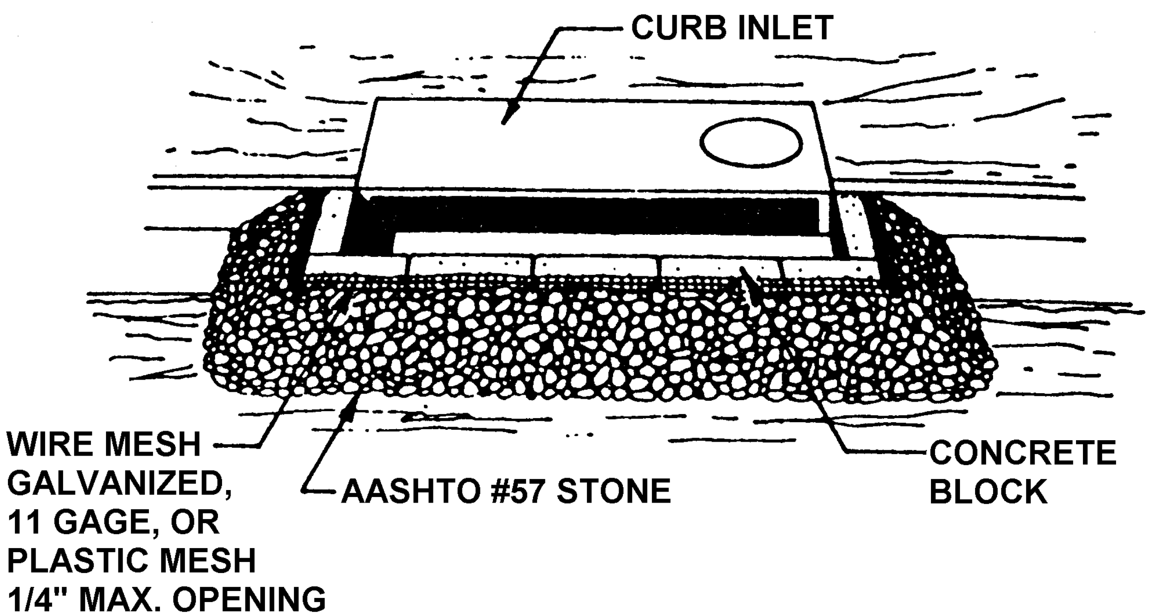
Maximum Drainage Area =1 acre.

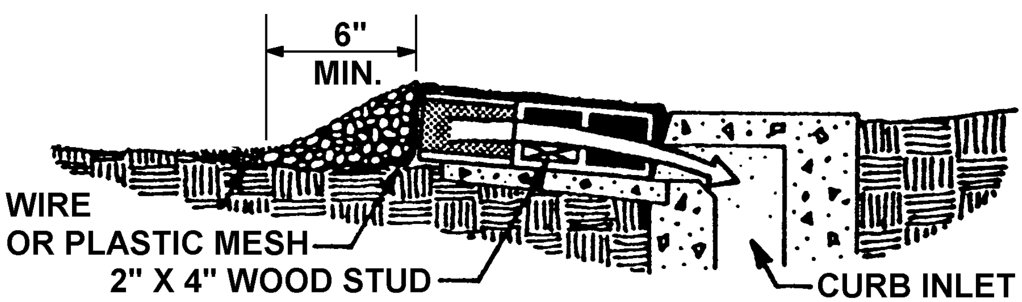
Inlet protection is not required for inlet tributary to sediment basin or trap. Berms required for all installations.

Earthen berm in roadway shall be maintained until roadway is stoned. Road subbase berm on roadway shall be maintained until roadway is paved. Earthen berm in channel shall be maintained until permanent stabilization is completed or to remain permanently.

DO NOT USE ON MAJOR PAVED ROADWAYS WHERE PONDING MAY CAUSE TRAFFIC HAZARDS

STANDARD CONSTRUCTION DETAIL #30
Stone & Concrete Block Inlet Protection
Curbed Roadway

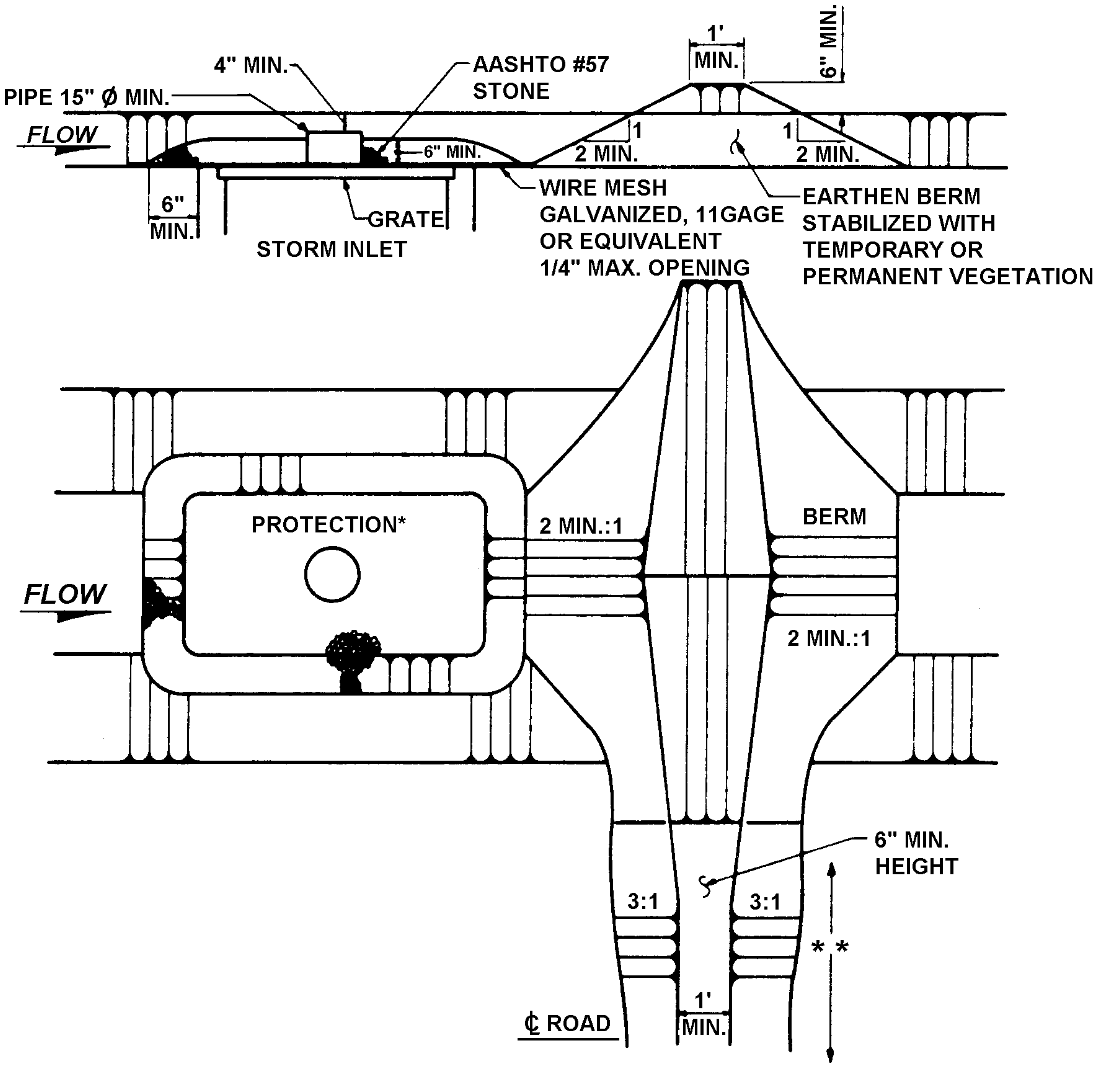




Maximum Drainage Area = 1 acre.
Inlet protection is not required for inlet tributary to sediment basin or trap. Berms required for all installations.
Earthen berm shall be maintained until roadway is stoned. Road subbase berm shall be maintained until roadway is paved.
Six inch minimum height asphalt berm shall be maintained until roadway surface receives final coat.

DO NOT USE ON MAJOR PAVED ROADWAYS WHERE PONDING MAY CAUSE TRAFFIC HAZARDS

STANDARD CONSTRUCTION DETAIL #31
Channel or Roadside Swale
Storm Inlet Protection and Berm(s)

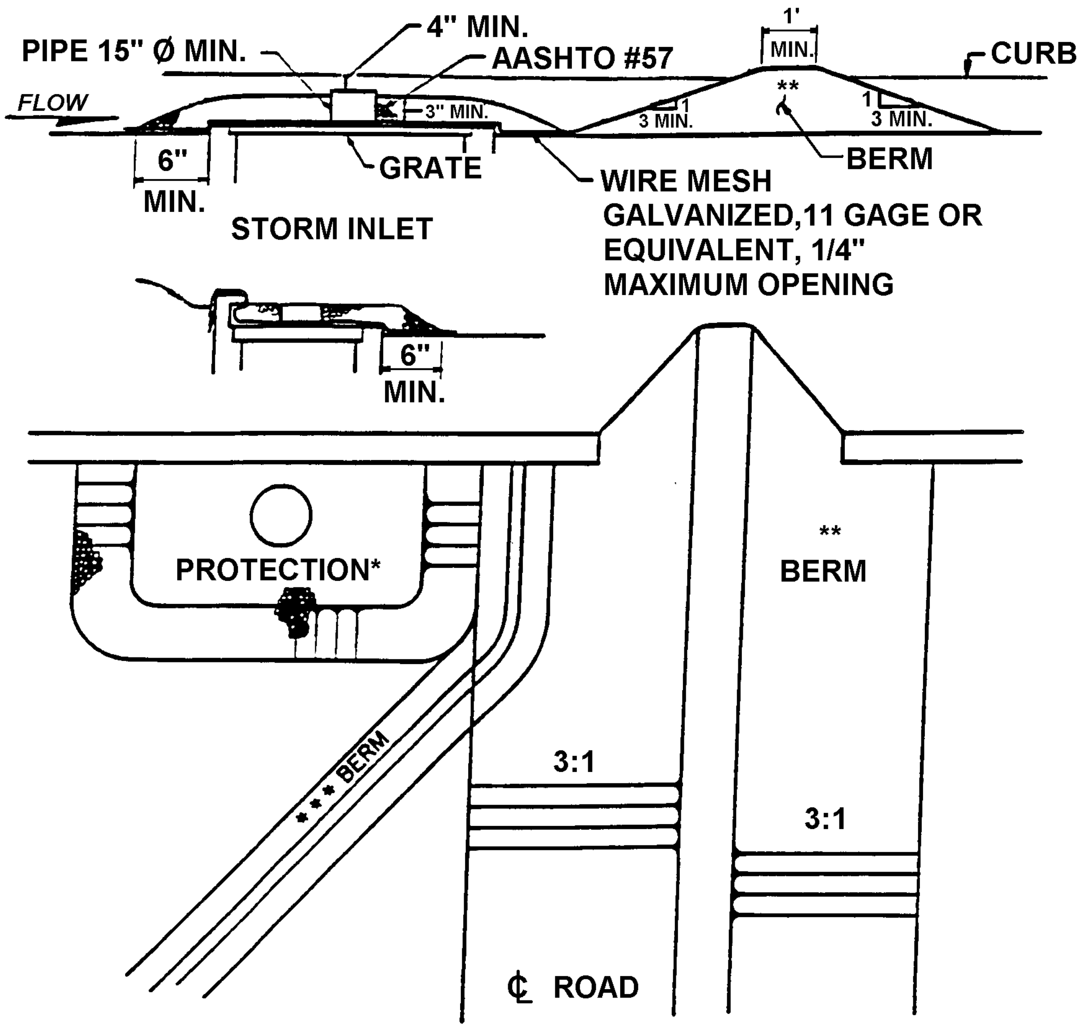


* Stone protection is not required for inlet tributary to sedimentation basins and sediment traps. Berms are required for all installations.

** Earthen berm in roadway shall be maintained until roadway is stoned. Road subbase berm on roadway shall be maintained until roadway is paved. Earthen berm in channel shall be maintained until permanent stabilization is completed or to remain permanently.

One acre maximum drainage area with 15” overflow pipe and 4” head.

STANDARD CONSTRUCTION DETAIL #32
Curbed Roadway
Storm Inlet Protection And Berm(S)



* Stone protection is not required for inlet tributary to sediment basin or trap. Berms are required for all installations.

** Earthen berm shall be maintained until roadway is stoned. Road subbase berm shall be maintained until roadway is paved.

*** Six inch minimum height asphalt berm shall be maintained until roadway surface receives final coat.

One acre maximum drainage area with 15” overflow pipe and 4” head.

OUTLET PROTECTION - Discharge velocities from culverts or similar structures must not cause erosion in downstream channels. The conditions in the downstream channel must be analyzed to determine if existing conditions will be stable or if a protective lining is necessary.

When a culvert is flowing full, the anticipated velocity can be calculated from the continuity equation (Q = VA).

$$\mathbf{V = Q/A}$$

where V = Velocity (fps)
Q = Design Discharge (cfs)
A = Cross-sectional Area of the Pipe (ft^2)

When a culvert is not flowing full, a different procedure must be used to determine the velocity. Due to the increased friction that occurs along an increased wetted perimeter, full flow does not represent the greatest flow capacity of a pipe. For circular pipes, peak flow actually occurs at 93% of the total inside diameter. Likewise, the average velocity of a pipe flowing ½ full is equal to that for one flowing full. Therefore, the anticipated velocity should be determined either by use of nomographs or by use of Figure 20.

To use Figure 20, the full flow capacity of the pipe must determined from the following equation.

$$Q_r = \frac{0.464}{n} D^{8/3} S^{1/2}$$

Use the Continuity Equation to determine the full-flow velocity:

$$V_f = \frac{Q_f}{A}$$

Calculate the ratio of part-full to full-flow discharge**:**

$$d / D = \frac{Q_d}{Q_f}$$

where d/D = Ratio of Part-Full to Full-Flow Discharge
Q_d = Design Discharge (cfs)
Q_f = Full-Flow Discharge (cfs)
D = Diameter (ft)
S = Slope of pipe

Using Figure 20, find the value for d/D ratio. Project a vertical line from the d/D ratio upward to the FLOW curve, then a horizontal line to the VELOCITY curve, then follow a vertical line downward to determine the velocity ratio.

Multiply the velocity ratio by the velocity calculated from the Continuity Equation to determine the part-full velocity.

EXAMPLE: Calculate the anticipated discharge velocity for a 24" diameter circular concrete pipe with a 0.5% slope and a design discharge of 12.7 cfs.

Full-Flow Discharge

$$Q_f = \frac{0.464}{0.015} (2)^{8/3} (0.005)^{1/2}$$

$$Q_f = 30.93 \text{ x } 6.35 \text{ x } 0.07 = 13.7 \text{ cfs}$$

Full-Flow Velocity

$$V_f = \frac{13.7 \text{ cfs}}{3.14 \text{ ft}^2} = 4.4 \text{ fps}$$

Ratio of Part-Full to Full-Flow Discharge:

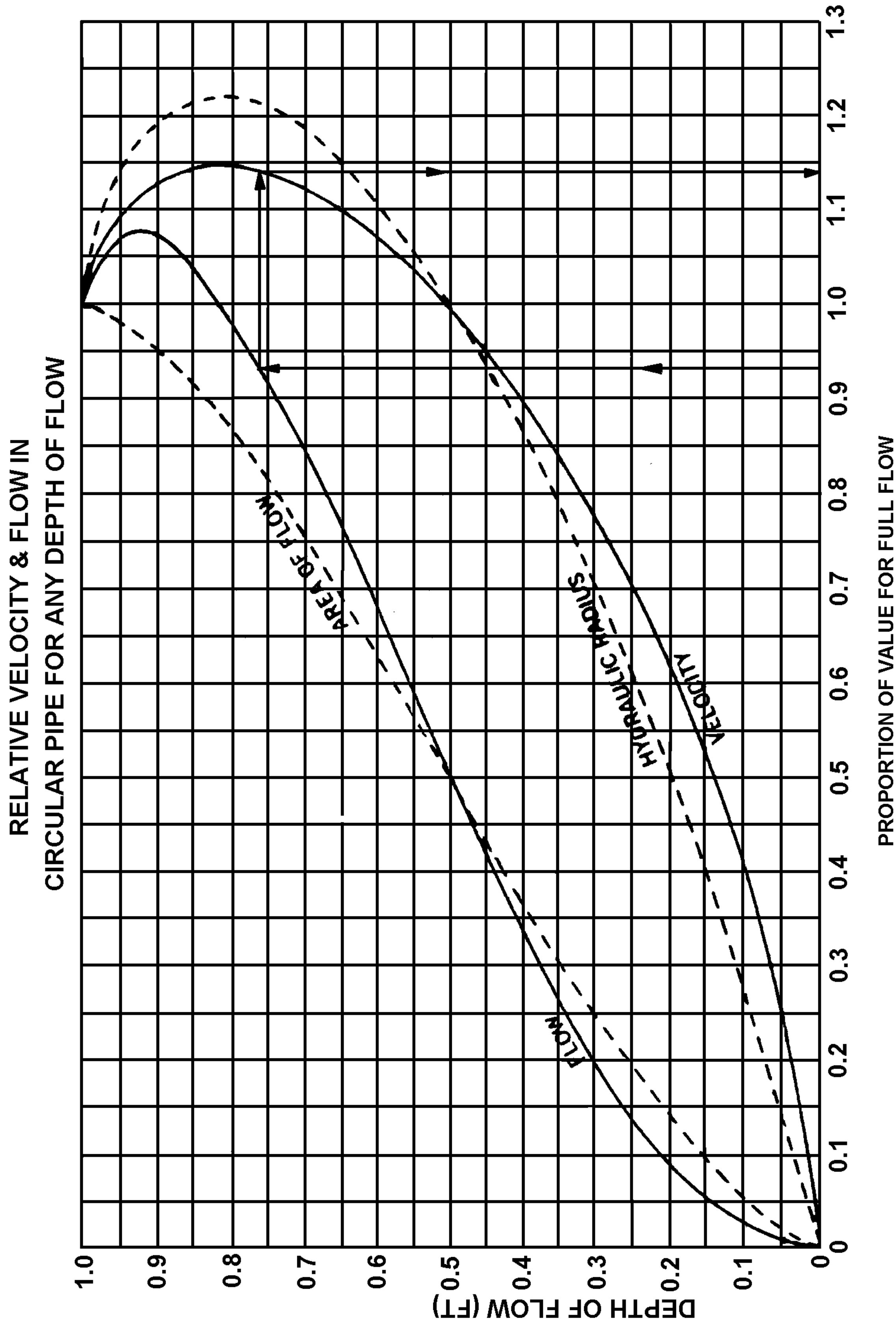
$$d / D = \frac{12.7}{13.7} = .93$$

From Figure 20, the Velocity ratio is 1.13

$$V_d = 4.4 \text{ fps x } 1.13 = 5.0 \text{ fps}$$

The downstream channel lining must be able to withstand a velocity of 5.0 fps.

FIGURE 20


RELATIVE VELOCITY & FLOW IN
CIRCULAR PIPE FOR ANY DEPTH OF FLOW
PROPORTION OF VALUE FOR FULL FLOW
DEPTH OF FLOW (FT)
AREA OF FLOW
HYDRAULIC RADIUS
VELOCITY
FLOW
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3
1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0

RIPRAP APRONS - Riprap aprons may be used to prevent scour at pipe or channel outfalls where anticipated discharge velocities do not exceed 14.5 feet per second and where the aprons can be installed on a level grade. In cases where discharge velocities exceed 14.5 fps, a suitable means of velocity reduction must be used prior to discharging onto a riprap apron.

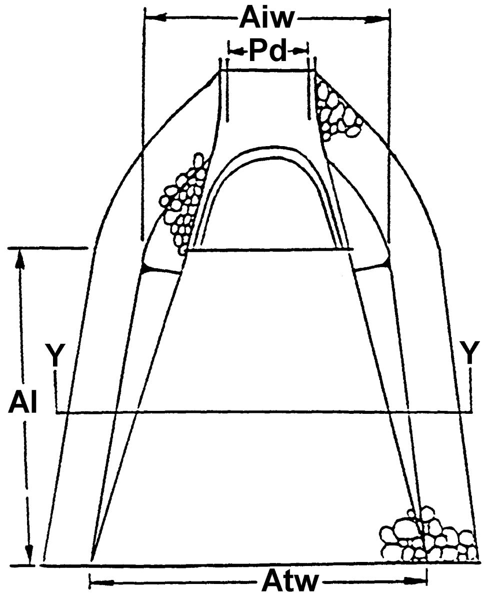
Riprap aprons should be constructed according to the dimensions shown in Standard Construction Detail #33.

Determine whether MAXIMUM or MINIMUM TAILWATER conditions exist at the outfall for the design discharge.

Minimum Tailwater exists when the depth of flow in the receiving water course, as calculated by Manning's equation, is less than ½ the diameter of the discharge pipe, or where no channel or swale exists at the point of discharge. When this condition exists, use Figure 21

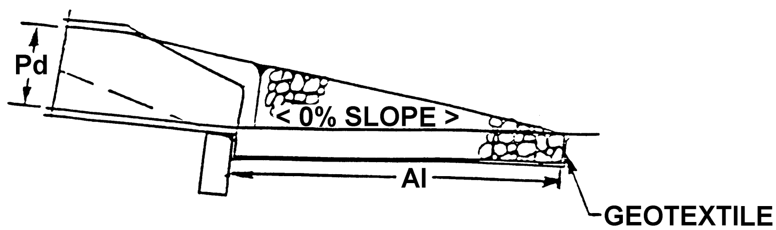
Maximum Tailwater exists when the depth of flow in the receiving water course, as calculated by Manning's equation, is greater than ½ the diameter of the discharge pipe. When this condition exists, use Figure 22.

STANDARD CONSTRUCTION DETAIL #33
Riprap Aprons At Pipe Outlets With Flared End Sections



PLAN VIEW

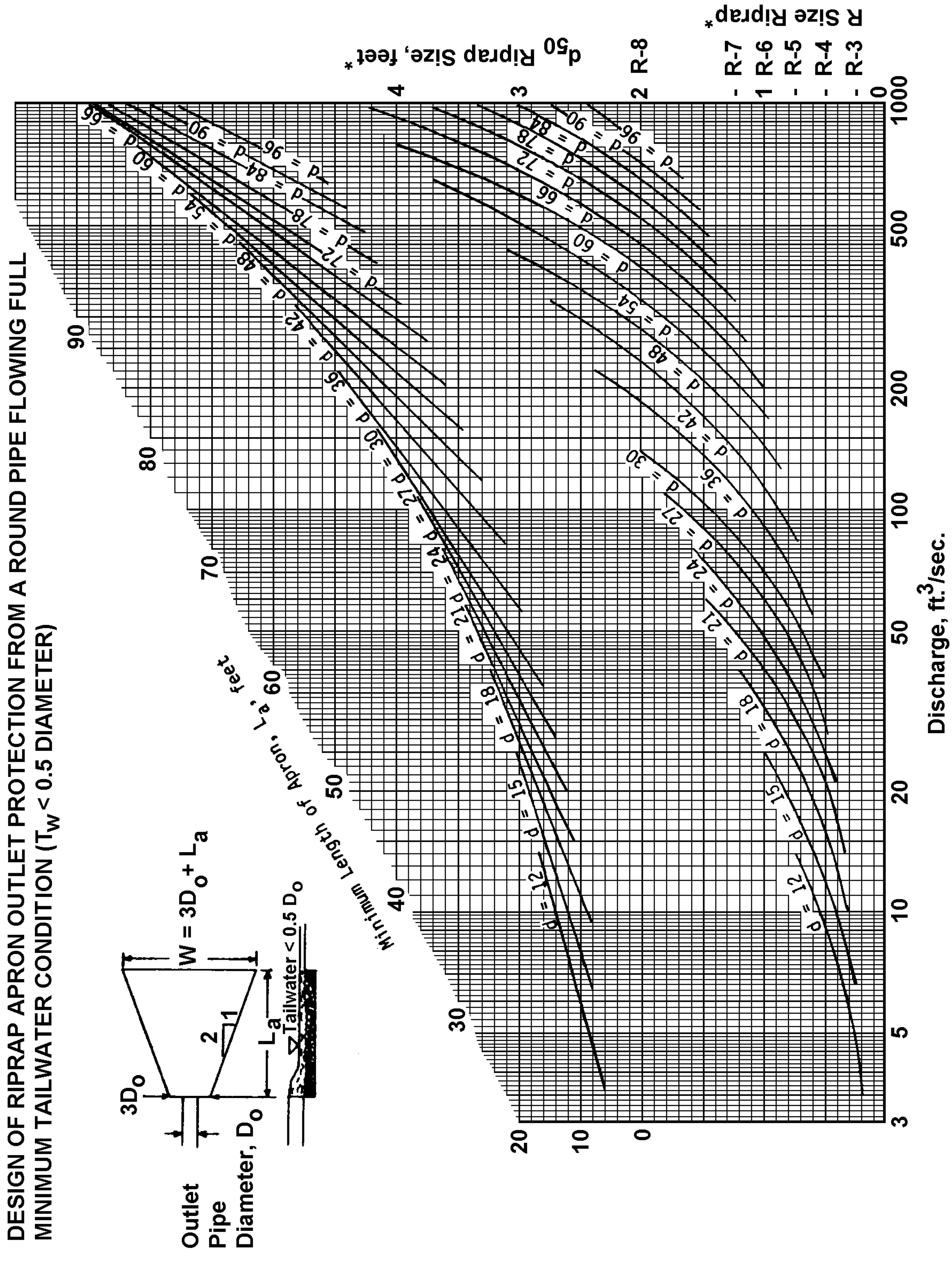
SECTION Y-Y



SECTION Z-Z

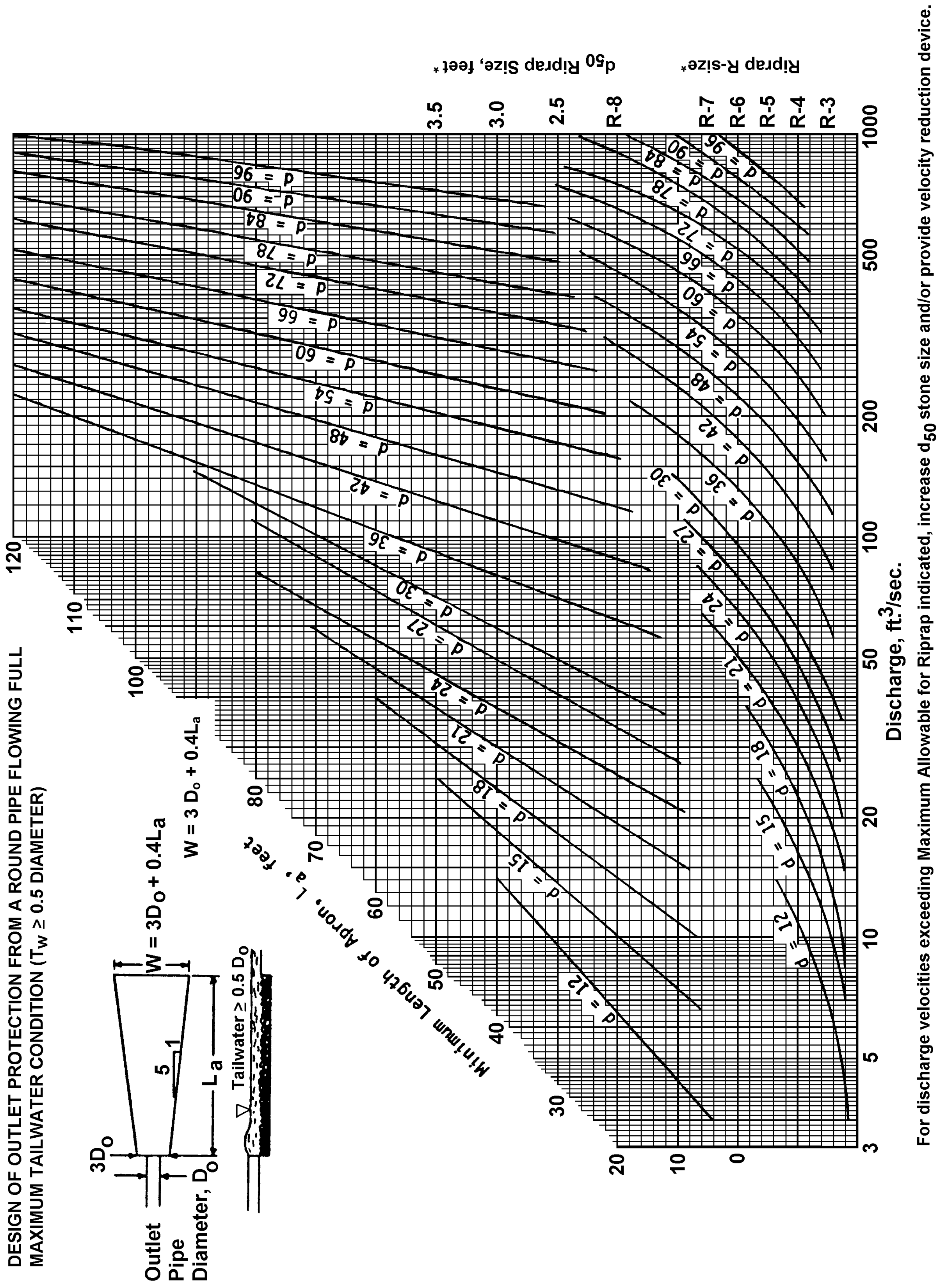
		RIPRAP		APRON		
OUTLET NO.	PIPE DIA Pd (IN)	SIZE (R-__)	THICK. Rt (IN)	LENGTH Al (FT)	INITIAL WIDTH Aiw (FT)	TERMINAL WIDTH Atw (FT)

FIGURE 21
Riprap Apron Design, Minimum Tailwater Condition



* For discharge velocities exceeding Maximum Allowable for Riprap indicated, increase d_{50} stone size and/or provide velocity reduction device.

FIGURE 22
Riprap Apron Design, Maximum Tailwater Condition



Locate the design discharge along the bottom of Figure 21 or 22. Follow a vertical line to the point where it intersects the first curve corresponding to the diameter of the discharge pipe. From that point follow a horizontal line to the right to determine the minimum d_{50} stone size of the riprap in feet.

Check Table 9 to make sure that the anticipated discharge velocity does not exceed the maximum permissible velocity for the size of riprap obtained in this step.

If the anticipated discharge velocity exceeds the maximum permissible velocity, increase the size of the riprap to a size whose permissible velocity is not exceeded.

Follow the same vertical line mentioned above to the point where it intersects the second curve corresponding to the diameter of the discharge pipe. From that point, follow a horizontal line to the left and read the Minimum Length of the Apron (L_a) in feet.

For Minimum Tailwater conditions, the apron width (W) may be calculated by the formula:

$$\mathbf{W = 3D_o + L_a}$$

where D_o = the outlet pipe diameter
L_a = the length of the apron

For Maximum Tailwater conditions, the apron width (W) may be calculated by the formula:

$$\mathbf{W = 3D_o + 0.4\,L_a}$$

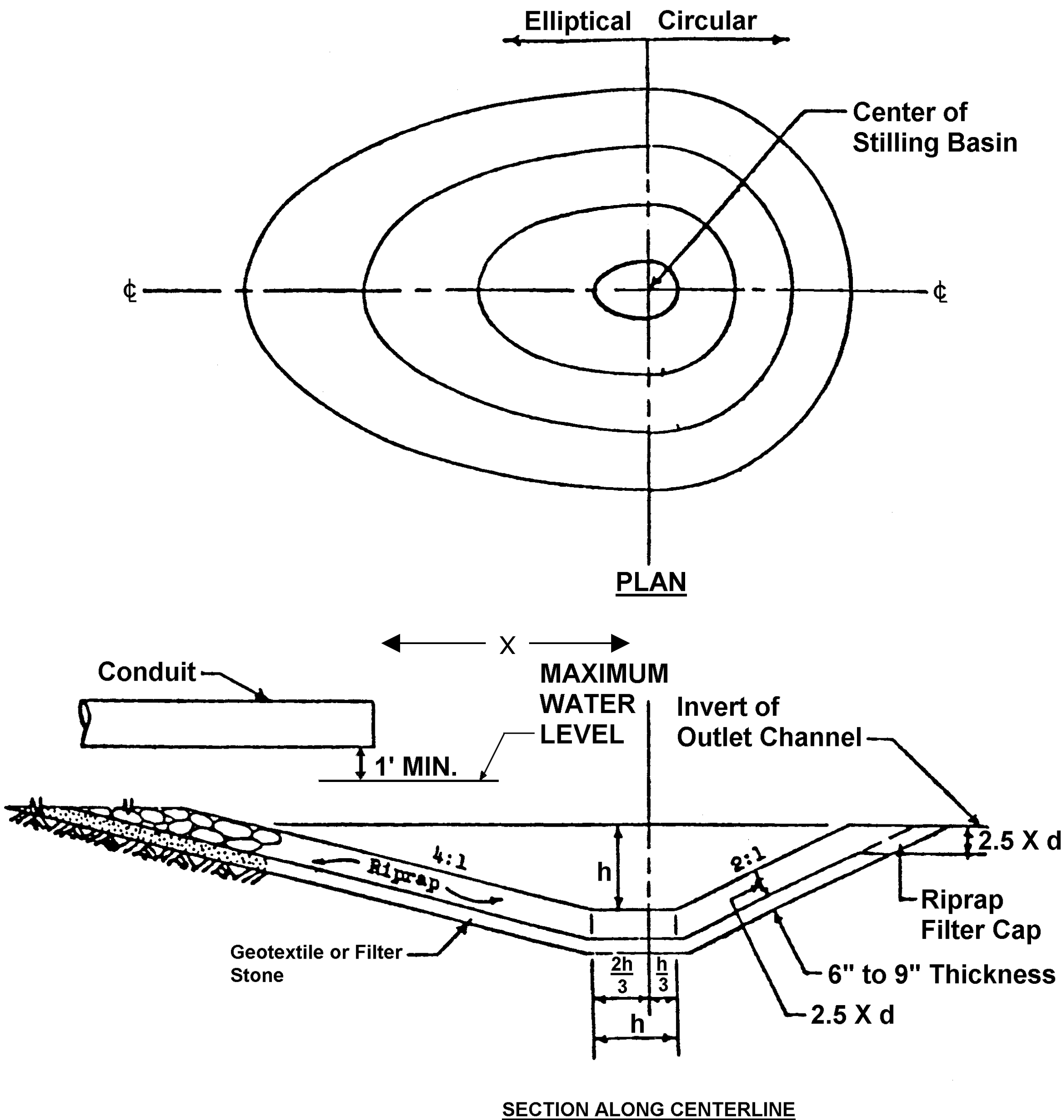
Where the apron design width (W) exceeds the downstream watercourse bottom width, a transition zone must be designed and installed downstream from the apron to the watercourse.

STILLING BASINS - Stilling basins may be used at pipe outfalls where the discharge is at or near horizontal and sufficient room exists to construct the basin between the pipe and the receiving watercourse. The size and shape of stilling basins is based upon the anticipated scour hole below a pipe outfall due to a design discharge.

Stilling basins should be designed and constructed according to the details shown in Figure 23 (Geotextile may be substituted for the filter stone underlayment.)

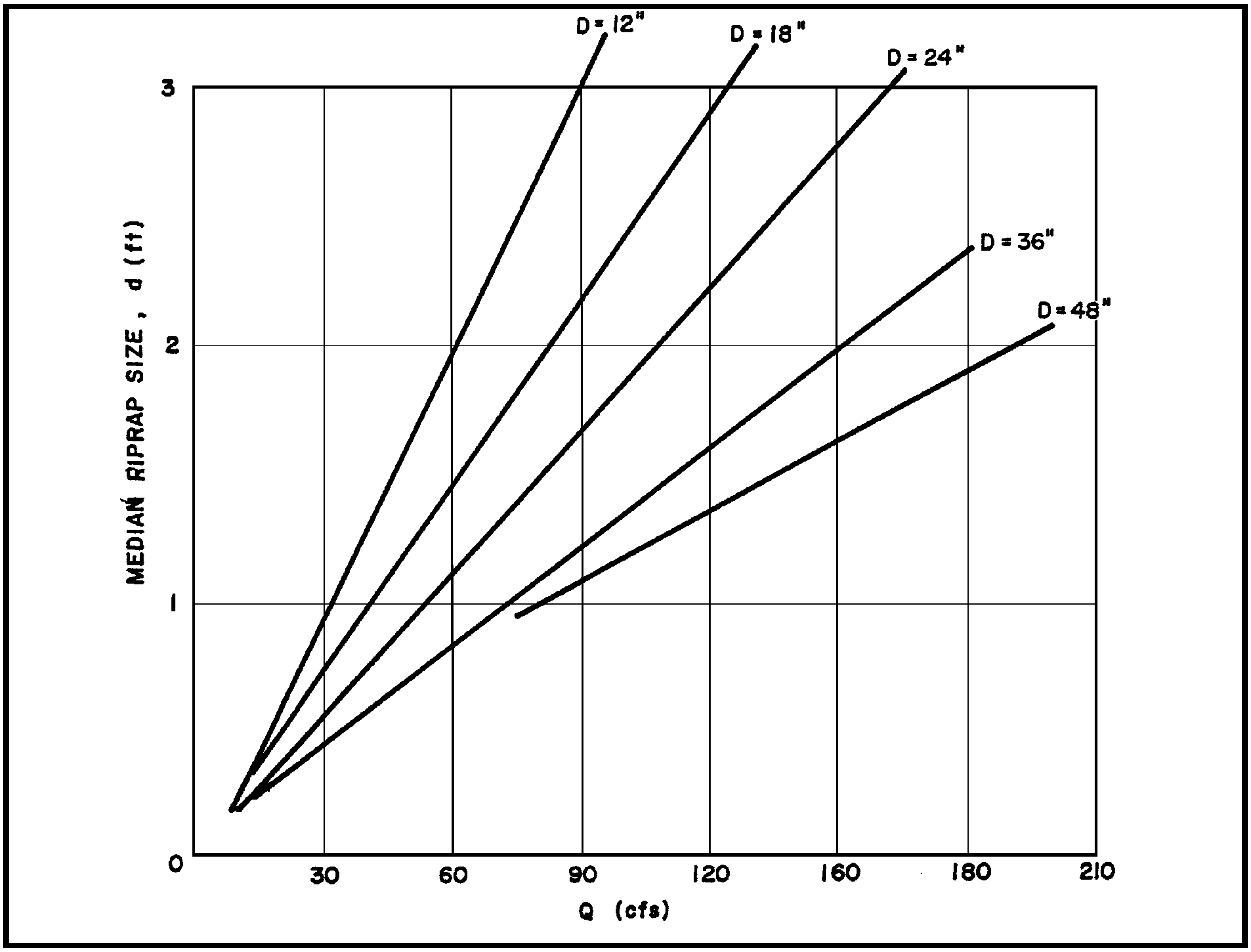
The minimum vertical distance from the bottom of the pipe to the maximum water surface elevation is 12 inches.

FIGURE 23
Typical Stilling Basin Details



Determine the d_{50} Stone Size (d) for the stilling basin from Figure 24 using the design discharge and the pipe diameter.

FIGURE 24
d_{50} Stone Size for Stilling Basins



Calculate the required basin depth (h) by the formula:

$$h = D^{1/3}\left[0.148\ \frac{Q}{Dd^{\ 1/2}} - 1.82\ (d)\right]^{2/3}$$

where: h = basin depth (ft)
D = inside diameter of the pipe (ft)
d = d_{50} stone size of the riprap (ft)
Q = design discharge (cfs)

Calculate the distance (X) in feet from the end of the discharge pipe to the "Center" of the basin by using the following formula:

$$X = (V^2\ /\ 2g)^{0.5}\ \left[(1 + m\ /\ p)^{0.5}\ + 1 + m\ /\ 2p\right]p^{0.5}$$

where: v = discharge velocity (fps)

g = acceleration due to gravity (32.2 ft/sec^2)

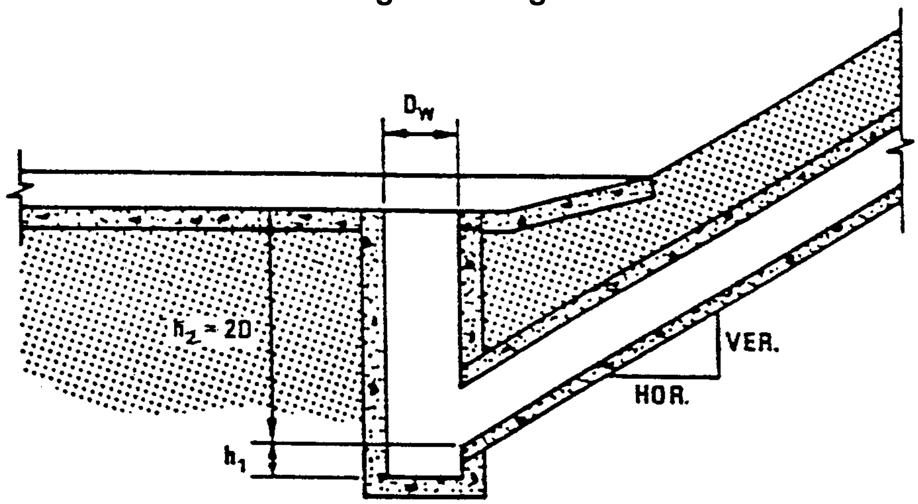
m = depth of water (ft) in the basin during maximum pipe discharge (i.e. h + channel flow depth)

p = vertical distance (ft) from inside crown of the pipe to the maximum water surface

STILLING WELLS - Stilling wells may be used where little floating or rolling debris is expected. Since tailwater increases the efficiency of a stilling well, whenever possible, it should be located in a sump or depressed area. Riprap protection should be provided for a distance of at least three times the well diameter downstream.

Stilling wells should be constructed according to the details shown in Figure 25.

FIGURE 25
Stilling Well Height



Using the Pipe Diameter (D) in feet and Design Discharge (Q) in cfs, determine the Well Diameter (D_W) from Figure 26.

Using the culvert slope (V:H) determine h_1/D_W from Figure 27.

Calculate the Depth of Well Below Invert (h_1) in feet by multiplying h_1/D_W by the diameter of the well (D_W).

Minimum Depth of the Well (h_2) above the culvert invert is 2 (D). Note: Increasing this depth will increase the efficiency of the well.

Total depth of the well (h_w) = $h_1 + h_2$.

FIGURE 26
Stilling Well Diameter

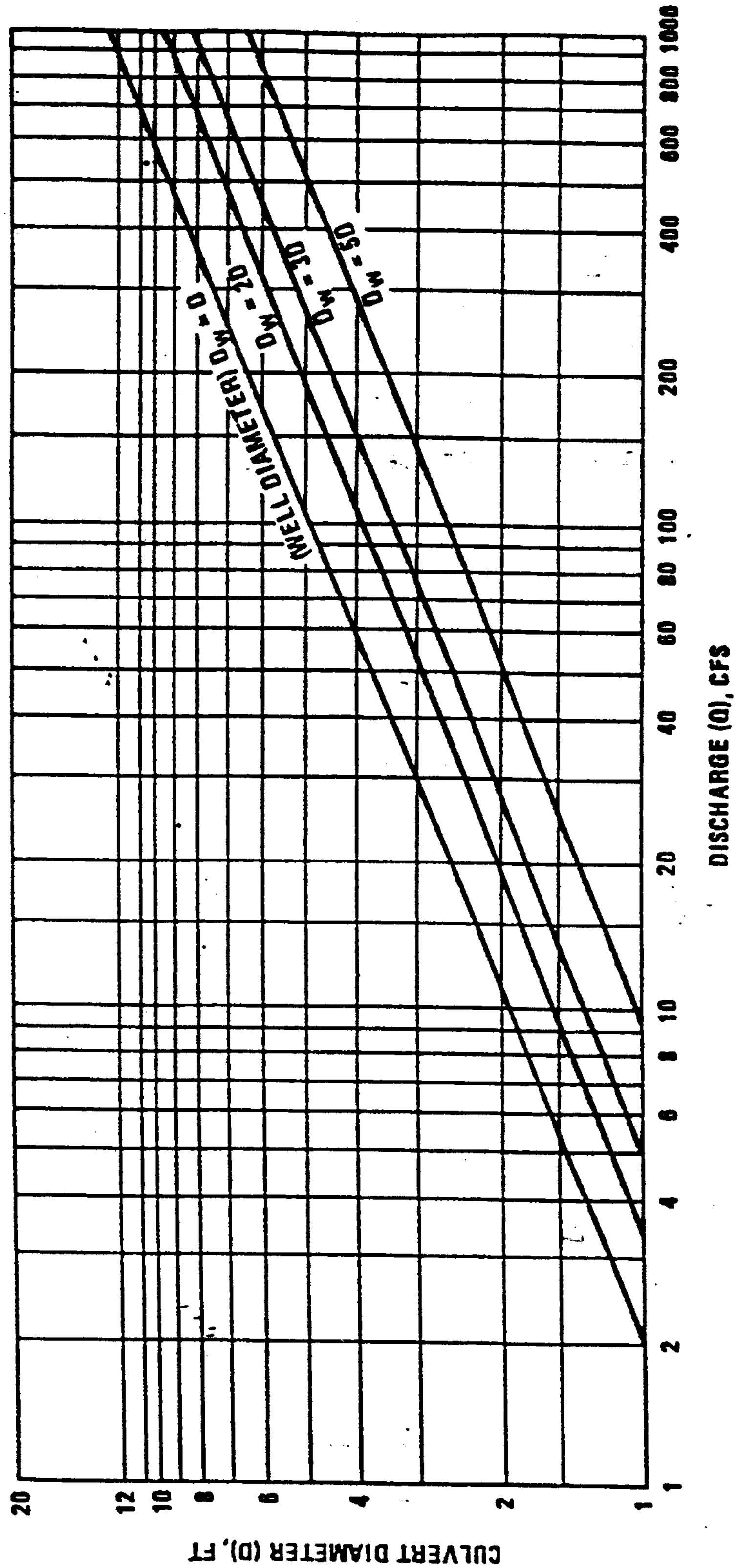
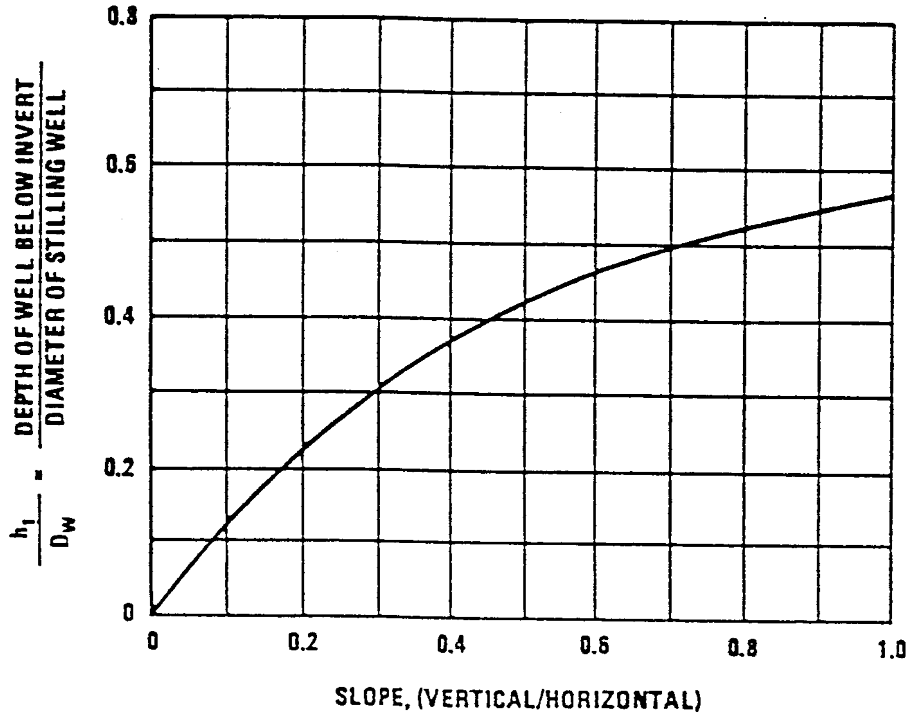


FIGURE 27
Depth of Well Below Invert



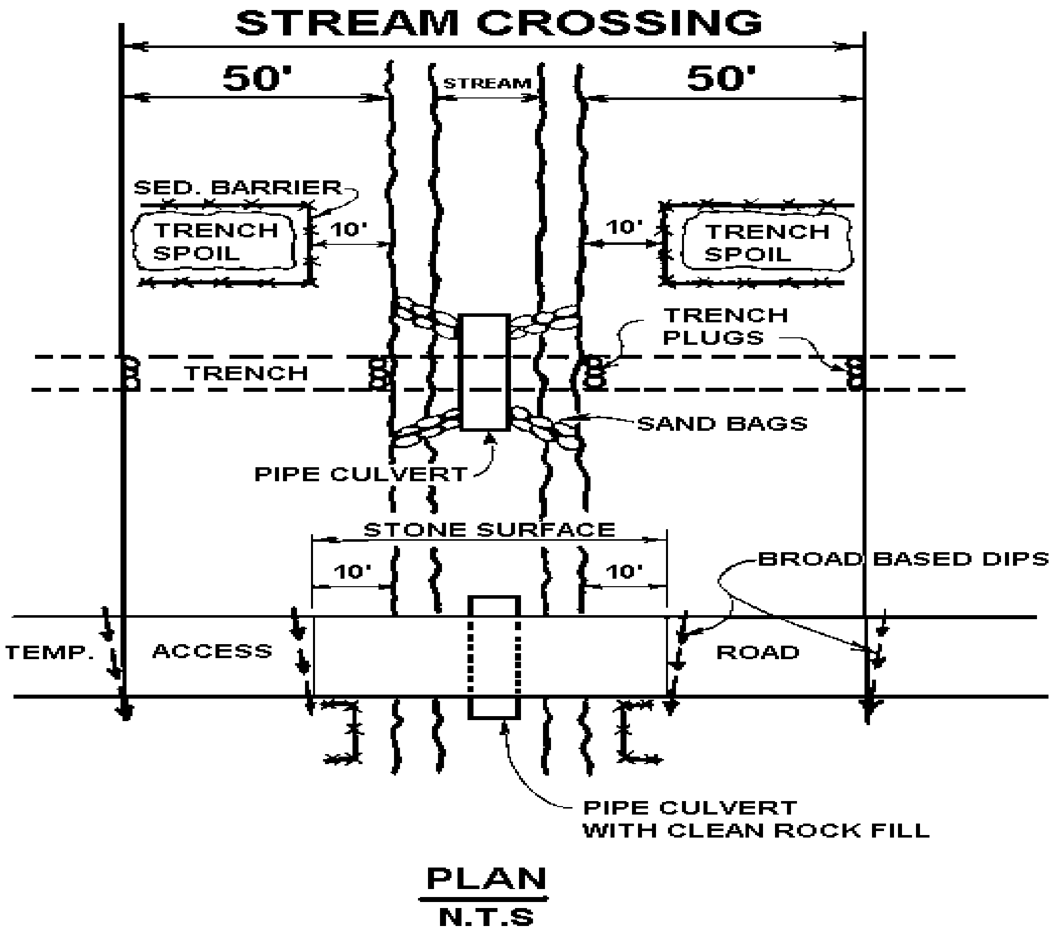
PIPELINE AND UTILITY LINE PROJECTS

Since pipeline and utility line construction tends to be repetitive, the construction sequence may be generalized. However, enough information must be provided to identify the BMPs that will be in place during each phase of construction (clearing & grubbing, initial grading, trenching operations, backfilling, and during final stabilization).

Pipelines with joints that allow a manufactured length of pipe to be placed in the trench with the pipe joint assembled/made in the trench require an open pipeline trench that is only slightly longer than the length of pipe being installed. The total length of excavated trench open at any one time should not be greater than the total length of pipeline/utility line that can be placed in the trench and back-filled in one working day. No more than 50 lineal feet of open trench should exist when pipeline/utility line installation ceases at the end of the workday. Soil supplements, seed and mulch should be applied within seven days after the pipeline/utility line is installed.

Specific instructions should be provided for each type of water crossing anticipated (major streams, minor streams, swales, wetlands, etc.). Minor streams ($\leq$ 10 wide at normal flow depth), swales, ditches, channels, and waterways should be flumed (see Figure 29) or pumped (see Figure 30) past the open trench at the time the crossing is made.

FIGURE 28
Typical Stream Crossing with Access Road



If there is an existing base flow or runoff at the time of the trenching, the flume should be installed prior to trench excavation at that location. The flume should be of sufficient size to convey normal stream flow over the open trench. Sandbags should be used to direct flow into the flume. If no base flow or runoff exists, the flume may be installed immediately following backfilling of the trench. In cases where the utility line is completed (from initial disturbance to final stabilization) within one day, no flume is required. The disturbed waterway must be re-established and stabilized as part of the final stabilization.

FIGURE 29
Typical Flumed Stream Crossing

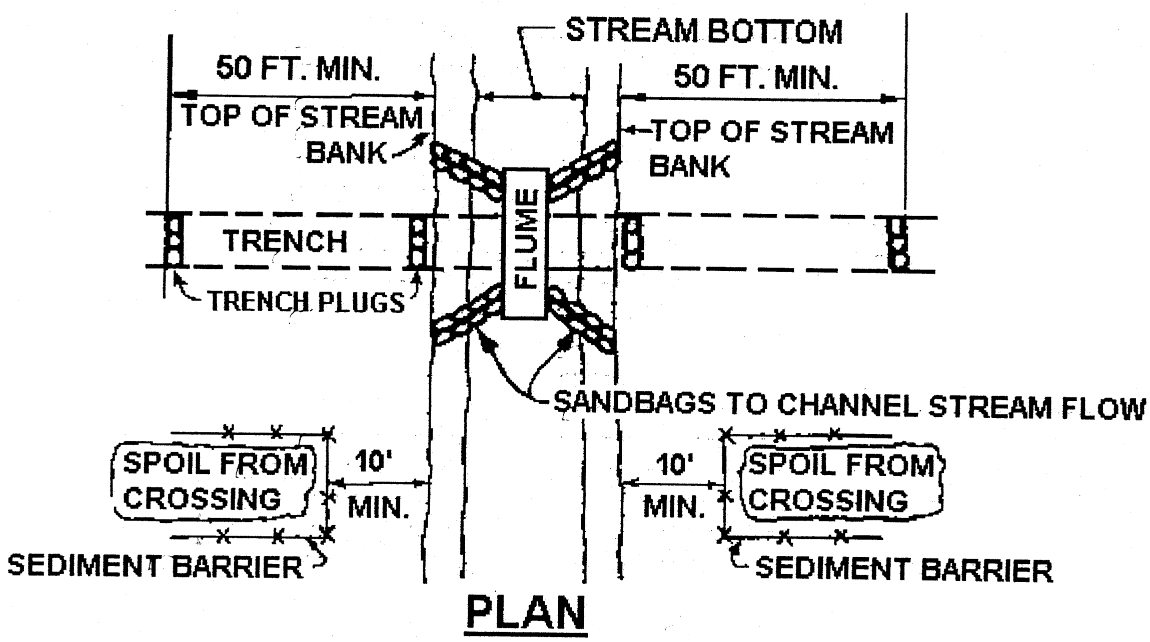
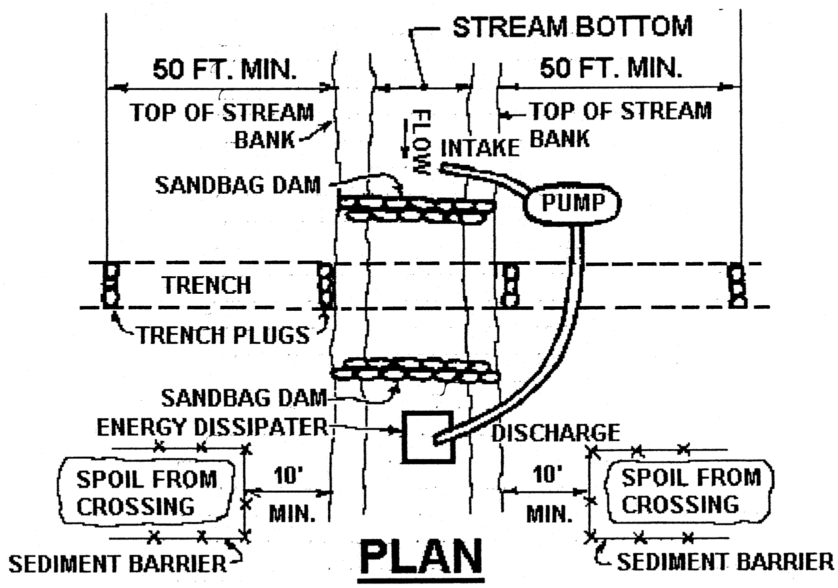


FIGURE 30
Typical Stream Crossing with Pump Bypass



Trench plugs should be installed within the trench on both sides of the stream channel (see Figure 31).

A utility line stream crossing of a stream 10 feet in (bottom) width or less should be completed within 72 hours (from start to finish) including the trench backfilling, stabilization of stream banks and stabilization of the area 50 feet back from the top of each stream bank.

Facilities for removing sediment from pumped water should be available at the utility line stream crossing site before trenching commences and maintained until trench backfilling is completed. Assembly areas, temporary equipment and nonhazardous material storage areas should be located at least 50 feet back from the top of stream bank.

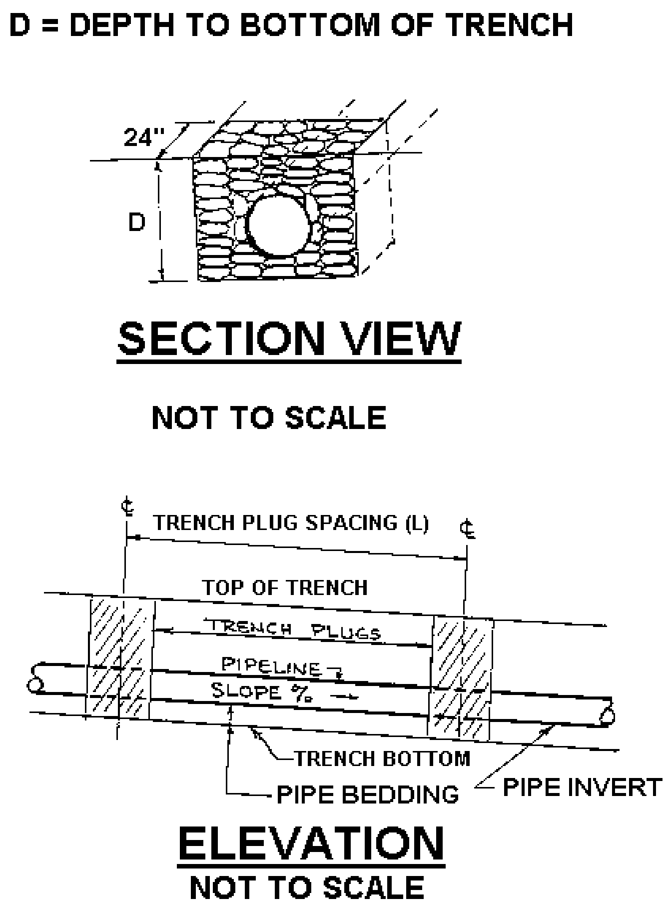
Hazardous or pollutive material storage areas should be located at least 100 feet back from the top of stream bank.

All excess excavated material shall be immediately removed from stream crossing.

Wetland Crossings: Staging areas should be located at least 50 feet from the edge of the wetland. Movement of vehicles across the wetland should be minimized. Where vehicles must be moved across wetlands, the use of pads or mats should be used. Excavated topsoil (with the vegetative root mass) should be carefully removed and stockpiled separately from the subsoil (unless there is standing water or the soil is too saturated to segregate). BMPs (e.g. trench plugs) should be taken to prevent the trench from draining the wetlands or changing its hydrology. Lime and fertilizer should not be applied. Annual ryegrass at the rate of 40 lb/acre should be applied to areas without standing water. Straw mulch should be used, at the rate of 3 T/acre and without binding agents.

The types and locations of control measures needed at roadway crossings depends upon the slope of the land and types of roadway drainage systems present at that location. Upslope runoff should be diverted around the work area by use of waterbars. Sediment barriers should be located downslope of trench or boring pit storage piles. Such storage piles should not be located in any roadway swale or ditch. Runoff from existing roadway culverts, storm sewers, swales, and ditches should be safely conveyed over any open trench. Inlet protection should be provided for any inlet that may receive runoff from a disturbed area.

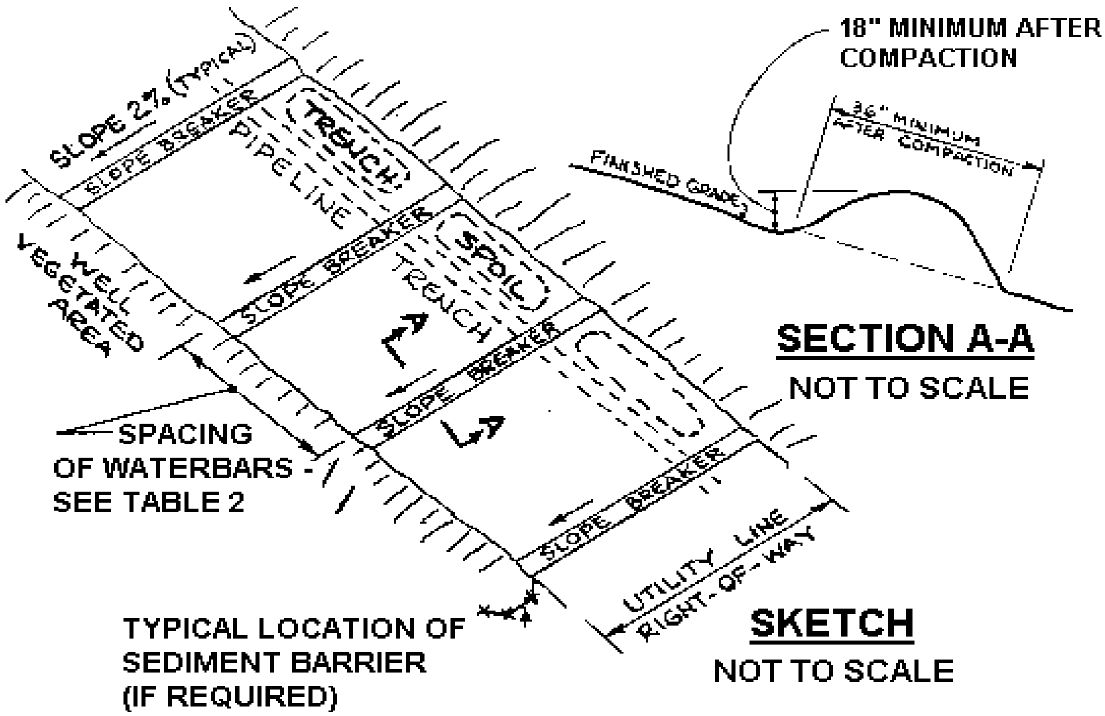
FIGURE 31
Typical Trench Plug Installation



Required Spacing and Materials for Trench Plugs		
Trench Slope (%)	**Spacing (FT)**	**Plug Material**
< 5	*	*
5 - 15	500	** Earth Filled Sacks
15 - 25	300	** Earth Filled Sacks
25 - 35	200	** Earth Filled Sacks
35 - 100	100	** Earth Filled Sacks
> 100	50	Cement Filled Bags (Wetted) or Mortared Stone

* Trench Plugs are required at all stream, river, or water-body crossings regardless of trench slope. Otherwise not required.
** Topsoil may not be used to fill sacks.

FIGURE 32
Waterbar Installation



Required Spacing for Permanent Waterbars	
Percent Slope	**Spacing (FT)**
< 5	*
5 - 15	150
15 - 30	100
> 30	50

* Permanent waterbars are required at all stream, river, and other water-body crossings as well as upslope from roadway and railroad cut slopes. Otherwise not required.

Water bars (slope breakers, interceptor dikes) should be installed across the entire right-of-way on all slopes greater than 5%.

Waterbars should be constructed at a slope of 2% and discharge to a well-vegetated area. Waterbars should not discharge into an open trench. Waterbars should be oriented so that the discharge does not flow back onto the right-of-way. Obstructions, (e.g. straw bales, silt fence, rock filters, etc.) should not be placed in any waterbars. Where needed, they should be located below the discharge end of the waterbar.

EROSION AND SEDIMENT CONTROLS FOR IN-CHANNEL WORK

Whenever possible, work should be scheduled for low flow seasons. Normal flow should be conveyed past the work area by means of a bypass channel, pipe, pump, or cofferdam. All such bypasses should be completed and stabilized prior to diverting flow.

Any in-channel excavations should be done from the top of banks wherever possible. Where this is not possible, a temporary crossing should be provided for any equipment working from within the channel. Upon completion, all channel entrances should be restored to pre-construction configurations, as much as possible, and stabilized.

All excavated channel materials that will be subsequently used as backfill should be placed in a temporary stockpile located outside the channel. A sediment barrier should be installed between the storage pile and the stream channel.

All excavated materials that will not be used on site must be immediately removed to a disposal site having an approved erosion and sediment pollution control plan.

Any pumped water from excavated areas must be filtered prior to discharging into waters of the Commonwealth. The use of filter bags is another acceptable method if located on a relatively flat (< 5% slope), well-vegetated area. The bag should be designed to trap particles larger than 150 microns. The pump discharge hose shall be inserted into the bags in the manner specified by the manufacturer and securely clamped. When the bag has been filled to ½ its total capacity, it should be replaced with a new bag and properly disposed. Wherever well-vegetated areas are not available, a geotextile underlayment should be used. Consideration should be given to how the bag will be accessed and removed once it has been 1/2 filled with sediment.

All disturbed areas within the existing channel should be completed and stabilized before flow is redirected into it. Suitable protection should be provided for the stream channel from any disturbed areas that have not yet achieved stabilization.

Small stream channels - normal flow width < 10 feet

Wherever a temporary bypass channel is used, it should conform to Figure 33. It is recommended that consideration be given to using a geotextile protective lining for temporary bypass channels.

A temporary bypass channel must be designed to pass normal base flows if the crossing will be completed in one to three days, otherwise the channel must be designed to pass the one year frequency storm.

Whenever a temporary bypass pipe is used, it should conform to Figure 34.

Pumped water bypass systems should conform to Figure 35.

Whenever an in-stream cofferdam diversion is used, it should conform to Figure 35a.

FIGURE 33
Bypass Channel With Non-Erosive Lining

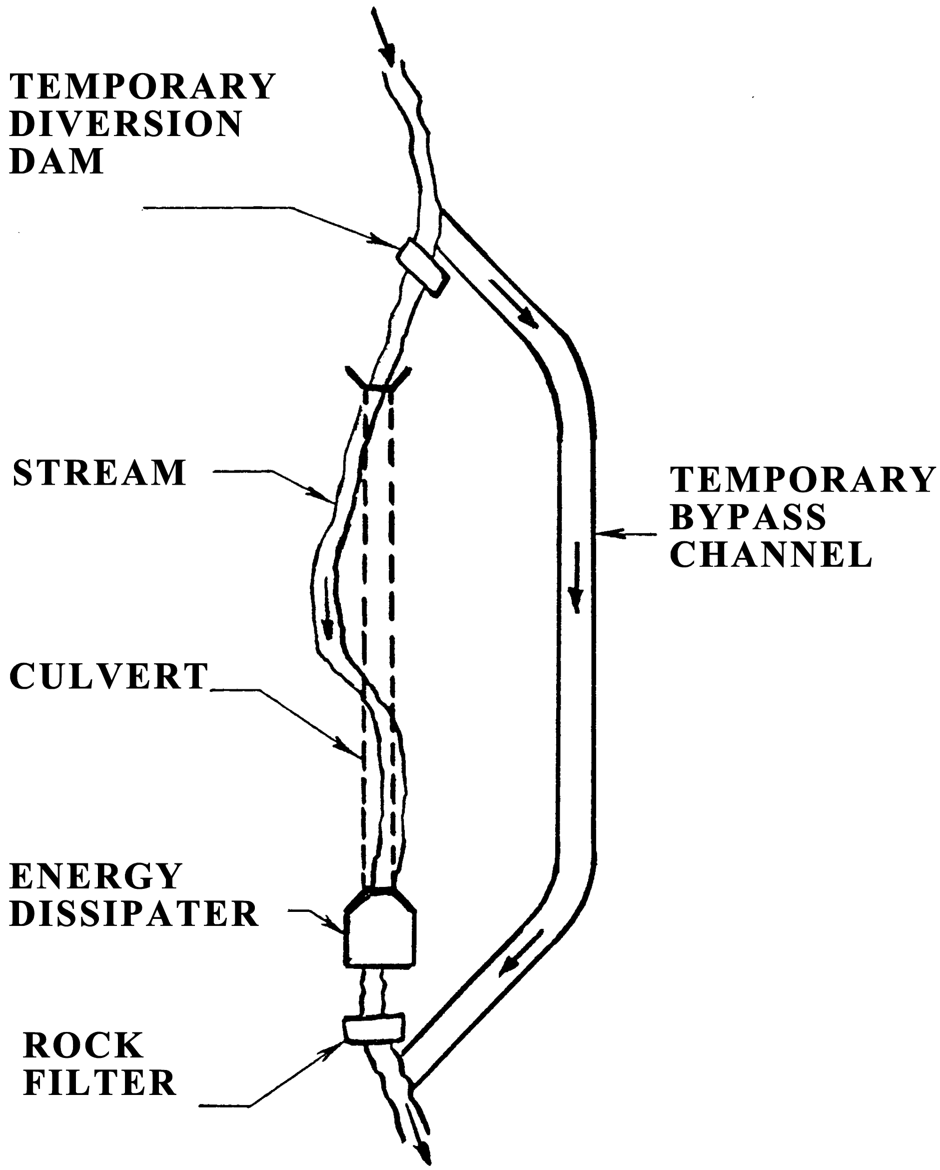


FIGURE 34
Rigid Or Flexible Pipe Flume Through A Work Area

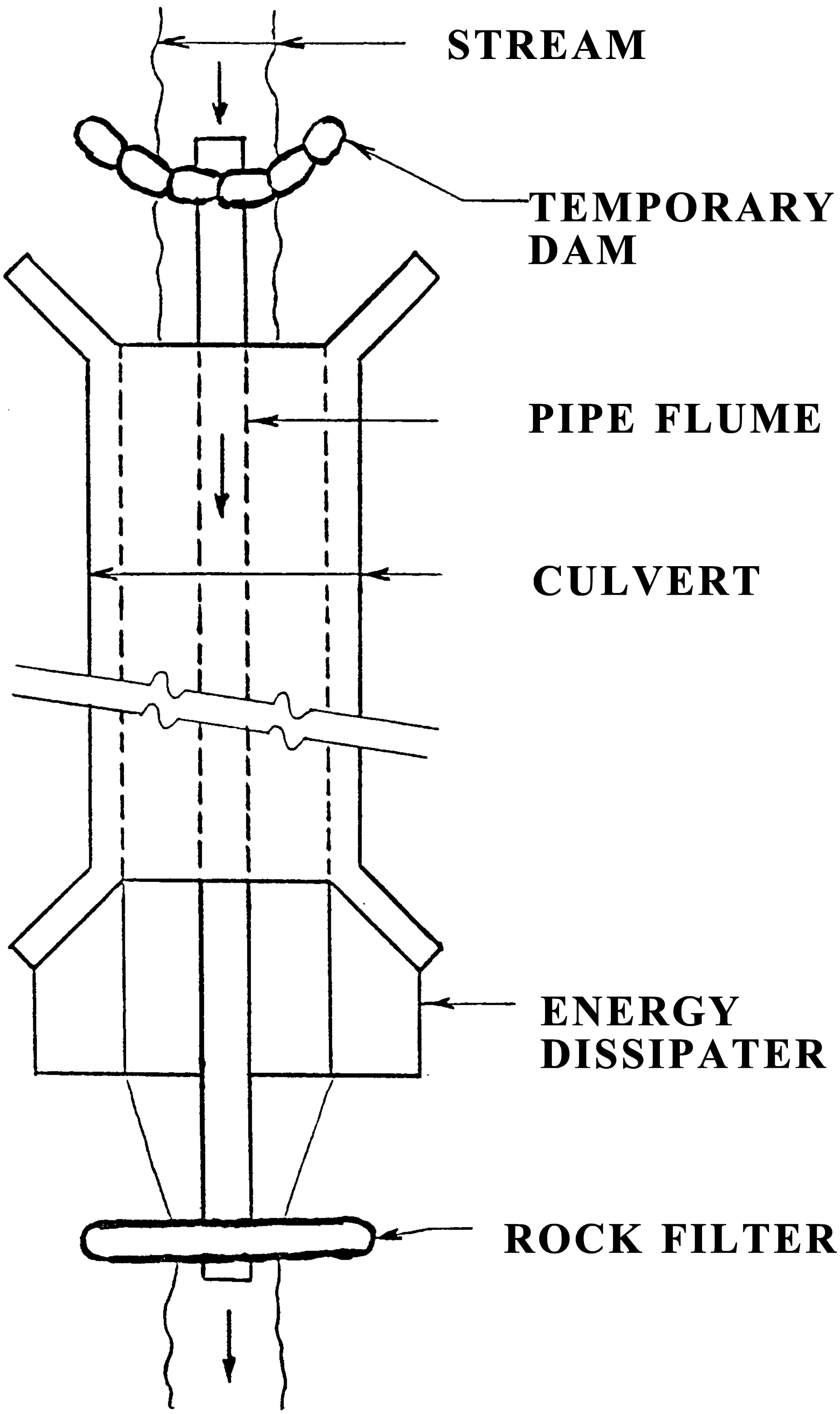


FIGURE 35
Temporary Cofferdam And Pump Bypass Around In-Channel Work Areas

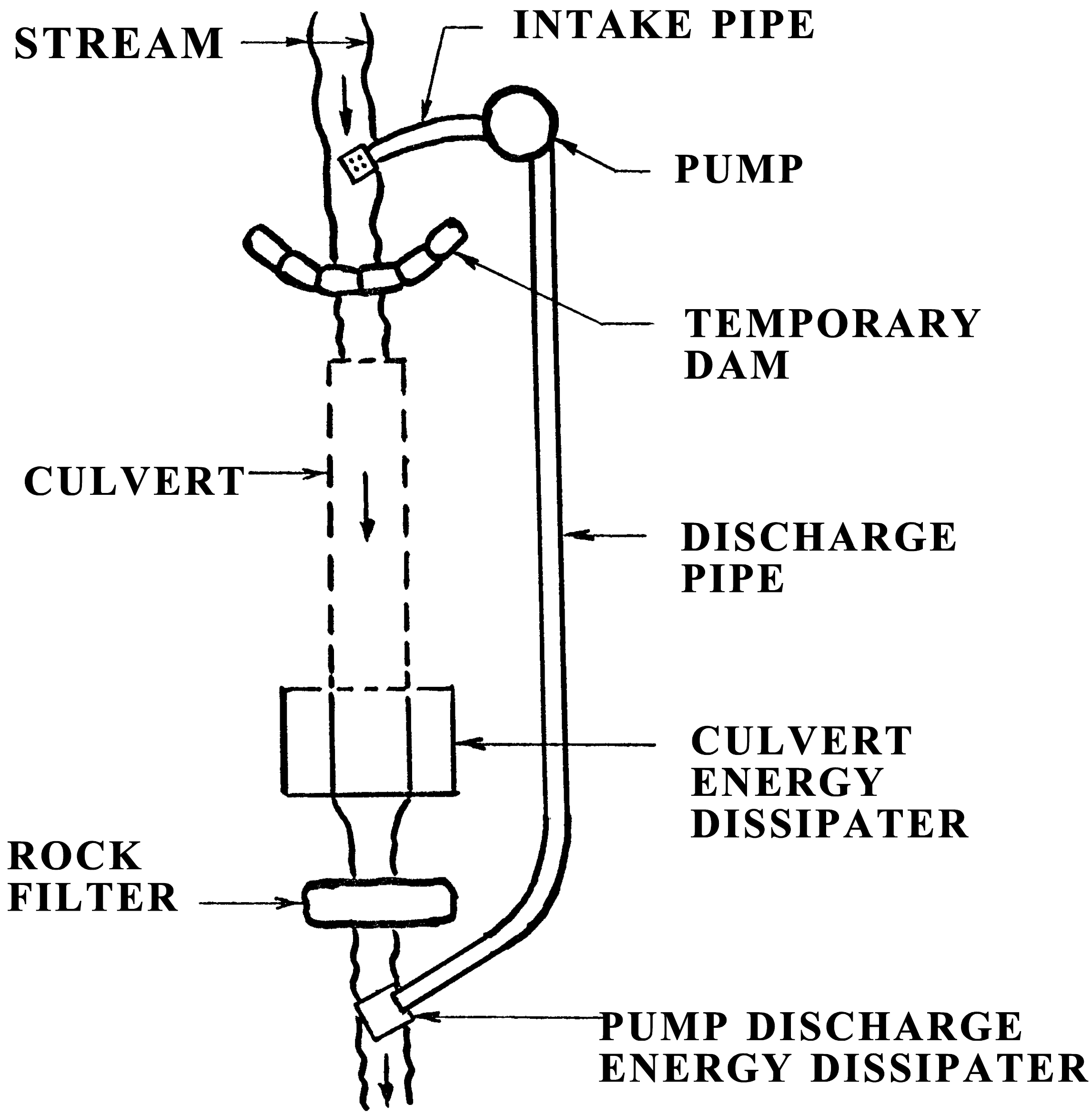
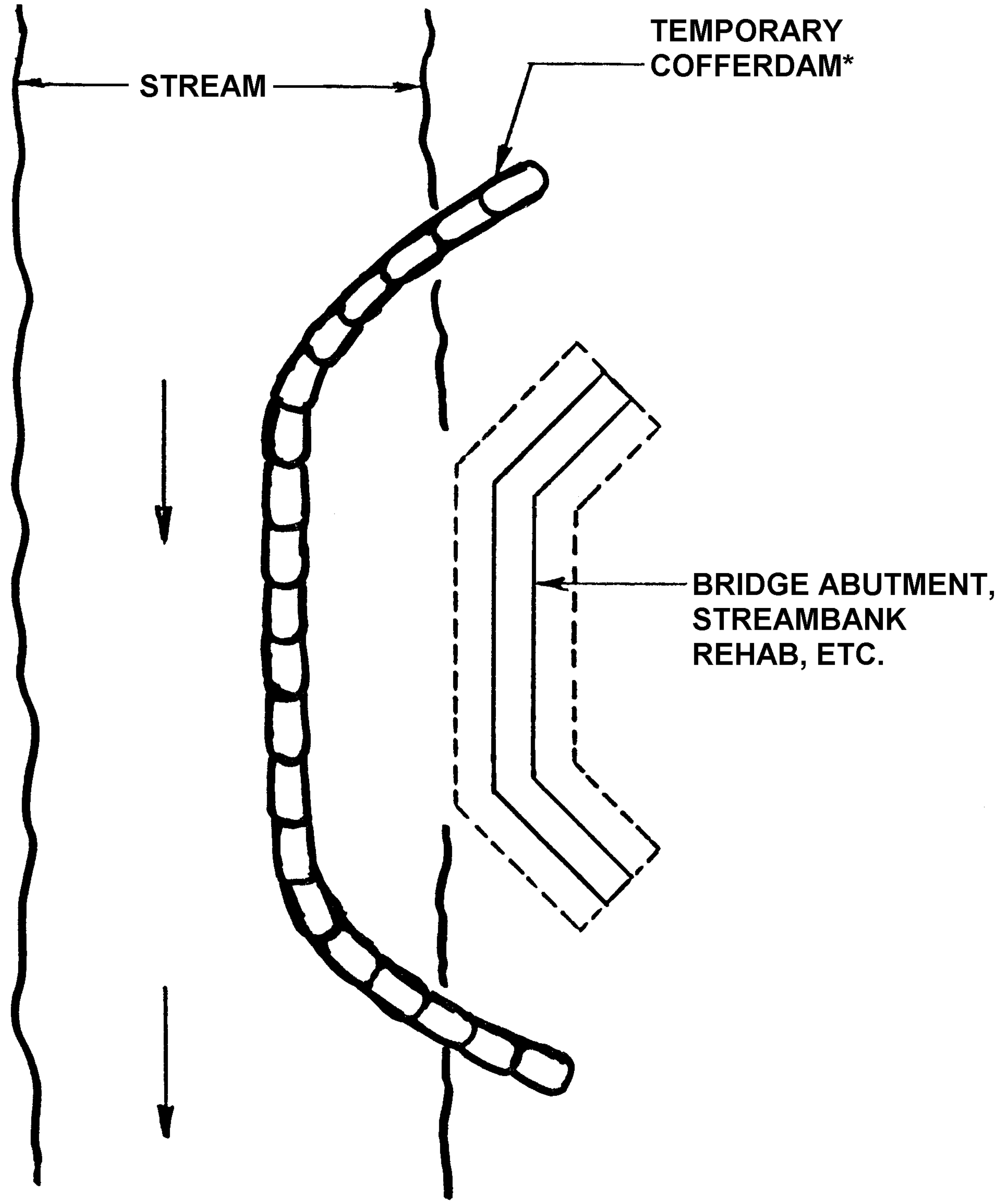


TABLE 35a
In-Stream Cofferdam Diversion



NEW PRODUCTS AND PROCEDURES

The BMPs set forth in this manual shall be appropriately incorporated into all erosion and sedimentation control plans unless the designer shows that alteration of these BMPs or inclusion of other BMPs shall effectively minimize accelerated erosion and sedimentation. Since the burden of proof for whether a proposed new product or procedure will be effective lies with the designer, all necessary information required to approve the use of the new product or procedure must be submitted as part of the application. At a minimum, this should include:

1. The name of the product (and type of control if a brand name is used)
2. Proposed use (e.g. storm sewer inlet protection). If this product or procedure has the potential to minimize accelerated erosion and sedimentation more effectively or efficiently than current methods, this should be stated and the reason given (e.g. same protection for less cost, less maintenance required, etc.). It should be demonstrated that the proposed use meets with any manufacturer's recommendations (e.g. manufacturer's recommendations showing such use, test data, limitations, etc.).
3. Where the proposed use is in a protected watershed (HQ or EV) or a critical area (e.g. adjacent to a stream channel or wetland), an alternative conventional BMP should be specified for installation should the innovative product or procedure fail. The definition of a product failure must be clearly stated.
4. Sufficient installation information must be provided to ensure its proper use. This should include a clear, concise sequence as well as a typical detail showing all critical dimensions and/or elevations.
5. The plan maps must show all locations where the proposed new product or procedure will be used. All receiving waters must be identified. Any downstream public water supplies, fish hatcheries, or other environmentally sensitive facilities must be noted.
6. A suitable maintenance program must be provided. Specific instructions, which identify potential problems and recommended remedies must be included.

New products and procedures which meet the above criteria will be reviewed on a case-by-case basis until their effectiveness has been sufficiently demonstrated by successful use in the field.

THE USE OF COMPOST AS AN EROSION AND SEDIMENT CONTROL BEST MANAGEMENT PRACTICE

MATERIAL

Compost shall be a well decomposed, weed free organic matter derived from agricultural, food, and yard or wood/bark organic matter source. The compost must be aerobically composted at a Pennsylvania Department of Environmental Protection (DEP), Bureau of Waste Management permitted site. The compost shall possess no objectionable odors and will be reasonably free (<1% by dry weight) of man-made foreign matter. The compost product shall not resemble the raw material from which it was derived.

The physical parameters of the compost should be:

pH	5.5 – 8.0
Moisture Content	35% - 55%
Particle Size	98% pass through 1" screen
Soluble Salt Concentration	5.0 dS Maximum

COMPOST FOR EROSION CONTROL

Compost shall be uniformly applied at a rate of 270 – 540 cubic yards per acre (2 to 4 inch layer) to slopes of up to 2:1. Slopes with problem soils and more runoff will require greater application rates. On highly unstable soils, use compost in conjunction with appropriate structural measures. Spread the compost uniformly, then track (compact) the compost layer using a bulldozer or other appropriate equipment. Alternatively, apply compost using a pneumatic (blower) unit. Project compost directly at soil, thereby preventing water from moving between the soil-compost interface. Apply compost layer approximately 3 feet over the top of the slope or overlap it into existing vegetation. Follow by seeding or ornamental planting.

Where planning immediate grass, wildflower, or legume seeding or ornamental planting, use only a well composted product that contains no substances toxic to plants. Very coarse composts should be avoided if the slope is to be landscaped or seeded, as it will make planting and crop establishment more difficult. Composts containing fibrous particles that range in size produce a more stable mat.

COMPOST FILTER BERMS

Compost may also be used to construct a filter berm for sediment control. Composts denser in nature and containing particles that range in size produce the most stable berms. Do not use compost filter berms in channels.

Construct a 1 ½ to 2 foot high by 2.5 to 3 foot wide berm of compost parallel to the base of the slope or other affected area. For maximum water filtration ability, construct a 1 ½ to 2 foot high trapezoidal berm which is 3 feet wide at the top and 4 feet wide at the base.

LOW HAZARD INDIVIDUAL LOT EROSION AND SEDIMENT CONTROL PLAN

Low hazard sites are those with limited disturbance, slopes of 5% or less, and at a distance of 100' or more from streams.

The E&S plan for a low hazard individual lot should be developed before the start of construction and must be available on site during construction. Local municipalities may require an E&S plan to be submitted to them or the County Conservation District for review prior to start of construction or issuance of building permits; therefore they should be contacted before the plan is developed.

General steps to be taken in developing a plan for an individual low hazard site include:

1. Prepare a sketch plan of the site and indicate general land slopes, limits of the proposed project and existing features such as roads, property boundaries and streams. Select simple E&S control BMPs such as silt fence, hay or straw bale barriers and a stabilized stone construction entrance and show their location on a sketch plan of the site. The silt fence and or hay or straw bale barriers should be located to filter the storm runoff from the disturbed area of the site before the runoff leaves the site and enters a stream or drainageway. The stabilized construction entrance is usually placed at the location where a driveway to the site will be installed and minimizes the tracking of mud from the site by construction vehicles. It becomes the base for a permanent driveway to be installed near the completion of construction. A note on the sketch plan should indicate that the various BMPs are to be installed as the first step in project installation. Details for installation of the BMPs are found in the Standard Worksheets and Standard Details section of this manual. Copies of those details should be attached to the E&S plan.

2. Hold site grading to the minimum possible to allow the construction of desired improvements. Access roads should avoid gradients in excess of 10%. Buildings should be located so there is positive drainage away from them. Any topsoil from areas where cuts or fills occur should be stockpiled for redistribution after grading to help establish vegetation.

3. Save existing vegetation to the maximum extent possible, especially trees because of their ability to reduce or prevent erosion. Protect tree and shrubs that are to be saved.

4. Minimize the size and time of exposure for areas that must be disturbed. The plan should call for restabilizing disturbed areas by seeding or paving as soon as possible.

5. Consider upslope runoff and divert it around the area to be disturbed if possible. If diversion is not practical, the runoff must be carefully directed through the area of disturbance.

The E&S plan should include such information as the name, address, and phone number of the person responsible for the project. A brief description of the project including the estimated time frame for its installation should also be included. If this information cannot be provided on the sketch plan of the site, a supplemental sheet with this information should be attached. Published USGS topographic maps should be consulted to determine the name of the nearest stream receiving runoff from the site. If the stream is in a Special Protection watershed, special precautions will be needed to avoid sediment pollution during construction. See Item 5, Erosion and Sediment Control Plan Content, at the beginning of this manual. The published County soil survey should be consulted to determine if any unusual problems can be expected with the soils on the site. If severe limitations are discovered, a means to deal with the limitations should be addressed in the E&S plan. The USGS maps, lists of Special Protection watersheds, and the County Soil Survey publications are available at the County Conservation District office. The County Conservation Districts are a valuable source of information regarding E&S plan development and have county specific information available. They should be consulted for assistance in developing low hazard individual lot E&S plans.

CHECKLISTS

The Complete Plan Checklist is used to determine if an erosion and sediment control plan includes all required elements. This checklist is intended to serve as a tool to determine whether an erosion and sediment control plan addresses all eleven items required by Section 102.4(b)(5). It need not be included as part of the plan submittal.

The E&S Control Plan Technical Review Checklist is used to determine the technical adequacy of an erosion and sediment control plan. Information contained elsewhere in this manual provides additional guidance for preparing and reviewing the various Best Management Practices (BMPs) used in a plan. This checklist is to be used by the reviewing agency to ensure the erosion and sediment control plan meets the requirements of Chapter 102 and the standards of the Department's Erosion and Sediment Pollution Control Program Manual, No. 363-2134-008 (January 2000), as amended and updated. It should not be included as part of the plan submittal.

COMPLETE PLAN CHECKLIST

Project: _________________

I. Existing topographic features of the project site.

A. The existing topographic features of the project site and the immediate surrounding area are shown on maps included in the drawings .... ☐

B. A location map has been provided (8½” x 11” copy of a USGS map with the outline of the project area) .... ☐

II. The Types, depth, slope, locations and limitations of the soils

A. A soils map with the project area outlined has been provided .... ☐

B. Physical characteristics of the soil types and their limitations are addressed in the narrative .... ☐

C. Construction techniques or special considerations to address the soil(s) limitations are noted on the drawings... ☐

III. Characteristics of the earth disturbance activity

A. Limits of the project are shown on the plan map(s) .... ☐

B. Original and final contours are shown on the plan map(s)... ☐

C. Past, present and proposed land uses are addressed in the narrative......................... ☐

IV. The amount of runoff from the project area and its upstream watershed area

A. Drainage areas to hydraulic BMPs are shown on plan map(s) .... ☐

B. Calculations are provided which show anticipated peak flows for the design storms ... ☐

V. The location of waters of the Commonwealth which may receive runoff within or from the project site.

A. The location(s) of streams or other waterbodies which may receive site runoff are shown on the plan map(s) .... ☐

B. The Chapter 93 classification of streams or other waterbodies which may receive site runoff is addressed in the narrative .... ☐

VI. Locations and types of perimeter and on site BMPs

A. Plan map(s) show locations of proposed temporary BMPs to control runoff and provide sediment removal .... ☐

B. Plan map(s) show locations of proposed permanent BMPs to control erosion .... ☐

C. Construction details and specifications for all proposed BMPs are shown on the plan map(s) .... ☐

VII. Sequence of BMPs installation & removal

A. A construction sequence has been provided on the plan map(s) .... ☐

VIII. Supporting calculations

A. Supporting calculations for all proposed BMPs are included in the narrative .... ☐

IX. Plan drawings

A. Plan drawings are complete and legible .... ☐

X. Maintenance Program

A. A maintenance program has been provided .... ☐

XI. Measures for the recycling or disposal of materials from the project site.

A. A program for the recycling or disposal of materials associated with or from the project site has been provided .... ☐

E & S CONTROL PLAN TECHNICAL REVIEW CHECKLIST

Project: ______________________________ NPDES/Project No. ________________

Project Location: ________________________ Date: ____________________________

Check-off: c = Complies, d = Deficient, na = Not applicable
Item Location: D = E&S Drawings, N = E&S Narrative, D&N = Drawings & Narrative

102.4(b)(3) "The Erosion and Sediment Control Plan shall be prepared by a person trained and experienced in erosion and sediment control methods and techniques, and shall be designed to minimize the potential for accelerated erosion and sedimentation".

Name ______________ Address __________________ Telephone No. __________ D&N
Qualifications __________ N

102.4(b)(5)(i) "The existing topographic features of the project site and the immediate surrounding area."

____________	Legible mapping	D
____________	Existing contours	D
____________	Existing improvements, i.e. roads, buildings, utilities , etc.	D
____________	Existing streams, wetlands, receiving watercourses, etc.	D
____________	Sufficient surrounding area	D
____________	Location map, i.e. USGS	D or N

102.4(b)(5)(ii) "The types, depth, slope, locations and limitations of the soils"

____________	Types, slopes, & locations of soil types	D
____________	Soil type use limitations and resolutions	N
____________	Hydric soils	N

102.4(b)(5)(iii) "The characteristics of the earth disturbance activity, including the past, present, and proposed land uses and the proposed alteration to the project site."

____________	Proposed NPDES boundary and limits of construction	D
____________	Proposed contours/grades	D
____________	Proposed waterways & stormwater management facilities	D
____________	Proposed improvements, i.e., roads, buildings, utilities, etc.	D
____________	Complete mapping symbols legend and north arrow	D
____________	Past, present and proposed land uses	N

102.4(b)(5)(iv) "The amount of runoff from the project area and its upstream watershed area."

____________	Maximum during construction drainage areas	D
____________	Offsite drainage area(s) on USGS quadrangle map	N
____________	Peak flow calculations for all channels	N

102.4(b)(5)(v)	**"The location of waters of the Commonwealth which may receive runoff within or from the project site and their classification pursuant to Chapter 93 of this title."**	
____________	Existing streams, wetlands, floodway, etc.	D
____________	Receiving watercourses	D
____________	Chapter 93 classification of streams or other waterbodies	N
102.4(b)(5)(vi)	**"A written depiction of the location and type of perimeter and on site BMPs used before, during, and after the earth disturbance activity."**	
102.4(b)(5)(vii)	**"A sequence of BMP installation and removal in relation to the scheduling of earth disturbance activities, prior to, during and after earth disturbance activities".**	
____________	Complete and site specific sequence of BMPs installation	D
____________	Activities planned to limit exposed areas	D&N
____________	Removal of temporary BMPs	D&N
102.4(b)(5)(viii)	**"Supporting calculations"**	
102.4(b)(5)(ix)	**"Plan Drawings"**	

Channels

____________	Locations ___________ Contours and Grades ___________ Complete details	D
____________	Capacity & freeboard calculations	N
____________	Protective lining calculations	N

Sediment Basins

____________	Locations ____________ Contours	D
____________	Complete berm & outlet details ______________ Cleanout information	D&N
____________	Capacity info ____________ Discharge calculations	N
____________	Dewatering calculations	N
____________	Discharge to waters of the Commonwealth or approved alternative	D
____________	Structurally sound	D&N

Sediment Traps

____________	Locations ____________ Contours	D
____________	Complete berm & outlet details ______________ Cleanout information	D&N
____________	Capacity information _____________ Discharge calculations	N
____________	Discharge to waters of the Commonwealth or approved alternative	D

Silt Fencing

____________	Locations ____________ Complete Details	D

Outlet Protection

____________	Locations ____________ Complete Details	D
____________	Design Calculations	N

Other BMPs (specify) ________________________

_____________	Locations _____________	Complete Details	D
_____________	Design Calculations		N

Temporary Stabilization

	Seed	Lime	Fertilizer	Mulch	Others	
Types	______	______	______	______	______	D
Rates	______	______	______	______	______	D

Permanent Stabilization

	Seed	Lime	Fertilizer	Mulch	Others	
Types	______	______	______	______	______	D
Rates	______	______	______	______	______	D

102.4(b)(5)(x) "A maintenance program which provides for inspection of BMPs on a weekly basis and after each measurable rainfall event, including the repair of the BMPs to ensure effective and efficient operation."

_____________	Inspection schedule	D
_____________	Maximum sediment storage elevation/level in BMPs	D
_____________	Time frames for completing specific maintenance & repairs for each type of BMP proposed.	D
_____________	Site stabilization repair parameters & directions	D
_____________	Disposal directions for sediment removed from BMPs	D

102.4(b)(5)(xi) "Procedures which ensure that the proper measures for the recycling or disposal of materials associated with or from the project site will be undertaken in accordance with Department regulations."

_____________	Project construction wastes are identified	N
_____________	Directions for recycling/disposal of construction wastes	D
_____________	Soil/rock disposal areas provided with BMPs	D&N

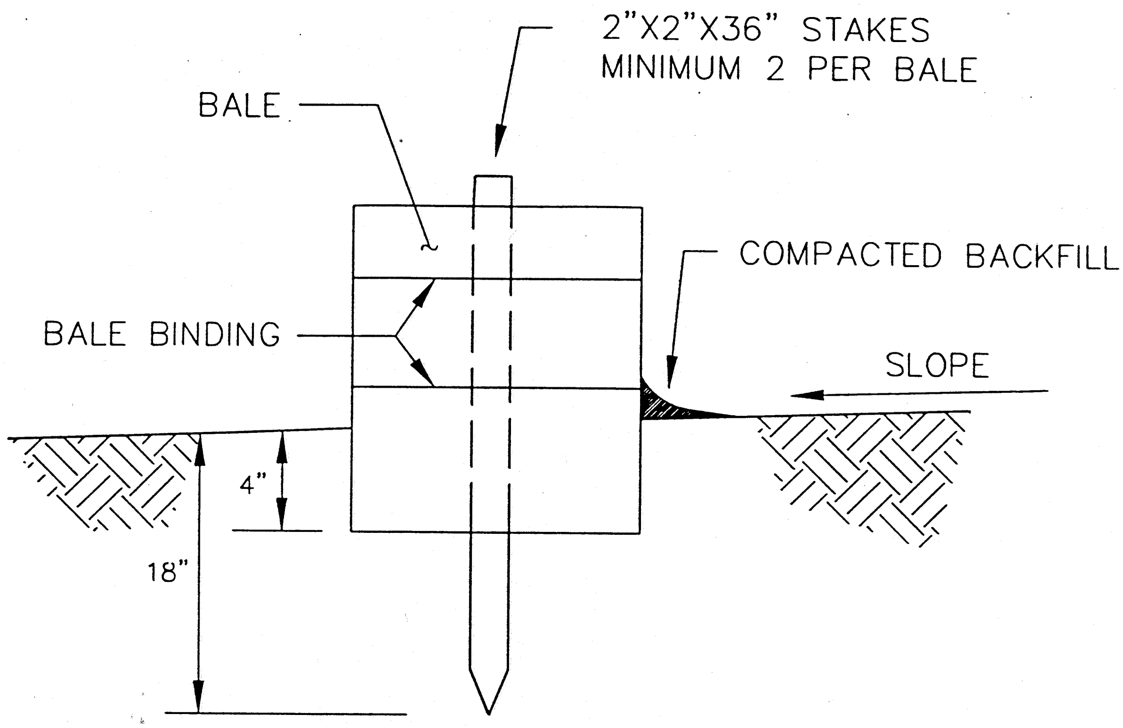
STANDARD WORKSHEETS

The Erosion and Sediment Control Standard Worksheets may be reproduced and used by plan preparers as a means of recording required design information for the various erosion and sediment control BMPs used in the E&S plan. The worksheets contain tables of dimensions and should be copied into the E&S plan drawings. Use of the worksheets ensures that all required information is included.

STANDARD WORKSHEET #1
Straw Bale Barriers

PROJECT NAME: ____________________
LOCATION: ____________________
PREPARED BY: ____________________ DATE: ____________________
CHECKED BY: ____________________ DATE: ____________________

CONSTRUCTION DETAIL:



Straw Bale Barriers should not be used for more than 3 months.

Straw Bale Barriers must be placed at existing level grade. Both ends of the barrier must be extended at least 8 feet upslope at 45 degrees to main barrier alignment.

Sediment must be removed where accumulations reach 1/3 the above ground height of the barrier.

Any section of straw bale barrier which has been undermined or topped must be immediately replaced with a rock filter outlet. See Rock Filter Outlet Detail.

BARRIER NO.	LOCATION	SLOPE-PERCENT	SLOPE LENGTH ABOVE BARRIER (FT)

STANDARD WORKSHEET #2
Standard Filter Fabric Fence

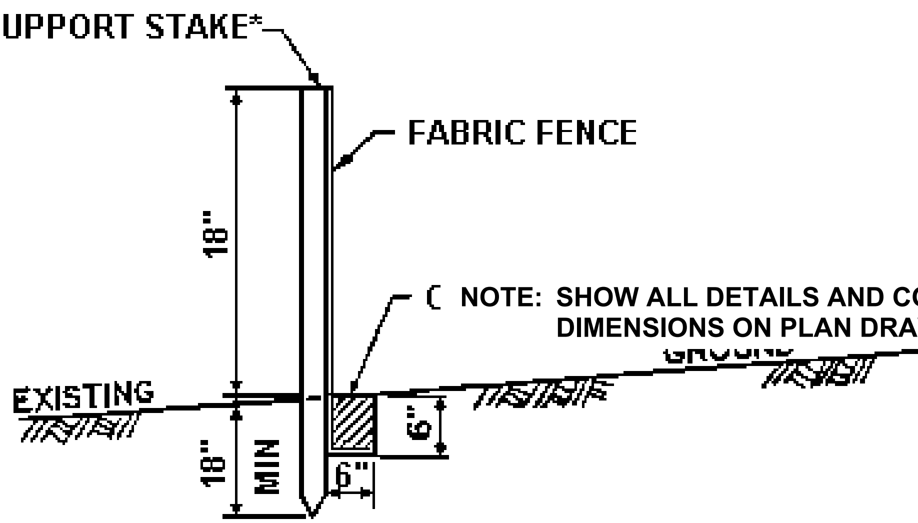
PROJECT NAME: ____

LOCATION: ____

PREPARED BY: ________________________ DATE: ____________________

CHECKED BY: ________________________ DATE: ____________________

CONSTRUCTION DETAIL:



NOTE: SHOW ALL DETAILS AND CONSTRUCTION DIMENSIONS ON PLAN DRAWINGS.

Filter fabric fence must be installed at existing level grade. Both ends of each fence section must be extended at least 8 feet upslope at 45 degrees to the main fence alignment.

Sediment must be removed where accumulations reach 1/ 2 the above ground height of the fence.

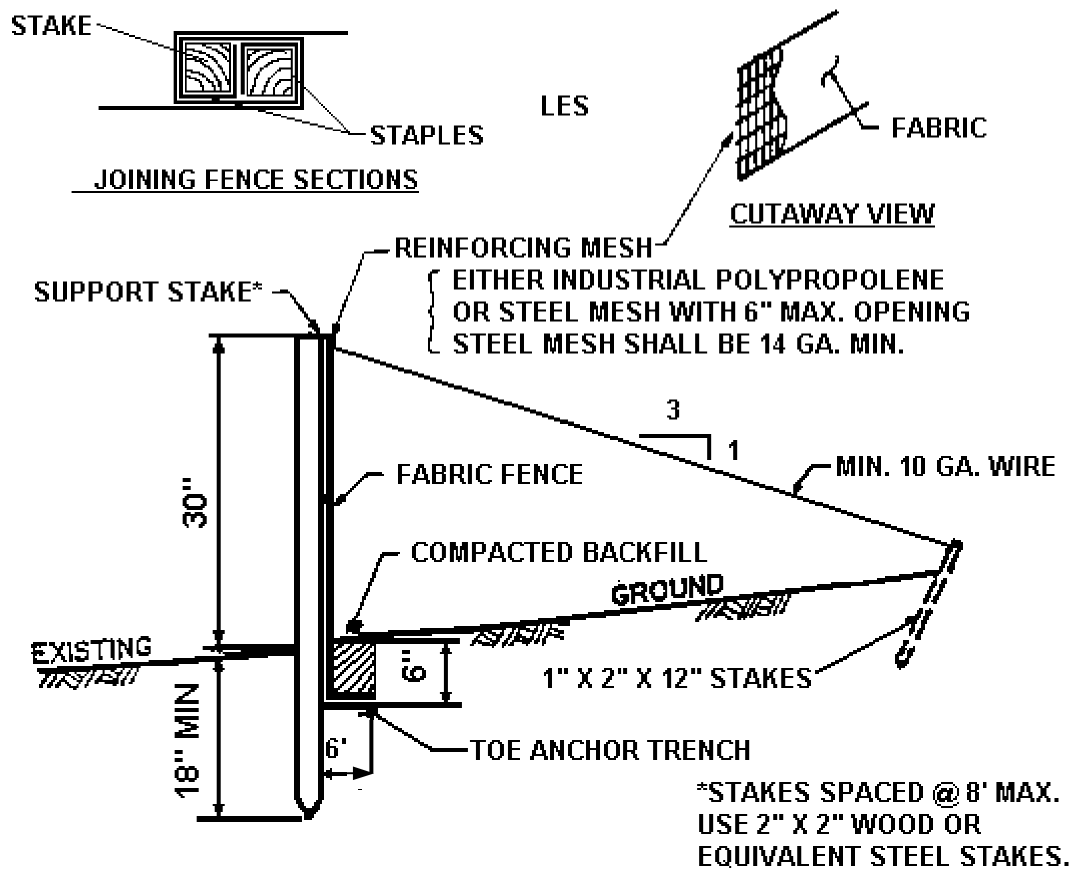
Any fence section which has been undermined or topped must be immediately replaced with a rock filter outlet. See Rock Filter Outlet Detail.

BARRIER NO.	LOCATION	SLOPE-PERCENT	SLOPE LENGTH ABOVE BARRIER (FT)

STANDARD WORKSHEET # 3
Reinforced Filter Fabric Fence

PROJECT NAME: ____________________
LOCATION: ____________________
PREPARED BY: ____________________ DATE: ____________________
CHECKED BY: ____________________ DATE: ____________________

CONSTRUCTION DETAIL:



Filter fabric fence must be installed at existing level grade. Both ends of each fence section must be extended at least 8 feet upslope at 45 degrees to the main fence alignment.

Sediment must be removed where accumulations reach 1/ 2 the above ground height of the fence.

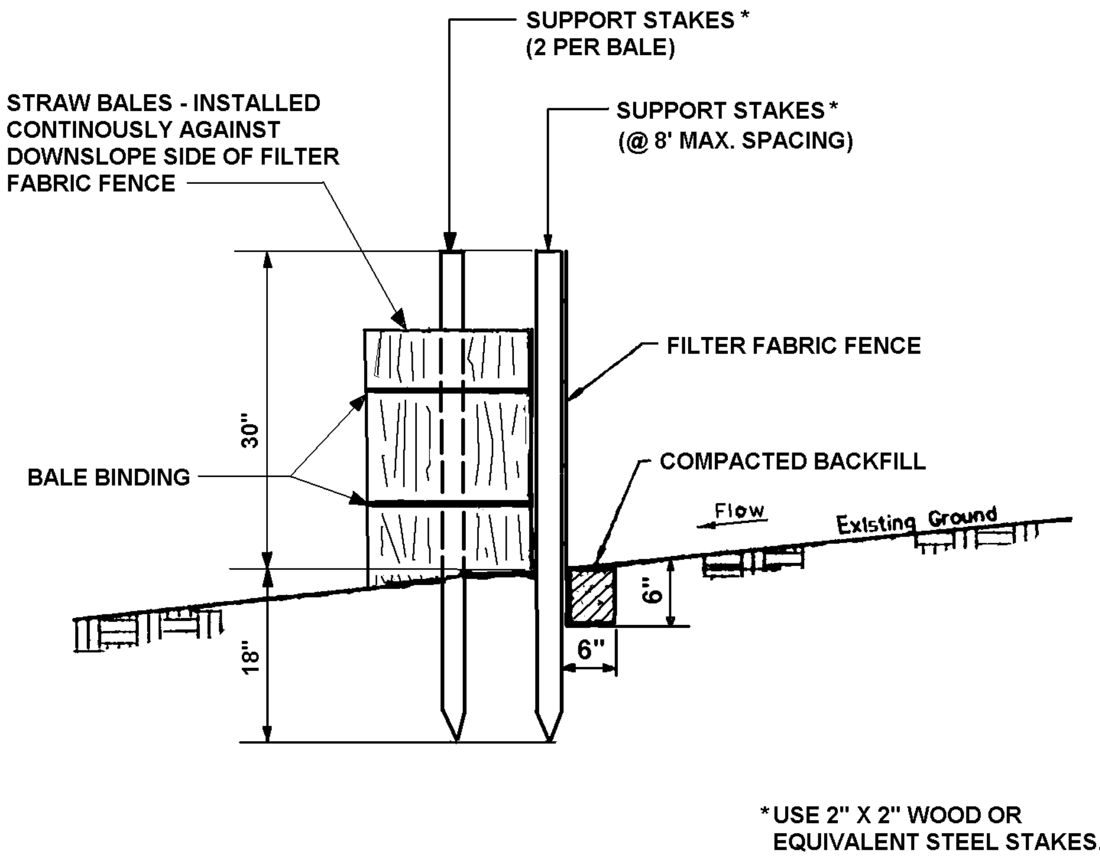
Any fence section which has been undermined or topped must be immediately replaced with a rock filter outlet. See Rock Filter Outlet Detail.

BARRIER NO.	LOCATION	SLOPE-PERCENT	SLOPE LENGTH ABOVE BARRIER (FT)

STANDARD WORKSHEET #4
Filter Fabric Fence With Straw Bale Backing

PROJECT NAME: ____________________
LOCATION: ____________________
PREPARED BY: ____________________ DATE: ____________________
CHECKED BY: ____________________ DATE: ____________________

CONSTRUCTION DETAIL:



Filter fabric fence must be installed at existing level grade. Both ends of each fence section must be extended at least 8 feet upslope at 45 degrees to the main fence alignment.

Sediment must be removed where accumulations reach 1/ 2 the above ground height of the fence.

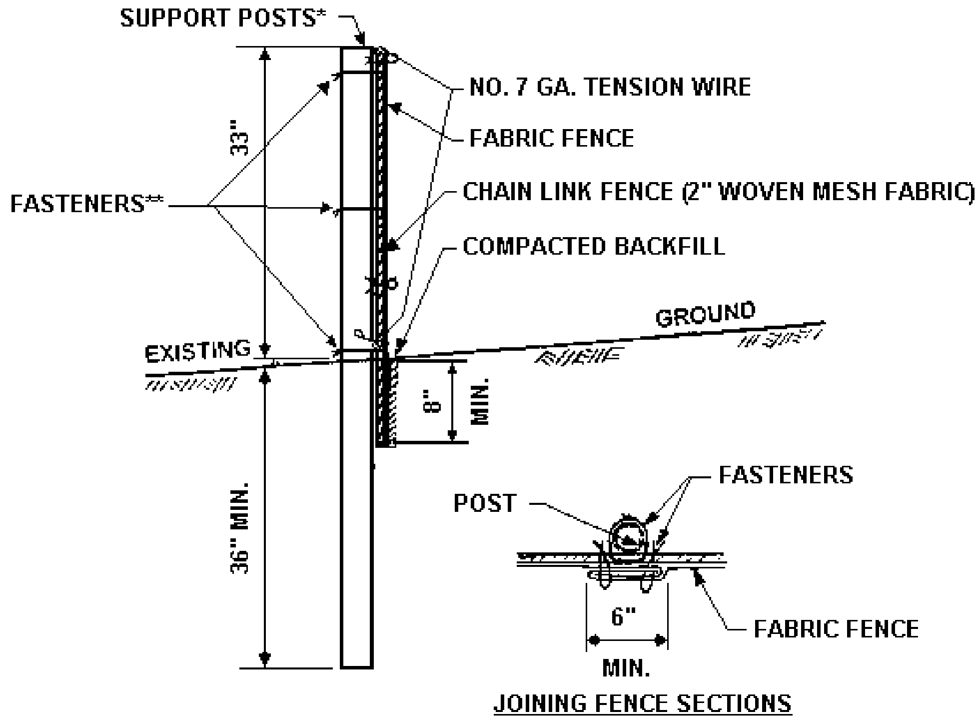
Any fence section which has been undermined or topped must be immediately replaced with a rock filter outlet. See Rock Filter Outlet Detail.

BARRIER NO.	LOCATION	SLOPE-PERCENT	SLOPE LENGTH ABOVE BARRIER (FT)

STANDARD WORKSHEET #5
Super Filter Fabric Fence

PROJECT NAME: ______________________________
LOCATION: ______________________________
PREPARED BY: ____________________ DATE: ____________
CHECKED BY: ____________________ DATE: ____________

CONSTRUCTION DETAIL:



* **Posts spaced @ 10' max. Use 2 1/2" dia. galvanized or aluminum posts.**

** **Chain Link To Post Fasteners spaced @ 14" max. Use No. 6 Ga. aluminum wire or No. 9 galvanized steel pre-formed clips. Chain Link To Tension Wire Fasteners spaced @ 60" max. Use No. 10 Ga. galvanized steel wire. Fabric To Chain Fasteners spaced @ 24" max. C to C.**

Filter fabric fence must be installed at existing level grade. Both ends of each fence section must be extended at least 8 feet upslope at 45 degrees to the main fence alignment.

Sediment must be removed where accumulations reach 1/ 2 the above ground height of the fence.

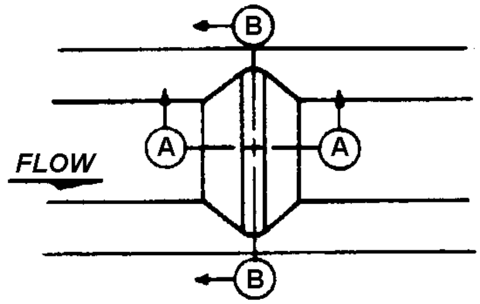
Any fence section which has been undermined or topped must be immediately replaced with a rock filter outlet. See Rock Filter Outlet Detail.

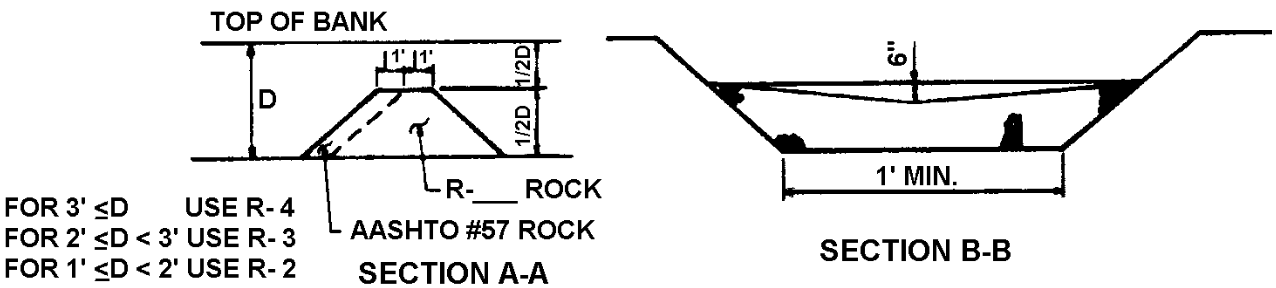
BARRIER NO.	LOCATION	SLOPE-PERCENT	SLOPE LENGTH ABOVE BARRIER (FT)

STANDARD WORKSHEET #6
Rock Filters

PROJECT NAME: ______________________________
LOCATION: ______________________________
PREPARED BY: ____________________ DATE: ____________
CHECKED BY: ____________________ DATE: ____________

CONSTRUCTION DETAIL:





NOTE: SHOW ALL DETAILS AND CONSTRUCTION DIMENSIONS ON PLAN DRAWINGS.

Note: Not Suitable for Channels less than one foot total depth

ROCK FILTER NO.	LOCATION	D (FT)	RIPRAP SIZE

STANDARD WORKSHEET #7
Temporary And Permanent Stabilization Specifications

PROJECT NAME: ____________________
LOCATION: ____________________
PREPARED BY: ____________________ DATE: ____________
CHECKED BY: ____________________ DATE: ____________

SPECIFICATIONS: The Department recommends the use of the Penn State publication "EROSION CONTROL & Conservation Plantings on Noncropland" as the standard to use for the selection of species, seed specifications, mixtures, liming and fertilizing, time of seeding, and seeding methods. Specifications for these items may also be obtained from Penn DOT's Publication # 408, Section 804 or by contacting the applicable county conservation district. Upon selection of a reference, that reference must be used to provide all specifications for seeding, mulching, and soil amendments. The following specification will be used for this project:

(TEMPORARY)
SPECIES: ____________________
% PURE LIVE SEED: ____________________%
APPLICATION RATE: ____________________LB./ACRE
FERTILIZER TYPE: ____________________(X-X-X)
FERTILIZER APPL. RATE: ____________________LB./ACRE
LIMING RATE: ____________________T./ACRE
MULCH TYPE: ____________________
MULCHING RATE: ____________________ T./ACRE

(PERMANENT)
SPECIES: ____________________
% PURE LIVE SEED: ____________________%
APPLICATION RATE ____________________LB./ACRE
FERTILIZER TYPE: ____________________(X-X-X)
FERTILIZER APPL. RATE: ____________________LB./ACRE
LIMING RATE: ____________________T./ACRE
MULCH TYPE: ____________________
MULCHING RATE: ____________________T./ACRE
ANCHOR MATERIAL: ____________________
ANCHORING METHOD: ____________________
RATE OF ANCHOR MATERIAL APPL.: ____________________LB./ACRE
SEEDING SEASON DATES: ____________________

(PERMANENT – STEEP SLOPE)
SPECIES: ____________________
% PURE LIVE SEED: ____________________%
APPLICATION RATE: ____________________LB./ACRE
FERTILIZER TYPE: ____________________(X-X-X)
FERTILIZER APPL. RATE: ____________________LB./ACRE
LIMING RATE: ____________________ T./ACRE
MULCH TYPE: ____________________
MULCHING RATE: ____________________T./ACRE
ANCHOR MATERIAL: ____________________
ANCHORING METHOD: ____________________
RATE OF ANCHOR MATERIAL APPL.: ____________________LB./ACRE
SEEDING SEASON DATES: ____________________

*If more than one species is used, indicate application rate for each species.
Note: Show information from this sheet on plan drawings.

STANDARD WORKSHEET #8
Sediment Trap Data

PROJECT NAME: ______________________________

LOCATION: ______________________________

PREPARED BY: ____________________ DATE: ____________________

CHECKED BY: ____________________ DATE: ____________________

TRAP NUMBER					
DRAINAGE AREA (5 ACRES MAX) AC					
REQUIRED CAPACITY (2000 CF/AC) CF					
* AVERAGE BOTTOM LENGTH (FT)					
* AVERAGE BOTTOM WIDTH (FT)					
BOTTOM ELEVATION (FT)					
TOP OF EMBANKMENT ELEVATION					
CREST OF SPILLWAY ELEVATION					
CLEAN-OUT ELEVATION (@ 700CF/AC)					
FLOW LENGTH/WIDTH RATIO (2:1 MIN)					

EMBANKMENT SPILLWAYS

OUTLET WIDTH (FT) (GREATER OF 2 x # AC OR 2 x h)					
OUTLET SIDE SLOPES (2:1 MIN.)					

RISER PIPE SPILLWAYS

Dr (RISER DIAMETER, 8” MIN.)					
Db (BARREL DIAMETER, 6” MIN.)					
BARREL OUTLET ELEVATION (FT)					
MAX WATER SURFACE ELEVATION (@ 1.5 CFS/AC. DISCHARGE)					

OUTLET BASIN

LENGTH (6 Db)	Ft.					
WIDTH (3 Db)	Ft.					
RIPRAP PROTECTION (Size)						

* For Irregular shaped traps, provide stage storage data.

NOTE: Add data from this worksheet to worksheet #9 or #10 and show information on plan drawings.

STANDARD WORKSHEET #9
Embankment Type Traps

PROJECT NAME: ____________________

LOCATION: ____________________

PREPARED BY: ____________________ DATE: ____________________

CHECKED BY: ____________________ DATE: ____________________

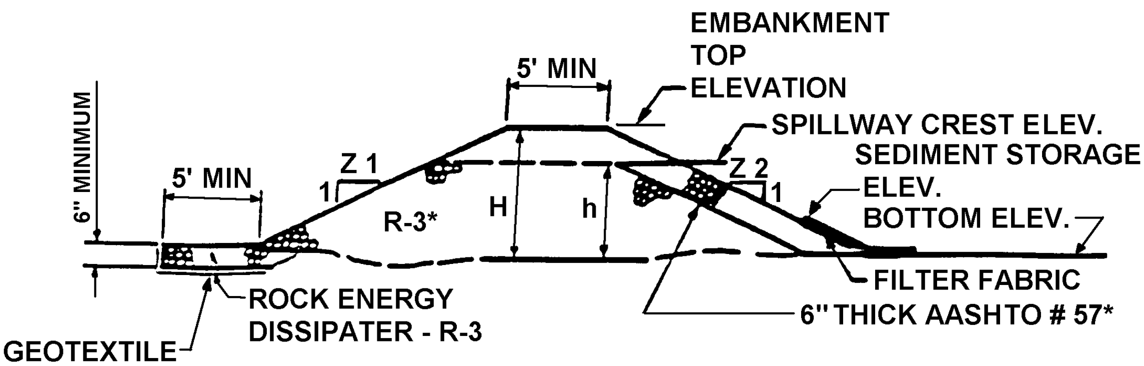
CONSTRUCTION DETAIL:

SEDIMENT TRAP NO. ____________

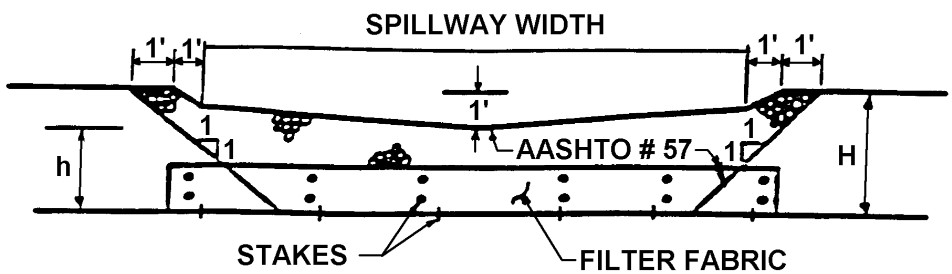
REQUIRED DIMENSIONS ____________X

Z1 = _____ Z2 = _____

H = _____ h = _____



SECTION THROUGH SPILLWAY*



NOTE: THE OUTLET EMBANKMENT IS TO BE COMPOSED ENTIRELY OF ROCK. THE MAIN BODY SHOULD BE LARGER STONE (R-3 MIN) WITH AN UPSTREAM LAYER OF SMALLER STONE (AASHTO #57 MAX).

NOTE: SHOW ALL DETAILS AND CONSTRUCTION DIMENSIONS ON PLAN DRAWINGS.

Minimum outlet top width (in feet) is 2 X the number of acres of contributing drainage area or 2 X h, whichever is greater. Maximum outlet side slope is 2:1.

Maximum embankment height is 5 feet. Outlet crest must be set at least 1 foot below top of embankment.

Outlet to stable erosion resistant areas.

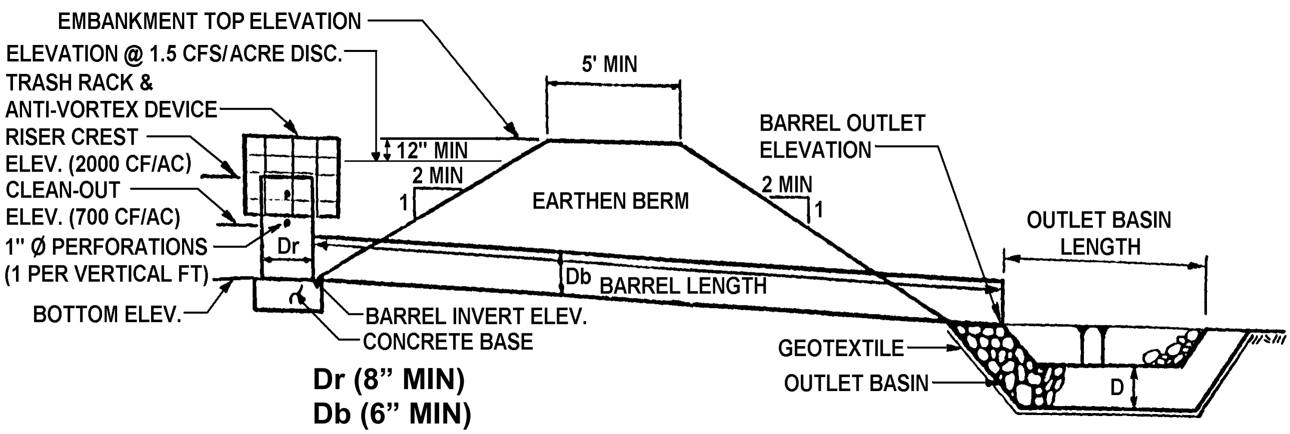
Increase outlet top width to 6 X the number of acres of contributing drainage area when traps do not outlet into channels.

Minimum water depth of trap is 2 feet.

STANDARD WORKSHEET #10
Barrel/Riser Sediment Traps

PROJECT NAME: ____
LOCATION: ____
PREPARED BY: _________________________ DATE: _________________
CHECKED BY: __________________________ DATE: _________________

CONSTRUCTION DETAIL:



Dr (8" MIN)
Db (6" MIN)

NOTE: SHOW ALL DETAILS AND CONSTRUCTION DIMENSIONS ON PLAN DRAWINGS.

OUTLET BASIN

Rock size = R-___
Width = ______ft.
Length = _____ft.
Depth = ______ft.

A trash rack and anti-vortex device must be provided for the riser. Provide details on plan drawings.

Crest of vertical risers must be set at the elevation which corresponds with the 2,000 CF per acre storage volume. The top elevation of the embankment must be set a minimum of one foot above the elevation at which 1.5 cfs per acre discharge capacity is provided.

Maximum embankment height is 5 feet.

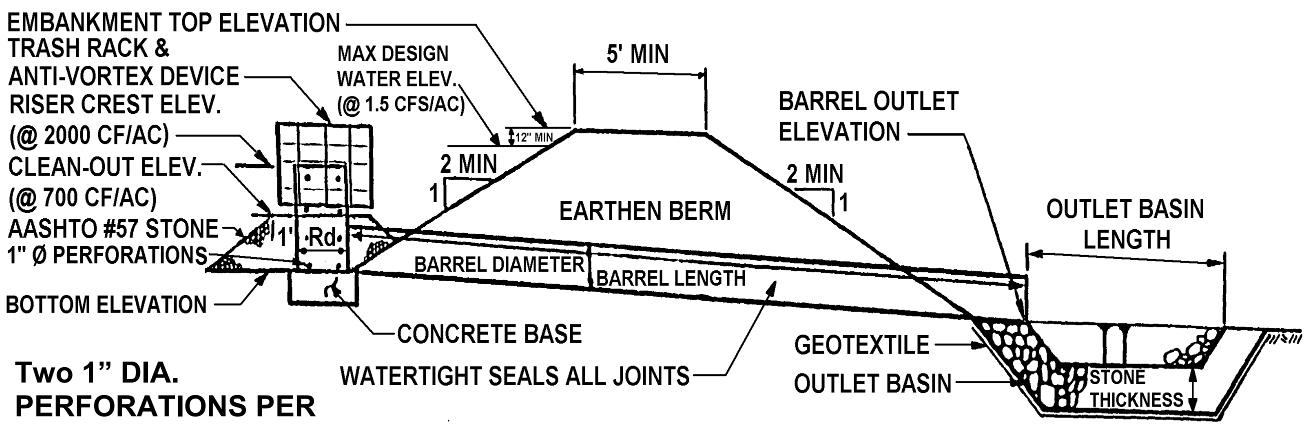
Perforations in the riser to dewater the trap should be limited to one 1" diameter opening per vertical foot of riser pipe with lowest perforation @ sediment storage elevation.

Outlets for pipe barrels should be protected with a rock outlet basin of width = 3 Db, length = 6 Db, and depth = Db. The riprap protection should be the R gradation whose maximum stone size equals Db.

STANDARD WORKSHEET #11
Dry Barrel/Riser Sediment Traps

PROJECT NAME: ____________________
LOCATION: ____________________
PREPARED BY: ____________________ DATE: ____________________
CHECKED BY: ____________________ DATE: ____________________

CONSTRUCTION DETAIL:



Two 1" DIA. PERFORATIONS PER ROW @ 1' VERTICAL

NOTE: SHOW ALL DETAILS AND CONSTRUCTION DIMENSIONS ON PLAN DRAWINGS.

OUTLET BASIN

Rock size = R-___
Width = ______ft.
Length = _____ft.
Depth = ______ft.

This configuration of riser may be used where it is necessary to completely dewater a sediment trap.

A trash rack and anti-vortex device must be provided for the riser. Provide details on plan drawings.

Crest of vertical risers must be set at the elevation which corresponds with the 2,000 CF per acre storage volume. The top elevation of the embankment must be set a minimum of one foot above the elevation at which 1.5 cfs per acre discharge capacity is provided.

Maximum embankment height is 5 feet.

Perforations in the riser to dewater the trap should be limited to two 1" diameter openings per vertical foot of riser pipe.

Outlets for pipe barrels should be protected with a rock outlet basin of width = 3 Db, length = 6 Db, and depth = Db. The riprap protection should be the R gradation whose maximum stone size equals Db.

STANDARD WORKSHEET #12
Sediment Basin Capacity Requirements

PROJECT NAME: ______________________________
LOCATION: ______________________________
PREPARED BY: ____________________ DATE: ____________
CHECKED BY: ____________________ DATE: ____________

BASIN NUMBER			
(A) MAXIMUM TOTAL DRAINAGE AREA (AC)			
(I) INITIAL REQ'D SETTLING VOLUME (5,000 X A)	(CF)		
(T) REDUCTION FOR TOP DEWATERING (-700 X A)	(CF)		
(P) REDUCTION FOR PERMANENT POOL (-700 X A)	(CF)		
(L) RED. FOR 4:1 FLOW LENGTH:WIDTH (-350 X A)	(CF)		
(D) RED. FOR 4 TO 7 DAY DEWATERING (- 350 X A)	(CF)		
*** (Sv) REQUIRED SETTLING VOLUME [I - (T+P+L+D)]	(CF)		
(Sd) REQUIRED SEDIMENT STORAGE VOLUME (1000 X A)[1]			
(St) TOTAL REQUIRED STORAGE VOLUME (Sv + Sd)	(CF)		
**** TOTAL STORAGE VOLUME PROVIDED (CF)			
REQUIRED DISCHARGE CAPACITY (2 X A) (CFS)			
PRINCIPAL SPILLWAY CAPACITY (@ ELEV ⑤) (CFS)			
* EMERGENCY SPILLWAY CAPACITY (@ ELEV ⑤) (CFS)			
** EMERGENCY SPILLWAY PROTECTIVE LINING			

* Provide supporting computations.

** If grass lining is proposed, spillway must be constructed in original ground.

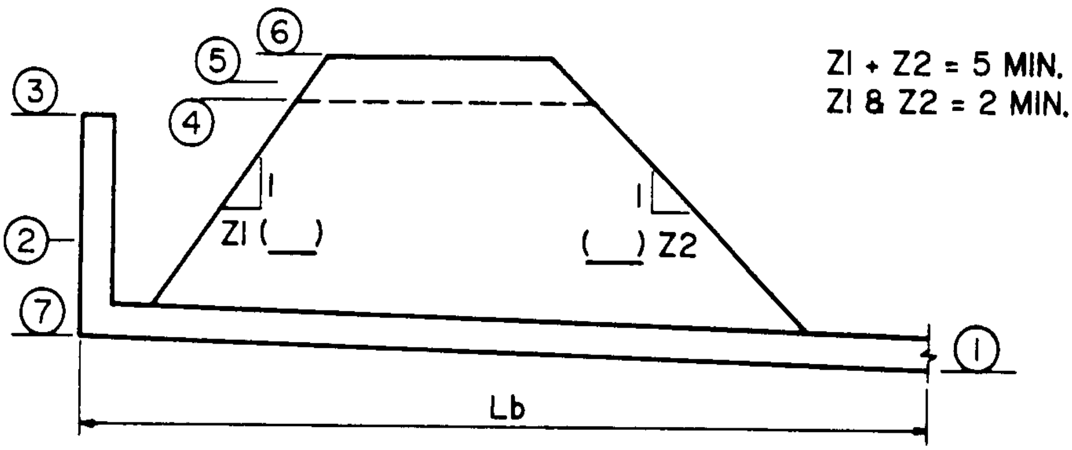
*** 5000 cubic feet per acre settling volume is required for basins located in Special Protection (HQ & EV) watersheds. In other watersheds, the basin settling volume may be reduced per the Department's "Erosion and Sediment Pollution Control Program Manual," No. 363-2134-008 (January 1996), as amended and updated. The minimum settling volume for such basins is (3600 X A).

**** Total Storage Volume provided at riser crest.

[1] A = Disturbed Acres in Drainage Area

STANDARD WORKSHEET #13
Sediment Basin Dimensions And Elevations

PROJECT NAME: ____________________
LOCATION: ____________________
PREPARED BY: ____________________ DATE: ____________
CHECKED BY: ____________________ DATE: ____________



BASIN NUMBER		
1. DISCHARGE PIPE ELEVATION		
2. TOP OF SEDIMENT STORAGE ZONE (@ Sd)		
3. ELEVATION AT TOP OF DEWATERING ZONE (St) (CREST OF PRINCIPAL SPILLWAY)		
4. EMERGENCY SPILLWAY CREST ELEVATION (MIN. 0.5' ABOVE ELEVATION ③)		
5. 2 CFS/ACRE FLOW ELEVATION		
6. TOP OF EMBANKMENT ELEVATION (MIN. 24" ABOVE ELEVATION ⑤)		
7. BOTTOM ELEVATION		
AVERAGE BOTTOM WIDTH (FT)		
AVERAGE BOTTOM LENGTH (FT)		
EMBANKMENT TOP WIDTH (FT, 8' MIN.)		
RISER DIAMETER/TYPE (15" MIN.)		
BARREL DIAMETER/TYPE (12" MIN.)		
Lb (BARREL LENGTH (FT)		
EMERGENCY SPILLWAY WIDTH (FT)		
EMERGENCY SPILLWAY SIDE SLOPES (H:V)		

SHOW ALL DETAILS AND CONSTRUCTION DIMENSIONS ON PLAN DRAWINGS USING STANDARD CONSTRUCTION DETAIL SHEETS.

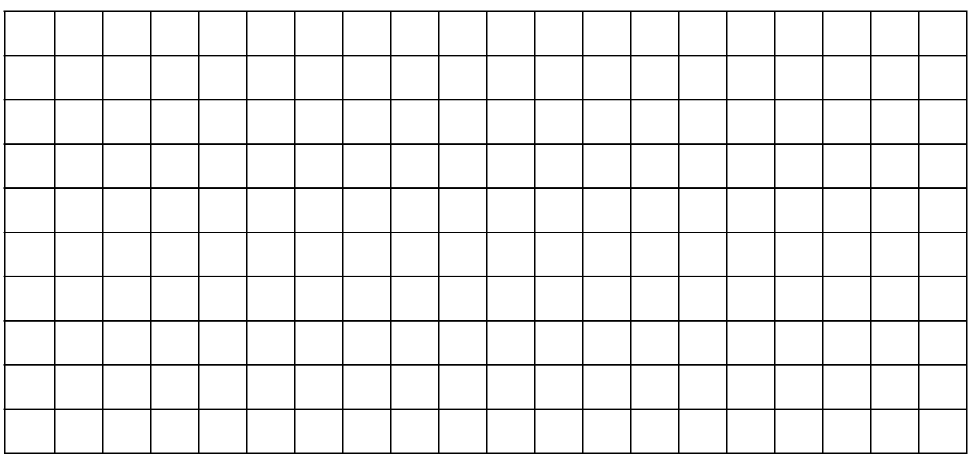
STANDARD WORKSHEET #14
Sediment Basin Storage Data

PROJECT NAME: ____
LOCATION: ____
PREPARED BY: ______________________ DATE: ________________
CHECKED BY: _______________________ DATE: ________________

WATER SURFACE ELEVATION (FEET)	AREA (SQ. FT.)	AVERAGE AREA (SQ.FT.)	DIFFERENCE IN ELEVATION (FEET)	STORAGE VOLUME (CUBIC FEET)	
				INCREMENTAL	TOTAL

STAGE STORAGE CURVE

ELEVATION (FT)



STORAGE VOLUME (CF)

STANDARD WORKSHEET #15
Sediment Basin Dewatering Discharge Data

PROJECT NAME: ______________________________
LOCATION: ______________________________
PREPARED BY: ______________________ DATE: ______________
CHECKED BY: ______________________ DATE: ______________

PERFORATION DISCHARGE (TOP OF RISER TO SEDIMENT CLEAN-OUT ELEVATION)

WATER SURFACE ELEVATION*	RISER ORIFICE ROW ELEVATION**									TOTAL DISCHARGE (CFS) ***
	ROW 1	ROW 2	ROW 3	ROW 4	ROW 5	ROW 6	ROW 7	ROW 8	ROW 9	

* From Worksheet #14

** All perforations should be the same size. One inch diameter perforations are preferred. Specify size of perforations _______ inch diameter. Each orifice row should have approximately the same number of perforations and the orifice rows should be equally spaced vertically. Specify the number of perforations in each orifice row ______ .

*** Insert value into column 4 of Standard Worksheet #16

STANDARD WORKSHEET #16
Sediment Basin Dewatering Time Data

PROJECT NAME: ______________________________
LOCATION: ______________________________
PREPARED BY: ____________________ DATE: ____________
CHECKED BY: ____________________ DATE: ____________

*WATER SURFACE ELEVATION (FT)	STORAGE VOLUME (CU. FT.)	INCREMENTAL STORAGE VOLUME (CU. FT.)	** DISCHARGE (CFS)	AVERAGE DISCHARGE (CFS)	TIME (HRS)	ACCUMULATED TIME (HRS)

*   From Worksheet #15, first column

** From Worksheet #15, last column

STANDARD WORKSHEET # 17
Sediment Basin Discharge Capacity

PROJECT NAME: ______________________________
LOCATION: ______________________________
PREPARED BY: ______________________ DATE: ______________
CHECKED BY: ______________________ DATE: ______________

PRINCIPAL SPILLWAY DISCHARGE CAPACITY

WATER SURFACE ELEVATION (FT)	RISER			BARREL PIPE FLOW		PRINCIPAL SPILLWAY CAPACITY ***(CFS)
	HEAD (FT)	ORIFICE FLOW Q(CFS)*	WEIR FLOW Q(CFS)	HEAD** (FT)	Q (CFS)	

* Flow into top of riser only (Flow through perforations not included).

** Water surface elevation minus elevation at centerline of pipe outlet.

*** Least of orifice, weir, or pipe flow

EMERGENCY SPILLWAY DISCHARGE CAPACITY

WATER SURFACE ELEVATION (FT)	WEIR FLOW Q (CFS)****	EMERGENCY SPILLWAY CAPACITY (CFS)

**** Use standard tables or equation for broad-crested weir [$Q = CLH^{1.5}$, where C = 2.8 (MAX)].

STANDARD WORKSHEET #18
Required Discharge Capacity For Channels

PROJECT NAME: ____________________
LOCATION: ____________________
PREPARED BY: ____________________ DATE: ____________________
CHECKED BY: ____________________ DATE: ____________________

Note: List runoff for each identified (#) sub-area that will be used to size a channel.

________ *Temporary = 1.60 cfs/acre × ________ acres = ________ cfs
________ Permanent = 2.75 cfs/acre × ________ acres = ________ cfs

________ Temporary = 1.60 cfs/acre × ________ acres = ________ cfs
________ Permanent = 2.75 cfs/acre × ________ acres = ________ cfs

________ Temporary = 1.60 cfs/acre × ________ acres = ________ cfs
________ Permanent = 2.75 cfs/acre × ________ acres = ________ cfs

________ Temporary = 1.60 cfs/acre × ________ acres = ________ cfs
________ Permanent = 2.75 cfs/acre × ________ acres = ________ cfs

________ Temporary = 1.60 cfs/acre × ________ acres = ________ cfs
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________ Temporary = 1.60 cfs/acre × ________ acres = ________ cfs
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________ Temporary = 1.60 cfs/acre × ________ acres = ________ cfs
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________ Temporary = 1.60 cfs/acre × ________ acres = ________ cfs
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________ Temporary = 1.60 cfs/acre × ________ acres = ________ cfs
________ Permanent = 2.75 cfs/acre × ________ acres = ________ cfs

________ Temporary = 1.60 cfs/acre × ________ acres = ________ cfs
________ Permanent = 2.75 cfs/acre × ________ acres = ________ cfs

*2.25 cfs/acre for Special Protection Watersheds.

STANDARD WORKSHEET # 19
Time Of Concentration

PROJECT NAME: ____________________
LOCATION: ____________________
PREPARED BY: ____________________ DATE: ____________________
CHECKED BY: ____________________ DATE: ____________________

OVERLAND FLOW:

PATH NUMBER	LENGTH L (FT)*	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME (minutes)

$$T = \left[\frac{2\,(L)\,(n)}{3\,(S)^{0.5}} \right]^{0.4673}$$

"n" values

0.02 smooth pavement
0.1 bare parched soil
0.3 poor grass cover
0.4 average grass cover
0.8 dense grass cover
***(L = 150' maximum)**

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (FT)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME (minutes)

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVG. SLOPE (ft/ft)	WET'D PERIM (ft)	HYDR. RADIUS (ft)	MANNING'S "n"	V (ft/sec)	CHANNEL TIME (minutes)	T_C (minutes)

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

STANDARD WORKSHEET #20
Rational Equation

PROJECT NAME: ______________________________
LOCATION: ______________________________
PREPARED BY: ____________________ DATE: ____________
CHECKED BY: ____________________ DATE: ____________

DETERMINE WATERSHED "C" VALUE

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_C	R_2	R_{10}	I_2	I_{10}

DETERMINE PEAK RUNOFF RATES ($Q = C \times I \times A$)

CHANNEL NUMBER	C VALUE	I (in. /hr.)	A (acres)	Q_2 (cfs)	Q_{10} (cfs)

STANDARD WORKSHEET #21
Channel Design Data

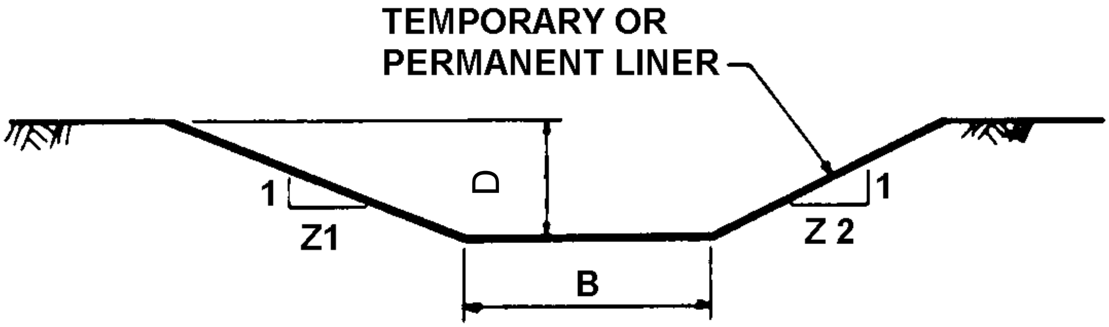
PROJECT NAME: ____________________
LOCATION: ____________________
PREPARED BY: ____________________ DATE: ____________________
CHECKED BY: ____________________ DATE: ____________________

CHANNEL OR CHANNEL SECTION					
**PROTECTIVE LINING ** **					
CHANNEL TOP WIDTH (FT)@ D					
CHANNEL TOP WIDTH (FT)@ d					
CHANNEL SIDE SLOPES (H:V)					
CHANNEL BOTTOM WIDTH (FT)					
d (FLOW DEPTH IN FT)					
BOTTOM WIDTH:DEPTH RATIO (12:1 MAX)					
A (AREA IN SQ. FT.)					
R (HYDRAULIC RADIUS)					
S (BED SLOPE, FT/FT)*					
VEGETATIVE LINING RETARDANCE					
n (MANNING'S COEFFICIENT)**					
V (AT FLOW DEPTH d, CFS)					
Q (AT FLOW DEPTH d, CFS)					
Q_r (REQUIRED CAPACITY) CFS					
S_c (CRITICAL SLOPE)					
$.7S_c$					
$1.3S_c$					
STABLE FLOW? (Y/N)					
FREEBOARD BASED ON UNSTABLE FLOW FT					
FREEBOARD BASED ON STABLE FLOW FT					
MINIMUM REQUIRED FREEBOARD FT					
D (TOTAL DEPTH) FT					
d_{50} STONE SIZE (IN					
DESIGN METHOD FOR PROTECTIVE LINING ** PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)**					
V_a (ALLOWABLE VELOCITY) FPS					
τ_d (SHEAR STRESS AT FLOW DEPTH d) LB/FT^2					
τ_a (MAX ALLOWABLE SHEAR STRESS) LB/FT^2					

* Slopes may not be averaged.
** For vegetated channels, provide data for temporary linings and vegetated conditions in separate columns.
*** Minimum Freeboard,F, is 0.5 ft.
**** Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is recommended for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

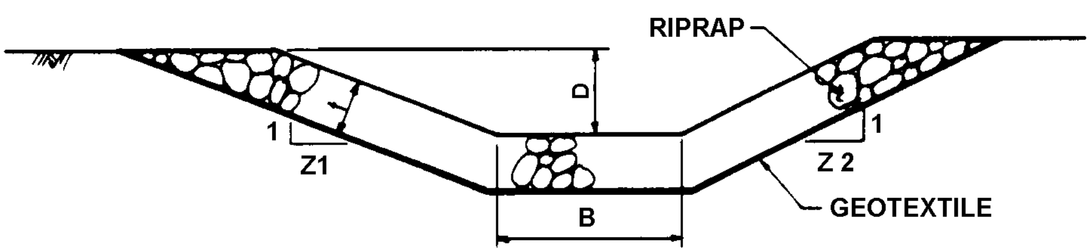
STANDARD WORKSHEET #22
Channel Cross-Section Data

PROJECT NAME: ______________________________
LOCATION: ______________________________
PREPARED BY: ____________________ DATE: ____________
CHECKED BY: ____________________ DATE: ____________



VEGETATED CHANNELS

CHANNEL	STATIONS	B (ft)	D (ft)	Z_1	Z_2	LINING



RIPRAPPED CHANNELS

CHANNEL	STATIONS	B (ft)	D (ft)	Z_1	Z_2	RIPRAP R-SIZE	t (ft)

NOTE: SHOW ALL DETAILS AND CONSTRUCTION DIMENSIONS ON PLAN DRAWINGS.

STANDARD WORKSHEET #23
Riprap Apron Outlet Protection

PROJECT NAME: ____

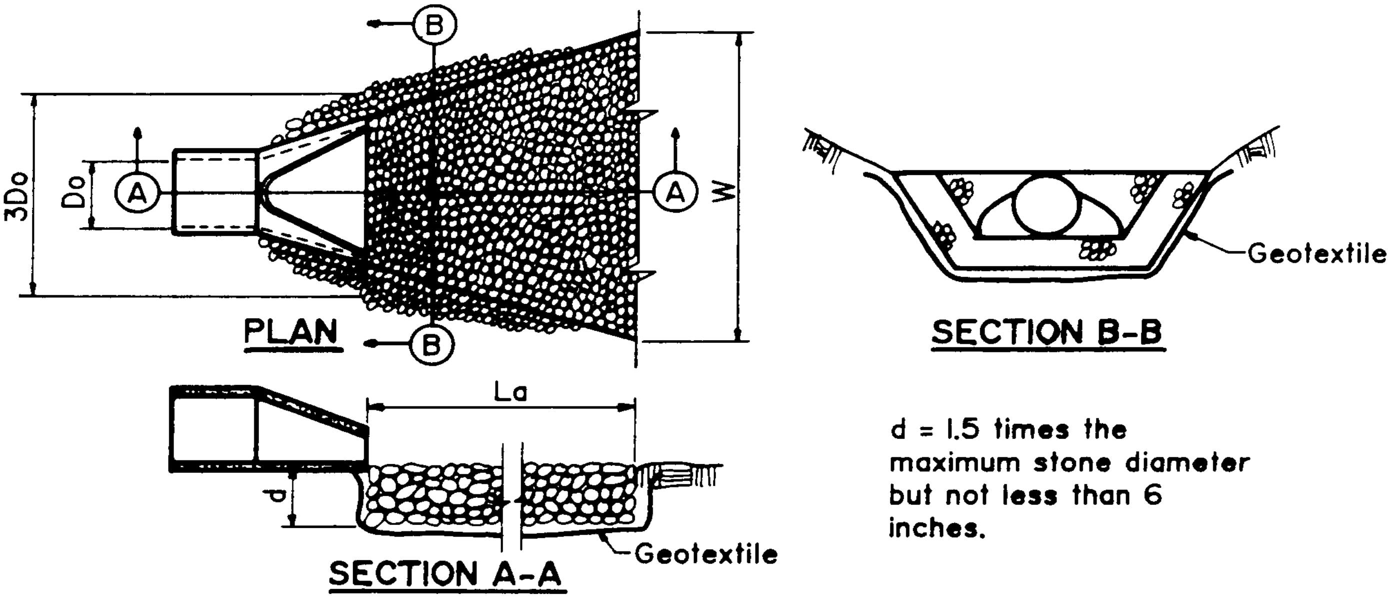
LOCATION: ____

PREPARED BY: ________________________ DATE: ____________________

CHECKED BY: ________________________ DATE: ____________________

CONSTRUCTION DETAIL:

NOTE: SHOW ALL DETAILS AND CONSTRUCTION DIMENSIONS ON PLAN DRAWINGS.



OUTLET NO.	PIPE DIA. Do (in.)	TAILWATER CONDITION (Max or Min)	Q (CFS)	V* (FPS)	RIPRAP SIZE	La (ft)	W (ft)

The anticipated velocity (V) should not exceed the maximum permissible shown in the Program Manual for the proposed riprap protection.

STANDARD EROSION AND SEDIMENT CONTROL PLAN NOTES

The use of the following notes is encouraged but not mandated on Erosion and Sediment Control plans. Not all of the notes apply to all plans, therefore they should be included where they are applicable.

1. Only limited disturbance will be permitted to provide access to _______________ for grading and acquiring borrow to construct those BMPs. (Insert type of BMP for which borrow is needed.)

2. Erosion and sediment BMPs must be constructed, stabilized, and functional before site disturbance begins within the tributary areas of those BMPs.

3. After final site stabilization has been achieved, temporary erosion and sediment BMPs must be removed. Areas disturbed during removal of the BMPs must be stabilized immediately.

4. Vehicles and equipment may neither enter directly nor exit directly form Lots______________ onto _______________. (Insert lot numbers and road names.)

5. Stockpile heights must not exceed 35 feet. Stockpile slopes must be 2:1 or flatter.

6. Until the site is stabilized, all erosion and sediment BMPs must be maintained properly. Maintenance must include inspections of all erosion and sediment BMPs after each runoff event and on a weekly basis. All preventative and remedial maintenance work, including clean out, repair, replacement, regrading, reseeding, remulching and renetting must be performed immediately. If erosion and sediment control BMPs fail to perform as expected, replacement BMPs, or modifications of those installed will be required.

STANDARDS FOR MAPS AND DRAWINGS

The following two figures illustrate acceptable standard mapping symbols and standard symbols for Erosion and Sediment Control Best Management Practices. Other legends, properly identifying symbols may be used as well.

FIGURE 36
Standard Mapping Symbols

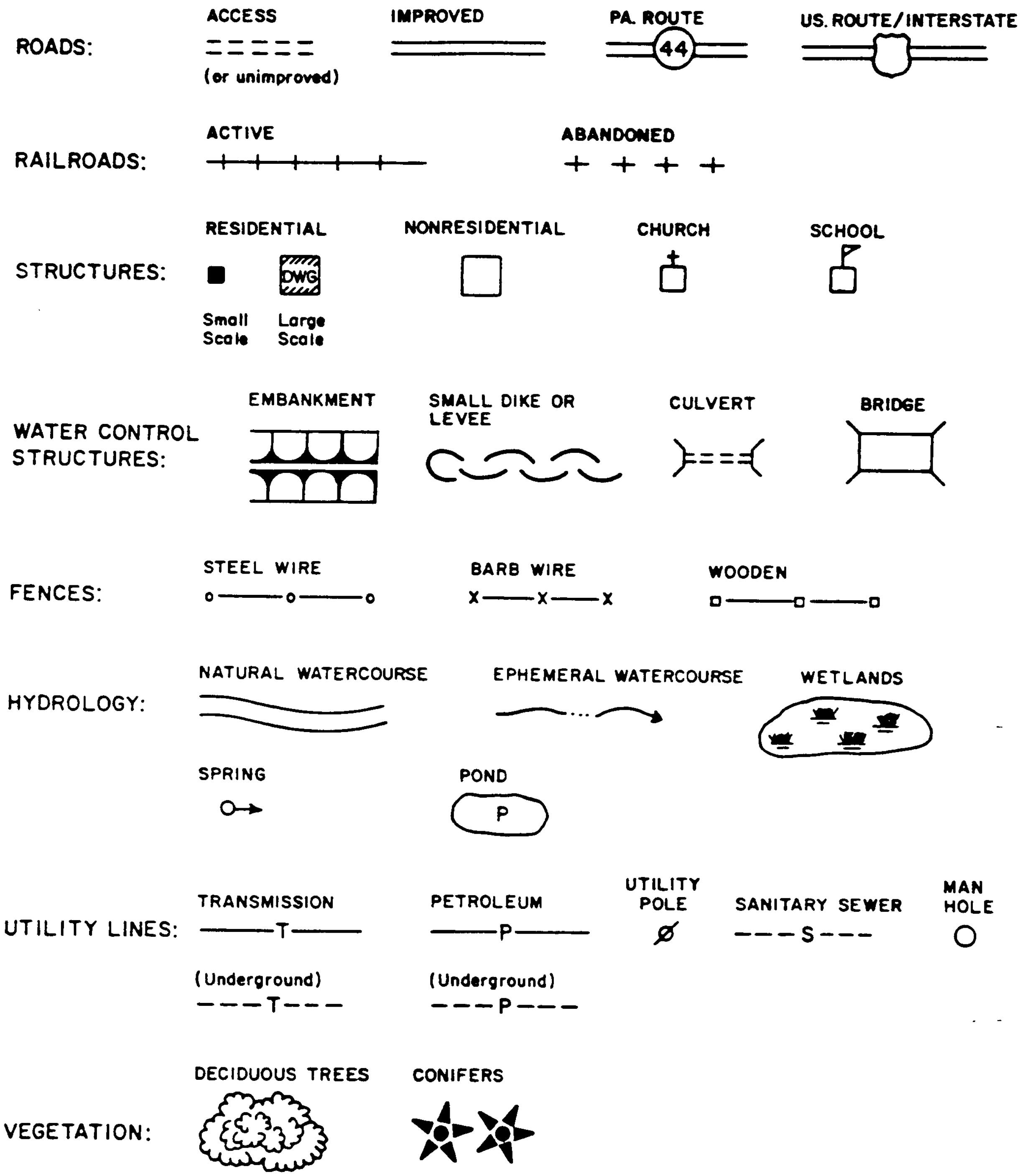


FIGURE 37
Standard Symbols for E&S BMPs

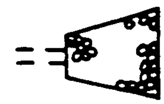
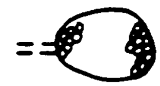
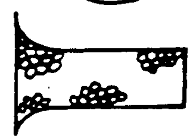
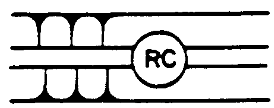
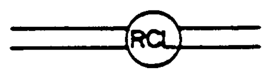
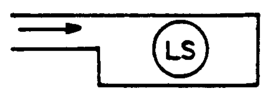
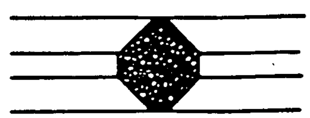
MEASURE/FACILITY	ILLUSTRATION	SYMBOL
ROCK ENERGY DISSIPATER		RD
" " "		RD
ROCK CONSTRUCTION ENTRANCE		RCE
ROCK RIPRAP OR ROCK FILL		RR RF
ROCK CHANNEL LINING		RCL
	or 	
LEVEL SPREADER		LS
ROCK FILTERS	 * or as required to illustrate configuration	RF
DROP STRUCTURE		DS

FIGURE 37 (Continued)
Standard Symbols for E&S BMPs continued

MEASURE/FACILITY	ILLUSTRATION	SYMBOL
BENCH	B	B
TERRACE	T	T
DIVERSION CHANNEL	DC	DC
COLLECTION CHANNEL	CC	IC
BYPASS CHANNEL	BC	FC
NOTE: DENOTE PERMANENT CHANNELS AS =	PDC PCC	
CHECK DAM		CD
SEDIMENT TRAP	as req'd to illustrate	ST
SEDIMENT BASIN	as req'd to illustrate	SB
FABRIC FENCE	FF-18 or FF-30	FF
STRAW BALE BARRIER	SBB	SBB
VEGETATIVE FILTER STRIP	VFS	VFS
TEMPORARY SEEDING		TS
SURFACE ROUGHENING		SR

For more information, visit DEP's Web site at http://www.depweb.state.pa.us/, Keyword: "Erosion Control."