EPSC ORDINANCE
QUALIFIED PLAN PREPARER
TRAINING MANUAL

JULY 2015

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TRAINING MANUAL

Introduction

The purpose of this training manual is to familiarize qualified design professionals with the requirements set forth in the Erosion Prevention and Sediment Control (EPSC) Ordinance. This manual provides EPSC plan designers with equations and calculations that can be used to successfully design BMPs recognized by the EPSC Ordinance. The BMPs referenced in this training manual are found in chapter 12 of the EPSC Design Manual.

The purpose of the manual is show different design techniques by example. The plan designer must always remember that each situation is specific and the problems given in the training manual are examples only. The input parameters for each design will have to be carefully selected by the designer, and the values used in this training manual should not be utilized as default values.

DESIGN CRITERIA FOR ECBS AND TRMS

The design of ECBs and TRMs is based on the anticipated shear stresses the fabric will encounter. These shear stresses are determined using design peak flow values and channel dimensions. Once the design shear stresses are known, a corresponding product that meets or exceeds this stress may be used.

- The first required variable is the peak flow rate (cfs), calculated for the 10-year 24-hour storm.

- The next required variables are the dimensions of the channel designed to carry the peak flow. For simplicity, all channels will be assumed to be trapezoidal in shape. The required variables are channel bottom width (B_o), channel side slopes (Z:1), and channel bed slope (S).

- The governing equation for maximum channel shear stress is:

$$\tau = \gamma\, d_n\, S$$

τ = maximum shear stress (lb/ft^2)
γ = unit weight of water = 62.4 lb/ft^3
d_n = normal channel flow depth (ft)
S = channel bed slope (ft/ft)

- The governing equation between flow, velocity and channel area is:

$$Q=VA$$

Q = peak flow rate (cfs)
V = flow velocity (ft/sec)
A = channel flow area (ft^2)

$$A = (B_o + Z * d_n) * d_n$$

B_o = bottom width of channel (ft)
Z = channel side slopes (Z:1)
d_n = normal channel flow depth (ft)

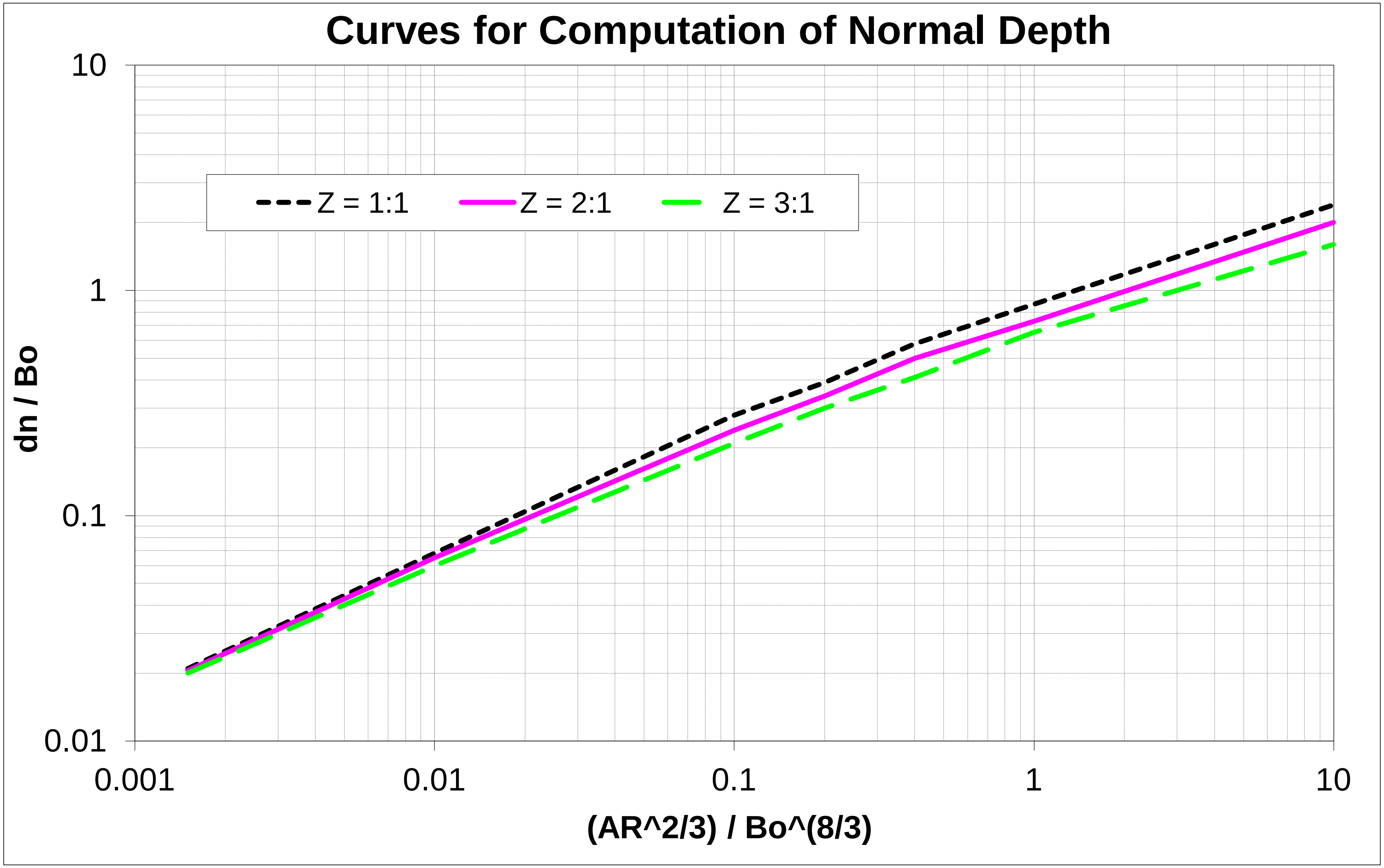
- The governing equation for channel velocity is Manning's Equation:

$$V = (1.49/n)*R^{2/3}*S^{1/2}$$

V = flow velocity (ft/sec)
n = Manning's roughness coefficient (dimensionless)
R = hydraulic radius (ft)
S = channel bed slope (ft/ft)

- Putting these two equations together the following ratio is obtained:

$$AR^{2/3} = \frac{(n*Q)}{1.49*S^{1/2}}$$



After Chow, Open Channel Hydraulics, 1959

Figure 1. Curves for Computation of Normal Depth in Trapezoidal Channel

Designing ECB and TRM Example

Given: Peak flow rate carried by channel: 80 cfs
Bottom width of design channel B_o: 4 feet
Side slopes of design channel: 2:1
Channel bed slope (ft/ft): 0.01

Find: A Short-term Degradable Erosion Control Blanket that will meet the maximum shear stress requirements.

Solution:

- Using Figure 1, the normal depth of flow in the channel (d_n) can be found.
- The maximum shear stress is then calculated.
- Select an appropriate ECB or TRM for the design conditions.

- Solve for $AR^{2/3}$

$$AR^{2/3} = \frac{(n*Q)}{1.49*S^{1/2}} = \frac{(0.025*80)}{1.49*(.01)^{1/2}} = 13.4$$

- Calculate the ratio: $\frac{AR^{2/3}}{B_o^{(8/3)}} = \frac{13.4}{4^{(8/3)}} = 0.33$

- For Side Slopes 2:1, Figure 1. Reads: $d_n/B_o = 0.45$

- Solve for $d_n = (0.45 * B_o) = (0.45 * 4) = 1.8$ feet

- Solve for $\tau = \gamma\, d_n\, S = (62.4 * 1.8 * .01) = 1.1\ (\# / ft^2)$

- Select a Class I Erosion Control Blanket that can handle a maximum shear stress of 1.1 pounds/ square foot (Type B) from the list of MSD Approved ECBs and TRMs.

RIPRAP LINED CHANNEL DESIGN

Straight Channel Section Example

Given: A trapezoidal channel has a depth (D) of 3 feet, a bottom width (B_o) of 8-feet, side slopes (Z) 2:1, and a 2% slope.

Find: A stable riprap size for the bottom and side slopes of the channel.

Solution:

1. From Exhibit 12-2, for a 3-foot-deep channel over a 2 percent grade,
   Read d_{50} = 0.75 feet or 9 inches.

2. Since the side slopes are steeper than 3:1, continue with step 3
   If side slopes were less than 3:1, the process would be complete.

3. From Exhibit 12-3, $B_o/d = 8/3 = 2.67$, Side slopes Z = 2,
   Read $K_1 = 0.82$.

4. From Exhibit 12-4, for d_{50} = 9 inches,
   Read Angle of Repose = 41

5. From Exhibit 12-5, side slopes Z = 2, and Angle of Repose = 41 ,
   Read $K_2 = 0.73$.

6. Stable Riprap = $d_{50} \times (K_1/K_2) = 0.75 \times (0.82/0.73) = 0.84$ feet or 10 inches

Curved Channel Section Example

Given: The preceding channel has a curved section with a radius of 50 ft.

Find: A stable riprap size for the bottom and side slopes of the curved channel section.

Solution:

1. R_o = 50 feet.

2. Calculate Channel Top Width of Water Surface
   $B_s = B_o + 2(Z*D) = 8 + 2(2*3) = 20$ ft.

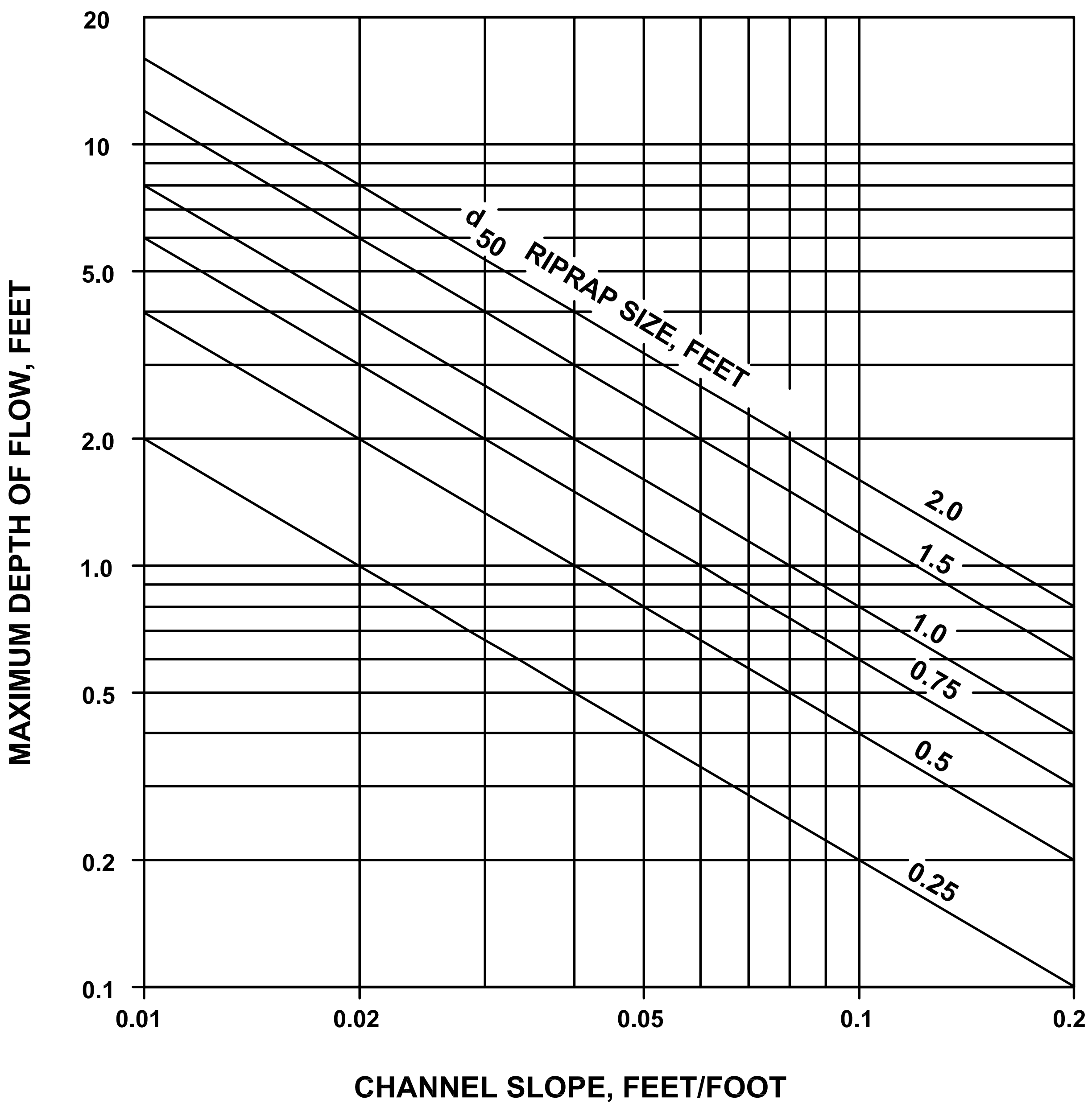
3. Calculate the Ratio B_s / R_o
   $= 20/50 = 0.40$

4. From Exhibit A, for $B_s / R_o = 0.40$
   Read K3 = 1.1

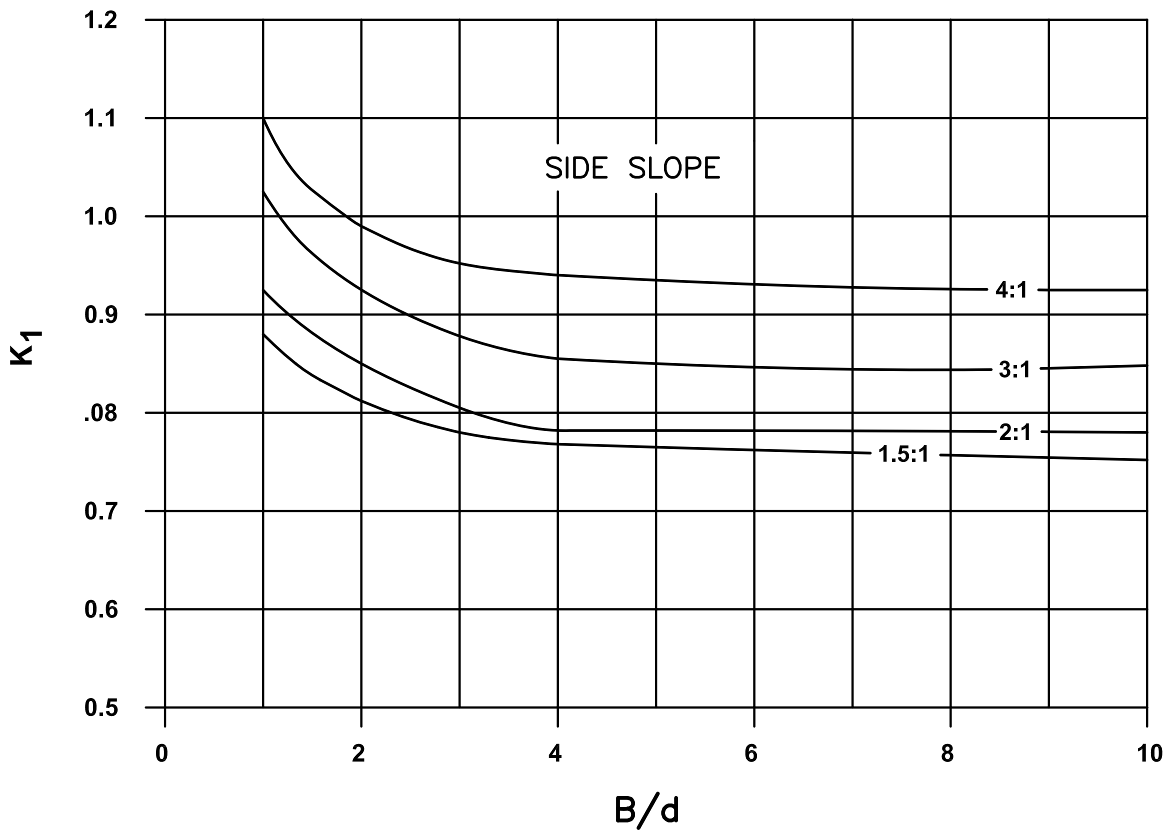
5. $d_{50} \times K_3$ = (0.84 ft. x 1.1) = 0.92 feet or 11 inches.

EXHIBIT 12-2
MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

EFFECTIVE DATE: JUNE 30, 2009



MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

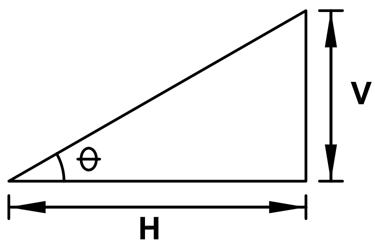


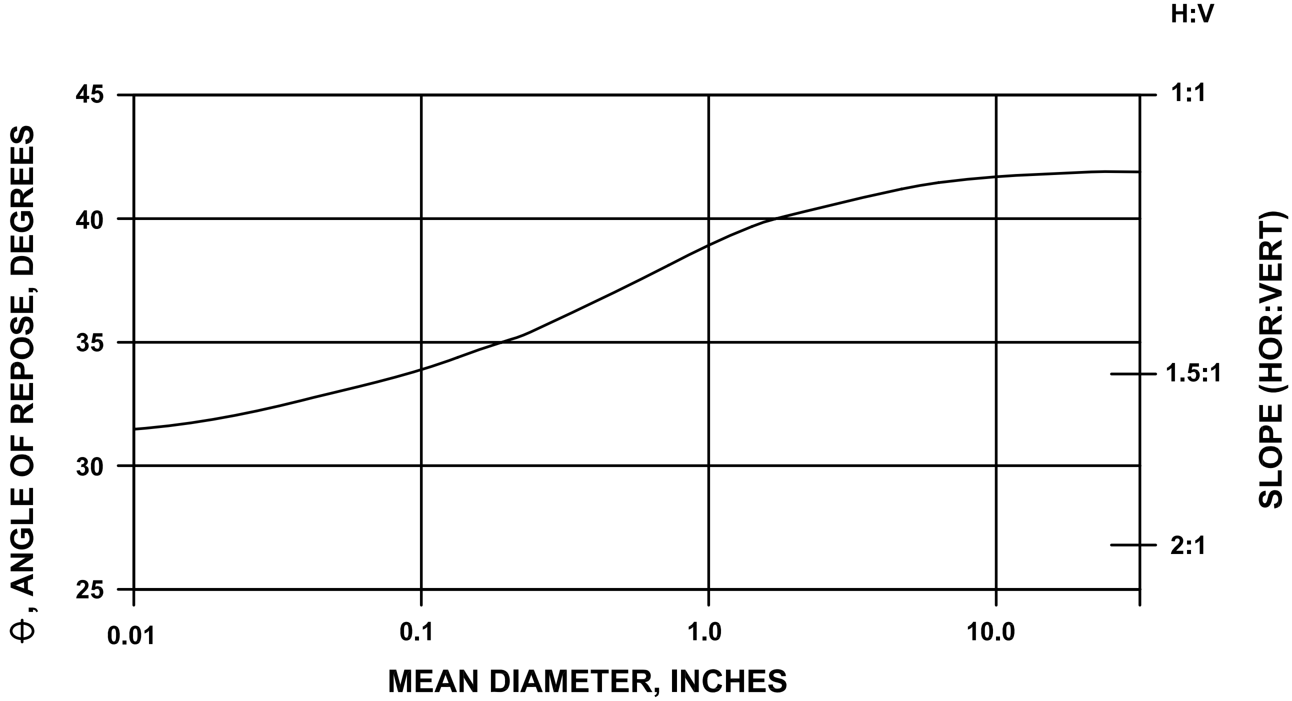
DISTRIBUTION OF BOUNDARY SHEAR AROUND WETTED PERIMETER OF TRAPAZOIDAL CHANNEL

MSD
Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913
502-587-0603 – WWW.MSDLOUKY.ORG

EXHIBIT 12-4
ANGLE OF REPOSE FOR RIPRAP STONES

EFFECTIVE DATE: JUNE 30, 2009

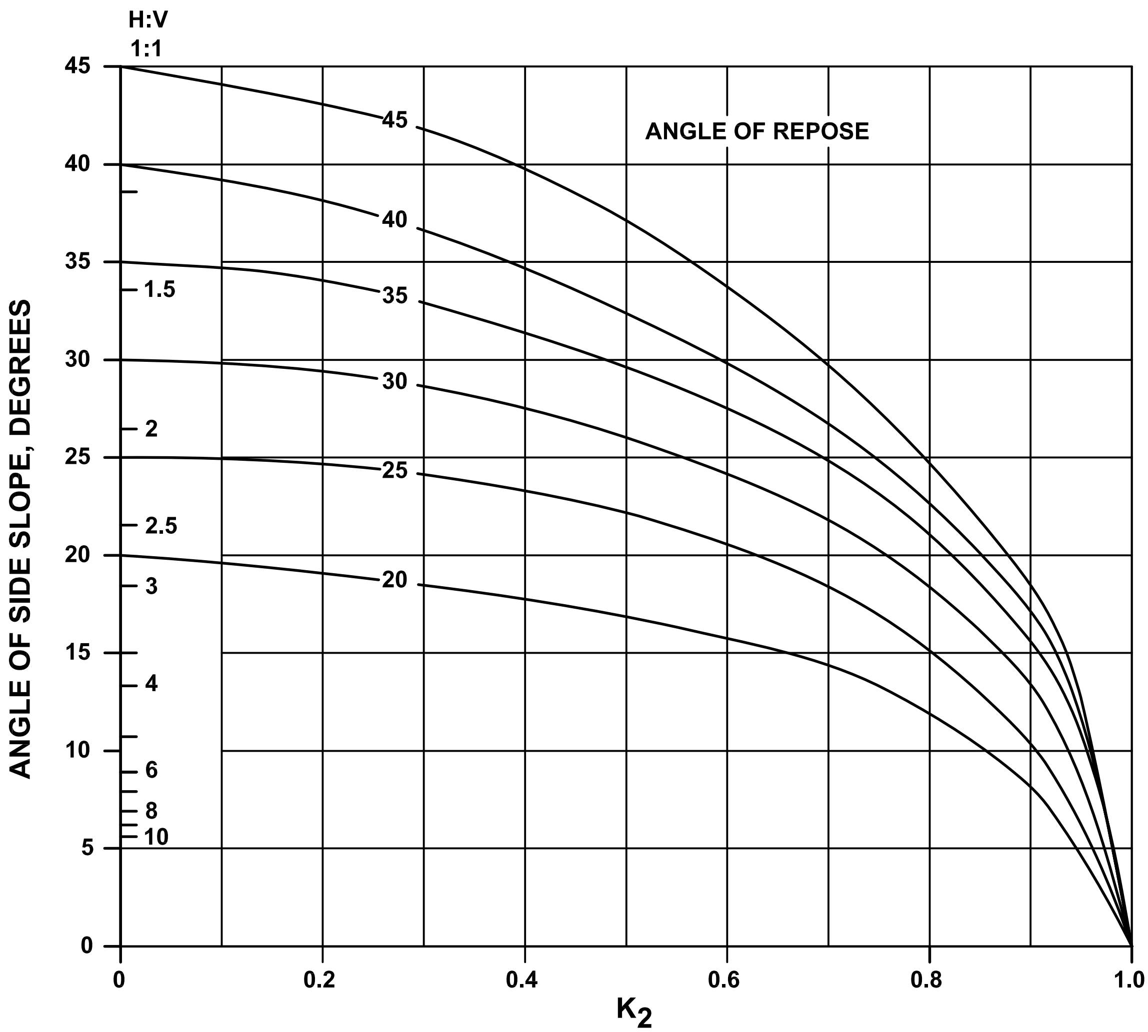




ANGLE OF REPOSE FOR RIPRAP STONES

EXHIBIT 12-5
RATIO OF CRITICAL SHEAR STRESS ON SIDES TO CRITICAL SHEAR STRESS ON BOTTOM

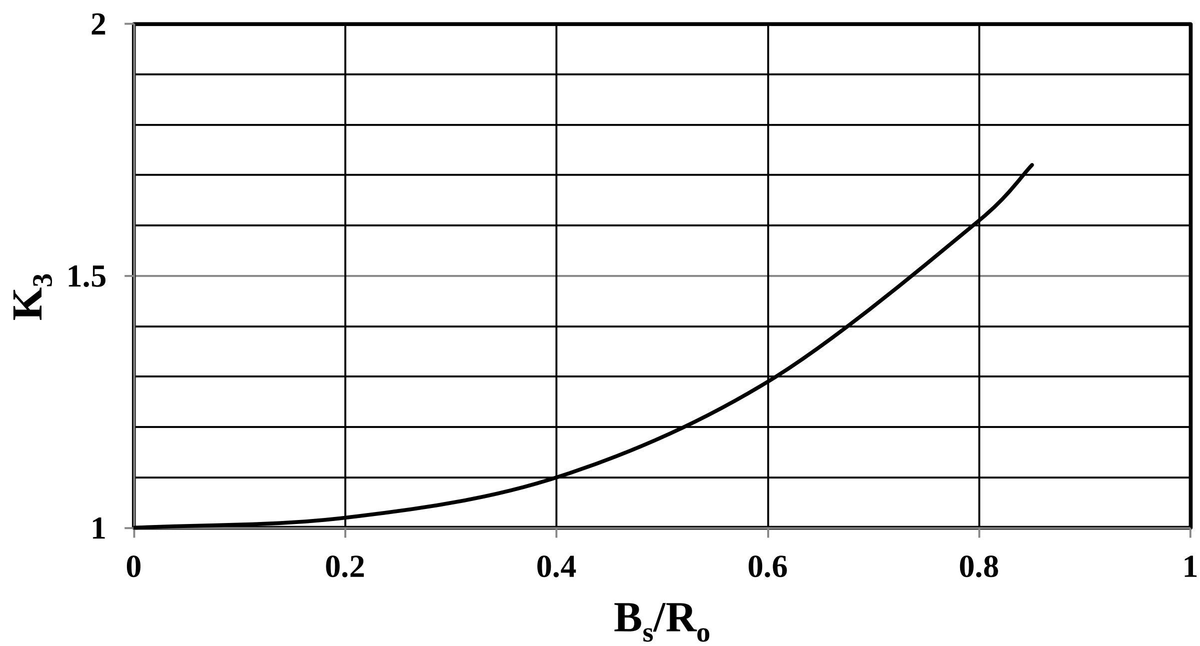
EFFECTIVE DATE: JUNE 30, 2009



RATIO OF CRITICAL SHEAR ON SIDES TO CRITICAL SHEAR ON BOTTOM

EXHIBIT A:

RATIO OF MAXIMUM BOUNDARY SHEAR IN BENDS TO MAIMUM BOTTOM SHEAR IN STRAIGHT REACHES



B_s = Surface Width
R_o = Mean Radius of Bend

Outlet Protection Example

Outlet protection should be designed according to the following criteria:

Round Pipe Flowing Full:

1. Tailwater Depth: The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. Manning's Equation may be used to determine tailwater depth.

   If the tailwater depth is less than ½ the diameter of the outlet pipe, it should be classified as a Minimum Tailwater Condition.

   If the tailwater depth is greater than ½ the pipe diameter, it should be classified as a Maximum Tailwater Condition.

   Pipes which outlet onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition.

2. Apron Length: The required apron length, L_a, according to the tailwater condition, should be determined from the appropriate graphs provided in Exhibits 12-6 and 12-7:

   Minimum Tailwater Condition - Use Exhibit 12-6
   Maximum Tailwater Condition - Use Exhibit 12-7

3. Apron Width: When the pipe discharges directly into a well-defined channel, the apron should extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank (whichever is less).

   If the pipe discharges onto a flat area with no defined channel the width of the apron should be determined as follows:

   - The upstream end of the apron, adjacent to the pipe, should have a width three times the diameter of the outlet pipe (3D).
   - For a Minimum Tailwater Condition, the downstream end of the apron should have a width equal to the pipe diameter plus the length of the apron ($D + L_a$).
   - For a Maximum Tailwater Condition, the downstream end should have a width equal to the pipe diameter plus 0.4 times the length of the apron ($D + 0.4 * L_a$).

4. Bottom Grade: The apron shall be constructed with no slope along its length (0% grade). The downstream invert elevation of the apron should be equal to the elevation of the invert of the receiving channel. There shall be no overfall at the end of the apron.

5. Side Slopes: If the pipe discharges into a well-defined channel, the receiving side slopes of the channel should not be steeper than 3H: 1V.

6. Alignment: The apron should be located so there are no bends in the horizontal alignment.

7. Materials:

   - The preferred apron lining shall be with an appropriate permanent turf reinforcement matting (TRM). The shear stress and maximum velocity should be calculated to determine which type of TRM is applicable for the situation (see Section 12.5.5).

   - When conditions are too severe for TRMs the apron may be lined with riprap, grouted riprap, concrete, or gabion baskets. The median-sized stone for riprap should be determined from the curves in Exhibit 12-6 and 12-7 according to the tailwater condition.

8. Filter Cloth: In all cases, filter cloth should be placed between the riprap and the underlying soil to prevent soil movement into and through the riprap.

Permissible Velocity:

1. The flow velocity at the outlet of paved channels flowing at design capacity **must not** exceed the permissible velocity of receiving unprotected grass-lined channels as provided in Table 1.

2. The paved channel end should merge smoothly with the receiving channel section with no overfall at the end of the paved section. When the bottom width of the paved channel is narrower than the bottom width of the receiving channel, a transition section should be provided with a maximum side divergence of 1 in 3F with:

$$F = \frac{V}{(gd)^{0.5}}$$

F = Froude number
V = Velocity at beginning of transition (ft./sec.)
d = Depth of flow at beginning of transition (ft.)
g = Acceleration due to gravity, (32.2 ft./sec.^{2})

3. Bends or curves in the horizontal alignment at the transition are not allowed unless the Froude number (F) is 1.0 or less, or the section is specifically designed for turbulent flow.

Table 1. Maximum Permissible Velocities For Unprotected Grass Lined Channels

Channel Slope	Lining	Velocity (ft./sec.)**
0 – 5 %	Bermuda Grass	8
	KY-31 Tall Fescue	7
	Kentucky Bluegrass	7
	Reed Canarygrass	7
	Grass-legume Mixture	5
	Lespedeza Sericea	3.5
	Small Grains	3.5
	Temporary Vegetation	3.5
5- 10 %	Bermuda Grass	7
	KY-31 Tall Fescue	6
	Kentucky Bluegrass	6
	Reed Canarygrass	6
	Grass-legume mixture	4
	Lespedeza Sericea	Not Recommended
	Small Grains	Not Recommended
	Temporary Vegetation	Not Recommended
Greater than 10%	Bermuda Grass	6
	KY-31 Tall Fescue	5
	Kentucky Bluegrass	5
	Reed Canarygrass	5
	Grass-legume mixture	Not Recommended
	Lespedeza Sericea	Not Recommended
	Small Grains	Not Recommended
	Temporary Vegetation	Not Recommended

***Allow velocities over 5 ft/sec only where good cover and maintenance will be provided.**

****For highly erodible soils, decrease permissible velocities by 25%.**

Source: Elementary Soil and Water Engineering, Shwab et. al.

Oulet Protection Example:

Given: An 18-inch pipe discharges 24 cfs at design capacity onto a grassy slope (no defined channel)

Find: The required length, width and median stone size (d_{50}) for a riprap lined apron.

Solution:

1. Since the pipe discharges onto a grassy slope with no defined channel, a **Minimum Tailwater Condition** is assumed.

2. From Exhibit 12-6, the intersection of a discharge of 24 cfs and a pipe diameter (d) of 18 inches,

   Gives an apron length (L_a) of 20 feet .

3. From Exhibit 12-6, the intersection of a discharge of 24 cfs and a pipe diameter (d) of 18 inches.

   Gives a median stone size (d_{50}) of 0.8 ft.

4. The upstream apron width equals 3 times the pipe diameter ($3D_o$)

   = 3 x 1.5 feet = 4.5 feet

5. The downstream apron width equals the apron length + the pipe diameter;

   = 20 feet + 1.5 feet = 21.5 feet

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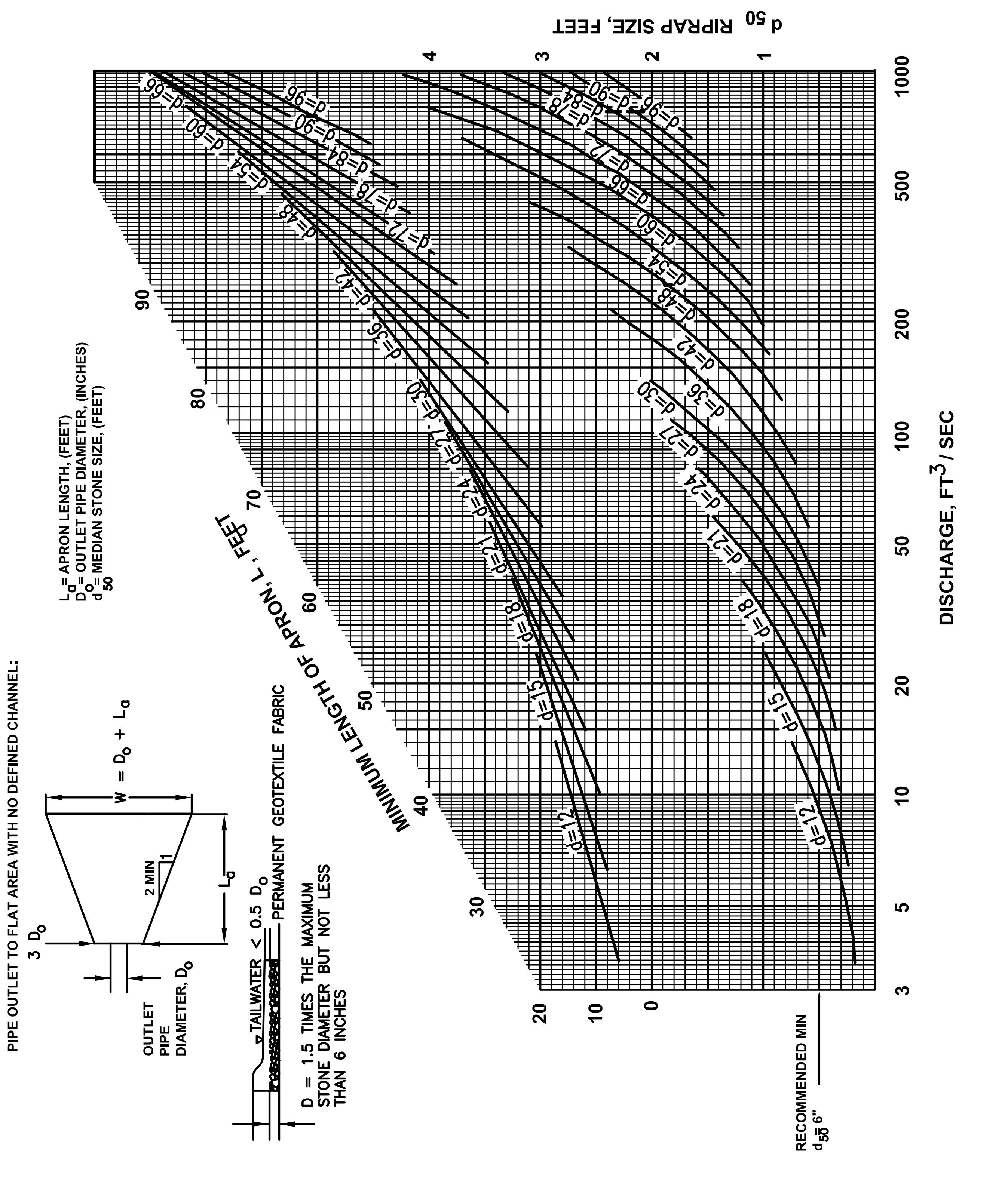
EXHIBIT 12-6
MINIMUM TAIL WATER CONDITION

EFFECTIVE DATE: JUNE 30, 2009

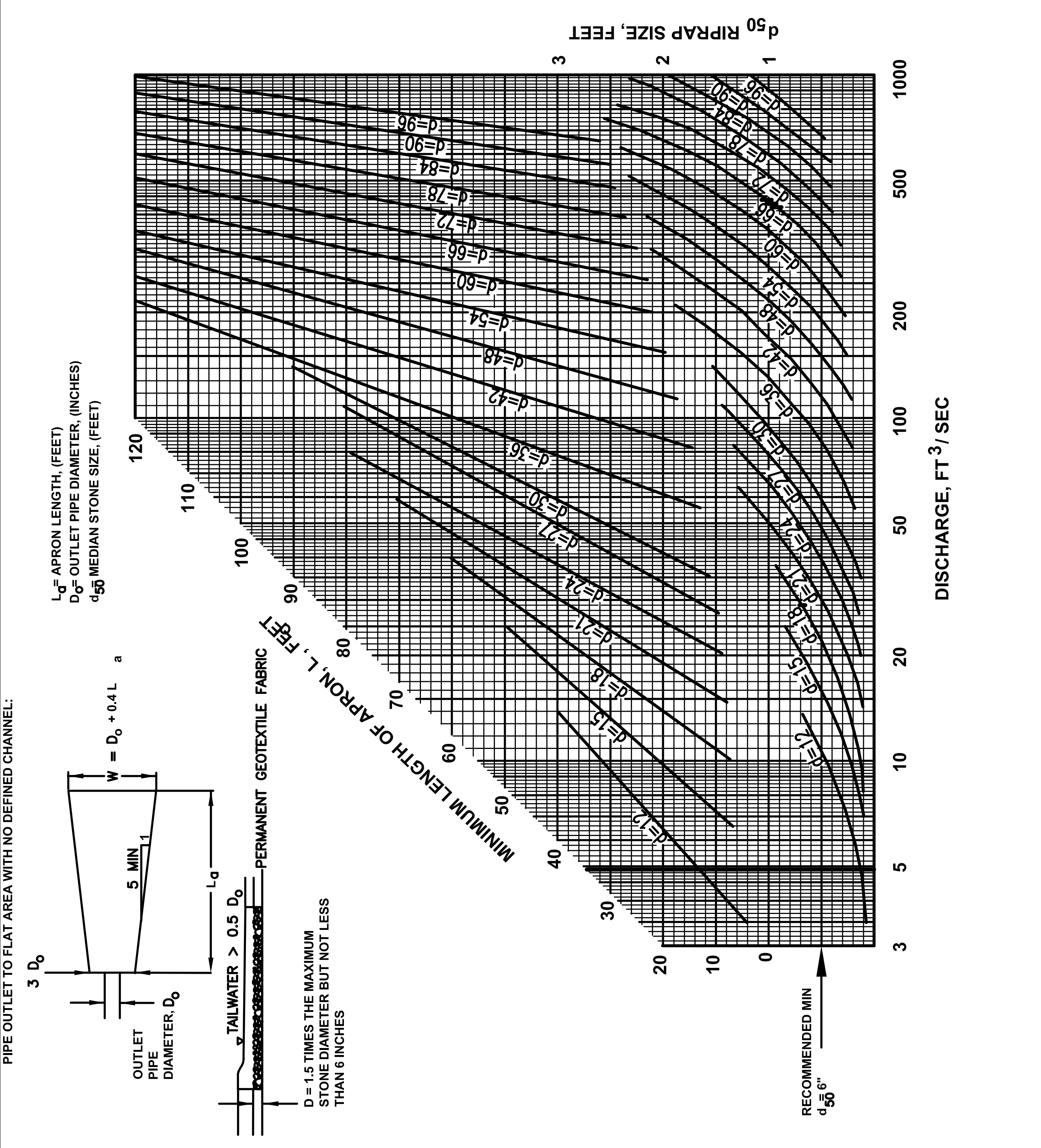


DESIGN OF OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL
MINIMUM TAILWATER CONDITION (T < 0.5 DIAMETER)

MSD
Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913
502-587-0603 – WWW.MSDLOUKY.ORG

EXHIBIT 12-7
MAXIMUM TAILWATER CONDITION

EFFECTIVE DATE: JUNE 30, 2009



DESIGN OF OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL MAXIMUM TAILWATER CONDITION (T_w < 0.5 DIAMETER)

STORAGE VOLUMES AND MAINTENANCE SCHEDULES

Designing for Sediment Storage Volumes

Calculating the appropriate sediment storage volume is very important in sediment basin,sediment trap, and other EPSC BMP design. This volume is the storage occupied by the sediment deposited over the given design period. Design periods may be the life of the basin, or the time between scheduled clean outs. Using computed sediment yields from the Universal Soil Loss Equation (USLE), along with the sediment bulk density, the sediment storage volume can be calculated by:

$$V_S = \frac{Y_D}{W * 43{,}560}$$

V_S = Sediment storage volume (acre-feet),
Y_D = Sediment deposited over the design period (pounds), and
W = Weight density (bulk density) of the deposited sediment (lbs./ft^3).

W can be found from soil survey data (given in grams/cm^3) or by the equation:

$$W = W_c P_c + W_m P_m + W_s P_s$$

W_c, W_m, and W_s = Unit weights of clay, silt, and sand in (lbs./ft^3) from Table 2, and
P_c, P_m, and P_s = Primary soil matrix percent clay, silt, and sand as listed in soil survey (used as a decimal).

Table 2. Unit Weight Values of Basin Sediment

Type of Basin Operation	Wc (#/ft^3)	Wm (#/ft^3)	Ws (#/ft^3)
Sediment always submerged (Wet Pond)	26	70	97
Basin normally empty (Dry Pond)	40	72	97

R Factors and EI Values

When designing for sediment storage volume, the sediment deposited over the design period **Y_D**, must be calculated. This value can be obtained by converting the sediment yield calculated by the Universal Soil Loss Equation (USLE) into pounds of sediment.

One of the variables used in the USLE is the R factor. R is the factor in the USLE that accounts for the damaging effects of rainfall. The R factor indicates the erositivity of the rainfall, not the average annual precipitation in a locality. The R factor is defined as the number of erosion index (EI) values in a normal year's rain. The EI index value of a given storm is equal to the kinetic energy of the storm (hundreds of foot-tons per acre) times its maximum 30-minute intensity (inches/hour). The EI values of individual storms may be summed to get an EI value for a month, six, months, or for any period of time. When EI values are summed and averaged over a period of years, they become R factors.

The distribution of EI values become important when soil losses need to be calculated for a period of time less than one year, such as a construction season. The distribution of the EI values over a known period of time is used to calculate an R factor for that time period. Table 1 in Supplemental Section B of this chapter shows the distribution of EI values for Jefferson County as a percentage of the R factor for Jefferson County. MSD requires a minimum EI value of 50 for any construction period.

Steps Used to Determine Storage Volume

The following steps are used to determine the storage volume for EPSC BMPs. All Universal Soil Loss Equation Values are found Supplemental Sections B and C of Chapter 12 of the Design Manual.

1. Determine the sediment yield from the site using the Universal Soil Loss Equation:

A = R •K •LS •CP

A = Average soil loss per unit area (tons/acre/specified design period),

R = Rainfall erosive index (100-ft-tons/acre x in/hr)

(EI Value for given design period * average annual R Value),

K = Soil erodibility factor (tons/acre per unit R),

LS = Length-Slope steepness factor (dimensionless),

(L) = Slope distance from the point of origin of overland flow to the point of concentrated flow or until deposition occurs (ft)

(S) = Land slope (%), and

CP = Control practice factor (dimensionless).

2. Determine the weight density **(W)** of the specific soil.

- The Jefferson County Soil Survey gives a soil bulk density in grams/cm^3
- Convert (grams/cm^3) to (lbs/ ft^3) by multiplying by 62.43

W = (bulk density in grams/cm^3) x (62.43) = lbs/ft^3

3. Convert sediment yield from (tons/acre) to acre-feet of sediment storage.

   - Determine the total disturbed area **DA** (acres)

   - Determine the sediment yield in tons

     Calculated by Multiplying **A** from step 1. * **DA** from step 3.

     tons/acre * Acres = tons

   - Convert tons to pounds to get $\mathbf{Y_D}$

     $\mathbf{Y_D}$ = (tons) * (2000 lbs/ ton) = pounds

$$V_S = \frac{Y_D}{W * 43{,}560} \quad = \ acre - feet$$

4. The designer can now determine what level the required sediment storage corresponds to, and require a clean out marking stake to be installed at this elevation. The contractor shall be required to clean out the basin or trap when this level is reached. Or the designer can simply state that based on the calculations, the basin or trap will be required to be cleaned out on a time period basis such as weeks, months or years.

R Factors and EI Value Example Problem

Table 3. Distribution of Rainfall Erosion Index (EI Curves) for Jefferson County

Date	EI Curve Number
January 1	0.0
January 15	1.0
February 1	3.0
February 15	6.0
March 1	9.0
March 15	12.0
April 1	16.0
April 15	21.0
May 1	26.0
May 15	31.0
June 1	37.0
June 15	43.0
July 1	50.0
July 15	57.0
August 1	64.0
August 15	71.0
September 1	77.0
September 15	81.0
October 1	85.0
October 15	88.0
November 1	91.0
November 15	93.0
December 1	95.0
December 15	97.0
January 1	100.0

- A yearly R factor of 175 has been calculated for Jefferson County, Kentucky.

- If construction of a particular site is scheduled to take place for 5 months from January 1 to June 1, the EI Curve value would be,

  37.0 – 0.0 = 37.

- The corresponding R factor for this time period is calculated to be

  0.37 * 175 = 64.8.

- If construction of a particular site is scheduled to take place for 5 months from March 1 to August 1, the EI Curve value would be,

  64.0 – 9.0 = 55.0

- The corresponding R factor for this time period is calculated to be

  0.55 * 175 = 96.3.

Sediment Storage Volume Example

Given: A 60-acre construction site to be cleared to a bare soil condition and developed. The contributing runoff slope length is 400 feet with a 2.5% slope. The primary soil is Crider Silt Loam. A sediment basin is to be designed to be the primary sediment control structure on the site. Determine the required sediment storage volume if construction is to take place between March 1 and September 1.

1. Determine the sediment yield form the site using the Universal Soil Loss Equation

A = R •K •LS •CP

- **R** = from Table 3, EI for September 1 = 77.0, and EI for March 1 = 9.0

(77.0 –9.0) = 68% of 175 **= 119**

- **K** = 0.32 for Crider Silt Loam
- **LS** = 0.365 for 400 ft slope length with 2.5%
- **CP** = 1.0 for a bare soil condition

A = (119) x (0.32) x (0.365) x (1.0) = 13.9 tons/acre

2. Determine the weight density **(W)** of the Crider Silt Loam soil.

- The Jefferson County Soil Survey gives a bulk density of $1.36\ \text{grams/cm}^3$
- Convert 1.36 (grams/cm^3) to ($\# / \text{ft}^3$) by multiplying by 62.43

W = (1.36) x (62.43) = $84.9\ \#/\text{ft}^3$

3. Convert sediment yield from (tons/acre) to acre-feet of sediment storage.

- Determine the total disturbed area (acres)
- Determine the sediment yield in tons

13.9 (tons/acre) * 60 (acres) = 834 tons

- Convert tons to pounds to get $\mathbf{Y_D}$

$\mathbf{Y_D}$ = (834 tons) * (2000 # / ton) = 1,668,000 pounds

$$V_S = \frac{Y_D}{W * 43{,}560} = \frac{1{,}668{,}000}{84.9 \times 43{,}560} = 0.45\ acre - feet$$

STAGE DISCHARGE EQUATIONS FOR BASIN RISER AND BARREL OUTLET SPILLWAYS

Flow control devices can operate as either open channel flow, in which the flow has a free water surface, or pipe flow in which the flow is in a closed conduit. In either situation, an increase in head on a structure increases the discharge flow rate through the structure.

The stage discharge relationship for basin outlet structures is controlled by weir, orifice or pipe flow (See Figure 2). A given spillway can have a variety of stage discharge relationships depending on the head. When the water level is just above a riser crest (a very low head on the riser), the riser crest acts like a weir, and flow is weir controlled. As the water level in the basin increases, water begins flowing in from all sides including directly above the inlet, and the inlet begins to act like an orifice. As the head continues to increase, the outlet eventually begins to flow full, and pipe flow dictates. To determine which of the three flow mechanisms is controlling at a particular water level in the basin, all three equations should be utilized at each level. The minimum flow for a given stage indicates the actual discharge from the basin and the flow mechanism that is controlling at that water level.

Weir Flow

$$Q = C\,L\,H^{\frac{3}{2}}$$

Q = Discharge (cfs),
C = Weir coefficient (weir shape dependant, typically between **3.0 and 3.2**),
L = Weir length (feet) which is the total length over which flow crosses the weir (**L** = circumference of a pipe for circular drop inlets), and
H = Water head (feet).

Orifice Flow

$$Q = C'\,a\,(2gH)^{\frac{1}{2}}$$

Q = Discharge (cfs),
C’ **=** Orifice coefficient (**C’ = 0.6** for sharp-edged orifices),
A = Cross sectional area of the orifice (ft^2),
g = **32.2 ft/sec²**, and
H = Head on the orifice (feet).

Pipe Flow

$$Q = \frac{a\left(2gH'\right)^{\frac{1}{2}}}{\left(1 + K_e + K_b + K_c L\right)^{\frac{1}{2}}}$$

Q = Discharge (cfs),

A = Cross sectional area of the pipe (ft^2),

g = 32.2 ft/sec^2,

H' = Head (feet) defined as the distance from the water surface in the basin to a point 0.6 D above the invert of the outlet barrel.

D = outlet barrel diameter in feet (See Figure 3),

$\mathbf{K_e}$ = Pipe entrance loss (typical value of $\mathbf{K_e = 1.0}$),

$\mathbf{K_b}$ = Pipe bend loss (typical value of $\mathbf{K_b = 0.5}$),

$\mathbf{K_c}$ = Head loss coefficient due to friction
$\mathbf{K_c}$ = $5087 * n^2 / D^{4/3}$
n = Manning's roughness coefficient of the barrel, and
D = barrel diameter in inches,

L is the total length of the pipe (feet).

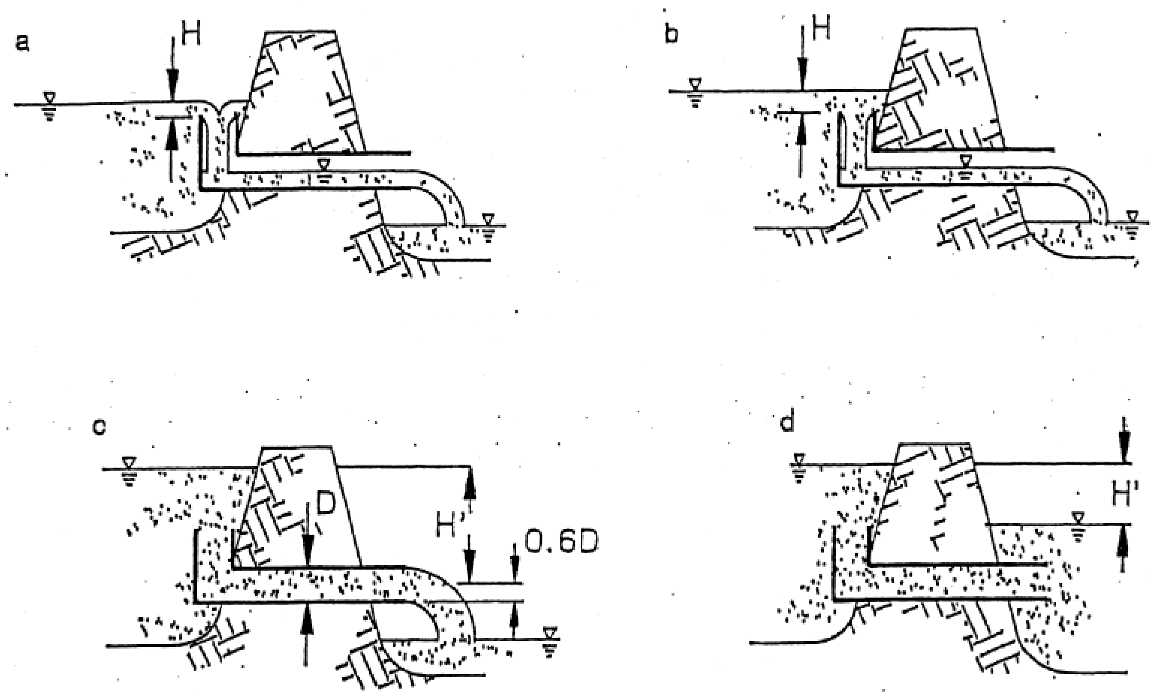


Figure 2 Illustration of drop inlet spillway as a flow control structure: (a) weir control, (b) orifice control, (c) pipe flow with free outfall, and (d) pipe flow with tailwater control.

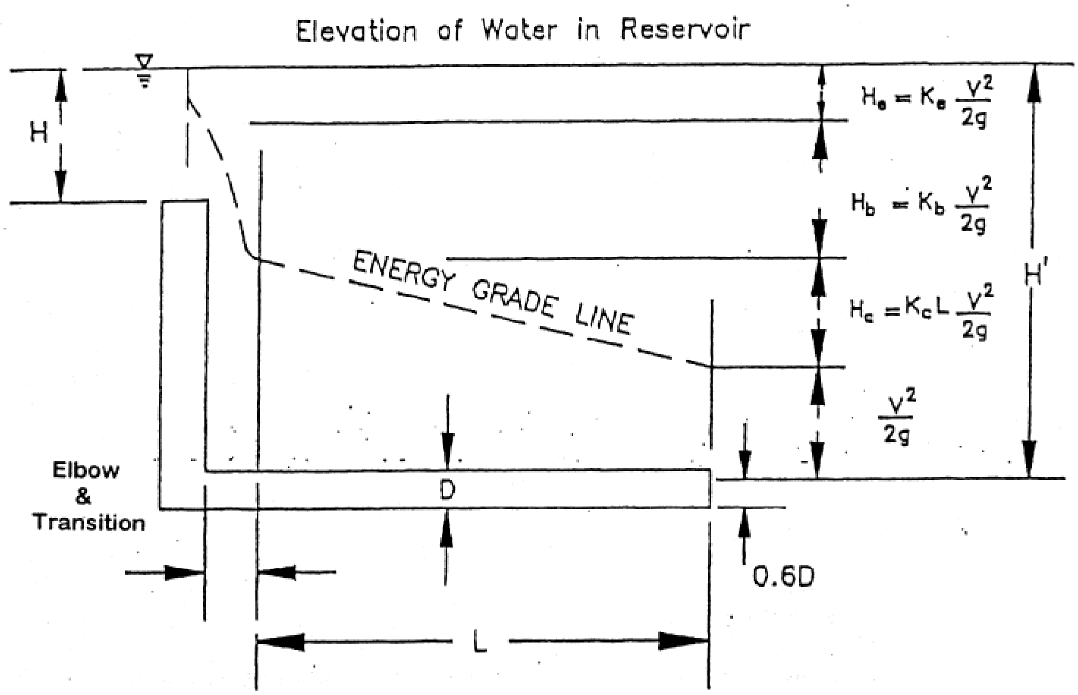


Figure 3: Energy losses for flow in a drop inlet spillway considering bend losses and entrance losses separately.

Stage Discharge Example

Develop a stage-discharge curve for a basin that has an 18-inch CMP vertical riser and a 50-ft long 18-inch CMP outlet barrel. The top of the basin riser is 10 feet above the barrel outlet invert. Assume Mannings n to be 0.025 for 18-inch CMP. (Solution shown in Figure 4).

1. **Weir Flow**

$$Q = C\,L\,H^{\frac{3}{2}}$$

- For an 18-inch circular pipe

C = 3.0
L = π * (18 in /12 in/ft) = 4.71 ft.
H = Head above weir
Q = (3.0)*(4.71) *H $^{3/2}$
Q = 14.1*H $^{3/2}$

2. **Orifice Flow**

$$Q = C' a \left(2gH\right)^{\frac{1}{2}}$$

- For an 18-inch circular pipe

C = 0.6
a = π/4 * (18 in /12 in/ft)^2 = 1.77 ft^2
g = 32.2 ft/sec^2
H = Head above orifice
Q = (0.6)*(1.77)*(2*32.2*H)$^{1/2}$
Q = 8.52* H$^{1/2}$

3. **Pipe Flow**

$$Q = \frac{a\left(2gH'\right)^{\frac{1}{2}}}{\left(1 + K_e + K_b + K_c L\right)^{\frac{1}{2}}}$$

- For an 18-inch circular pipe

A = π/4 * (18 in /12 in/ft)^2 = 1.77 ft^2
g = 32.2 ft/sec^2
H’ = H (head)+(top of riser elev. - barrel invert out elev.)–(0.6 * barrel out diameter)
H’ = H + (10) – [0.6 * (18 in/12 in/ft)]
H’ = H + 9.1
K_e = 1.0
K_b = 0.5
K_c = 5087*n^2 / D$^{4/3}$ = [(5087 * 0.025 ^{2}) / (18$^{4/3}$)] = 0.07
L = 50 ft.
Q = 5.80*(H + 9.1)$^{1/2}$

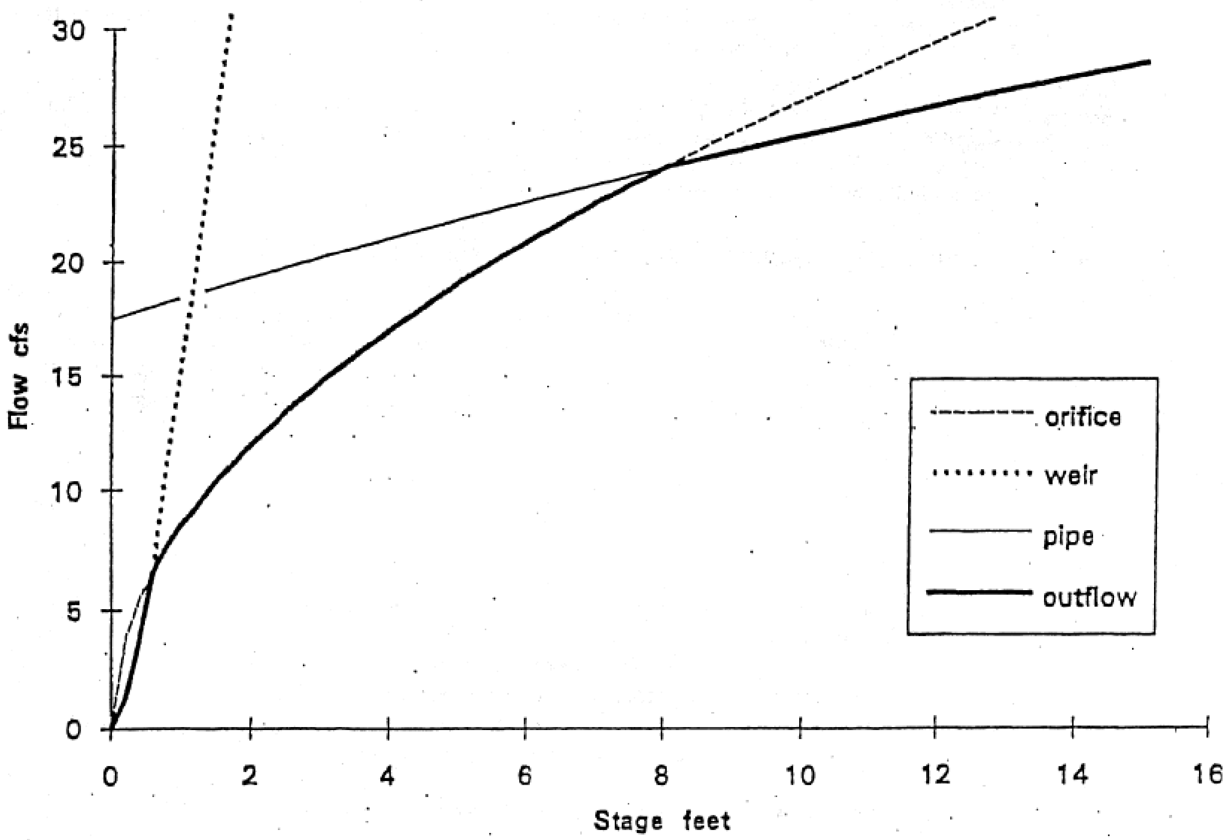


Figure 4 Stage–discharge curve for Example Problem ..

STAGE DISCHARGE EQUATIONS FOR ROCK STRUCTURES

Rock structures are commonly used as the outlet control structure of smaller sediment basins and sediment traps and in rock ditch checks. The flow through these structures is controlled by the following factors (see Figure 5):

- Static head drop as flow moves through the rockfill **(dh),**
- Upstream water depth **(h_1),**
- Downstream water depth **(h_2),**
- Flow length through the rockfill **(dl)** ,
- Average stone diameter of the rockfill **(d),**
- Porosity of the rockfill **(ξ)** (0.46 for graded rockfills constructed by dumping), and
- Reynolds Number **(R_e)** and friction factor **(f_k)**, which are dictated by flow length through the rockfill, rock size, and porosity of the rockfill.

In the original equations proposed by Herrera (1989), porosity was included as a parameter. However, Herrera and Felton (1991) deleted porosity from the equations because it was found to have a constant value of approximately 0.46 in all of their laboratory tests. The Herrera and Felton equations require a trial and error computation process that requires six steps for each stage.

Calculating the Stage-Discharge Relationship for Rockfill Structures

The Herrera and Felton equations incorporate detailed computations requiring computers and spreadsheets that are capable of trial and error programming. However, when quick estimates are needed, graphical procedures are helpful. A graphical procedure for predicting the average gradient through rockfills **(dh /dl)** can be used to develop head loss as a power function of flow, which eliminates any trial and error procedures. The governing equation is:

$$\frac{dh}{dl} = aq^{b}$$

dh = Static head drop of water in meters (difference between upstream and downstream water surface elevations)
dl = Average flow path length through the rock in meters,
a = Dimensionless coefficient based on flow path length shown in Figure 6,
b = Dimensionless exponent based on average rock diameter (m) shown in Figure 6, and
q = Flow per unit width of rockfill in cubic meters per second per meter (cms/m).

****All units must be converted to metric to use the graphical method.**

The equation can be rearranged so there is only one unknown, **q (csm/m)**.

$$q = \left[\frac{dh}{a(dl)}\right]^{\frac{1}{b}}$$

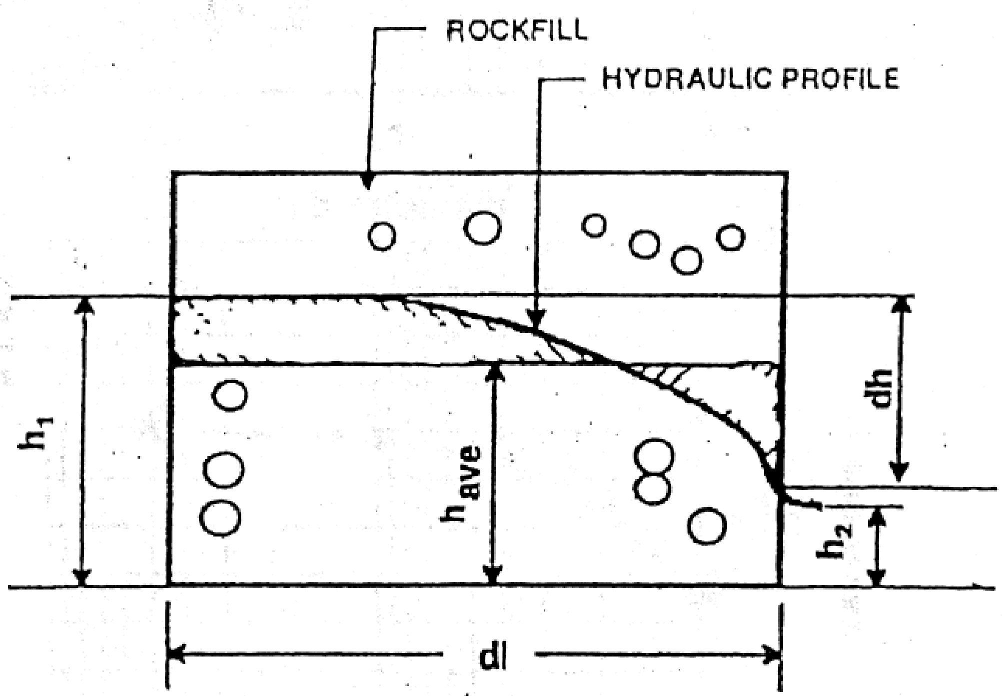
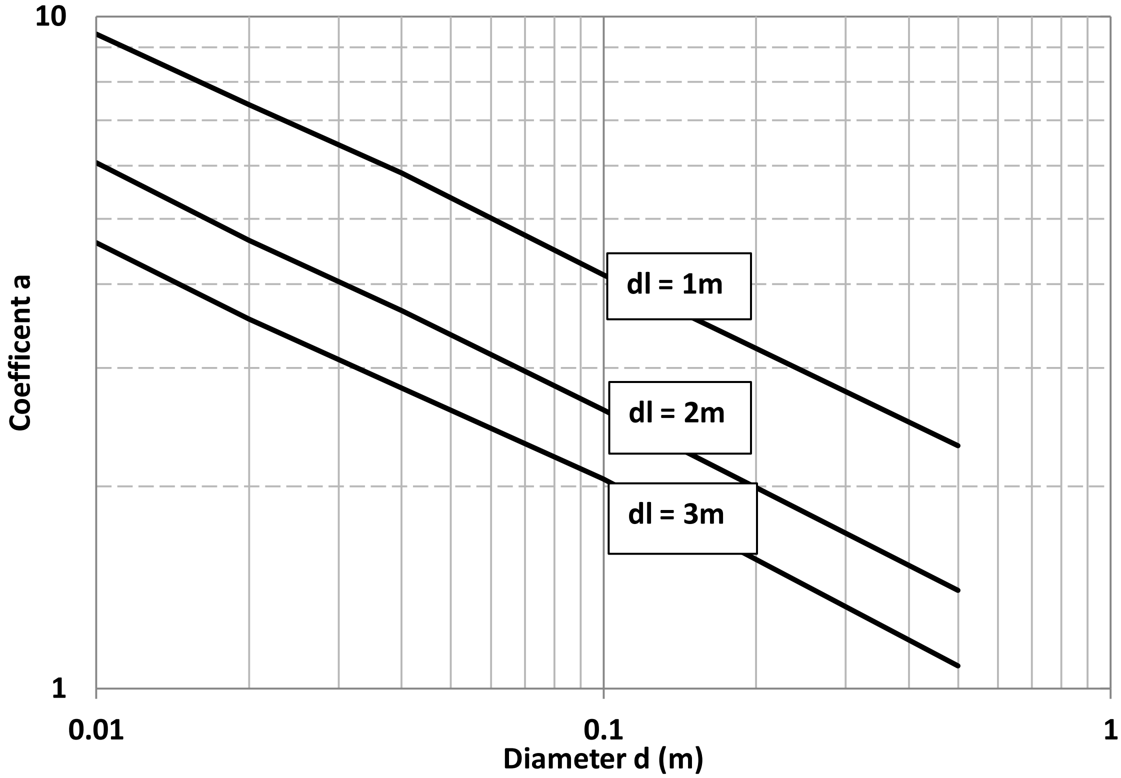
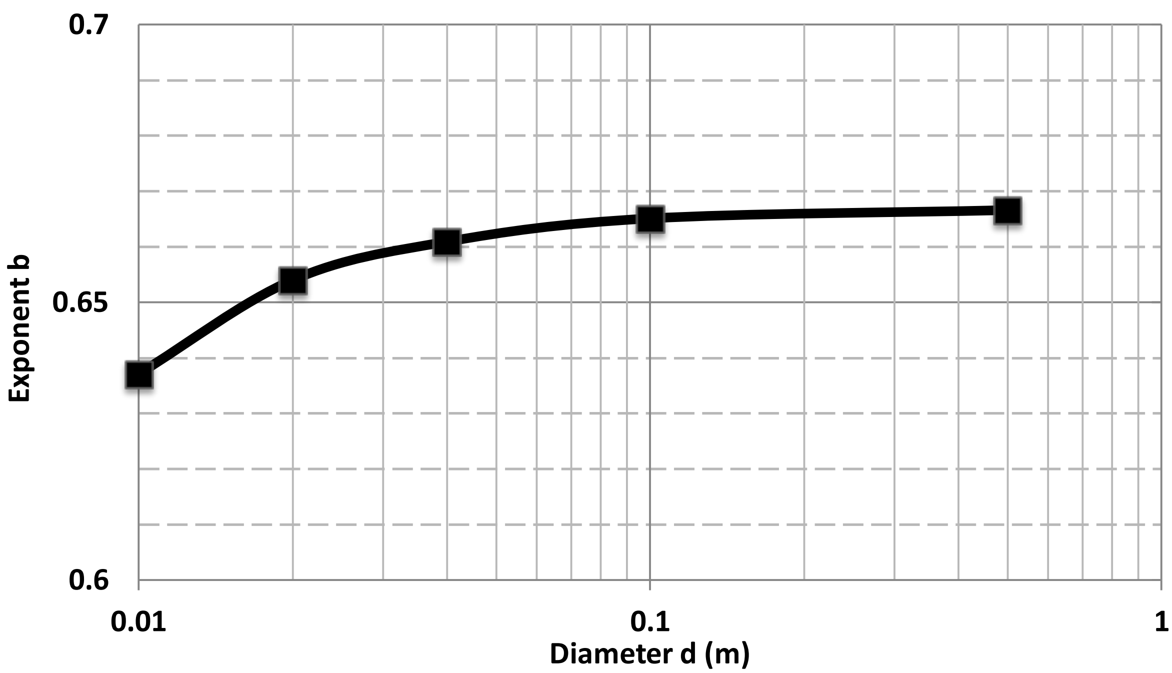


Figure 5 Definition sketch rockfill equations.


10
1
0.01
0.1
1
Coefficent a
Diameter d (m)
dl = 1m
dl = 2m
dl = 3m


0.7
0.65
0.6
0.01
0.1
1
Exponent b
Diameter d (m)

Flow Through a Rockfill Dam Example:

A rockfill dam is to be used as the principle spillway for a sediment trap. The average width of the dam is 10 feet. The dam is 5 feet high with rock side slopes of 1:1. The flow length at the top of the dam is 3.3 feet, while the flow length at the bottom of the dam is 9.9 feet. The average stone diameter is 6 inches. Calculate the stage discharge relationship for the rock dam. Assume that the downstream depth is negligible so **dh** = the stage (See Figure 8).

Determine the number of desired stage elevations for computations.

For this example calculations will be made every 1-foot.

Set up a table for each stage (see Table 4.)

Convert all units to **metric** before reading values from the graphs in Figure 9.

Calculate the discharge rate at each stage.
At a stage = 1 foot
dh = 0.31 meters
dl = 3.0 meters
stone diameter of 6 inches = 0.15 meters
a = 1.80 (from Figure 6)
b = 0.6657 (from Figure 6)

$$q = \left[\frac{dh}{a\,(dl)}\right]^{\frac{1}{b}} = \left[\frac{0.31}{1.80*(3.0)}\right]^{\frac{1.0}{0.6657}} = 0.0137\ \ cms/m$$

Convert cms/m to cms by multiplying by the average flow width at the stage

(0.0137 cms/m) * (3 m) = **0.041 cms**

Covert cms to cfs

(0.041 cms) * (35.315 cfs/cms) = **1.447 cfs**

Table 4. Graphical Method to Calculate the Stage-Discharge Relationship for Rockfill

Stage (ft)	Flow Length (ft)	Flow Width (ft)	dh Stage (m)	dl Flow Length (m)	a	B	Flow cms/m	Flow Width (m)	Flow cms	Flow cfs
0	9.9	10	0.00	3.00	3.12	0.6657	0.0000	3.0	0	0.0
1	9.9	10	0.31	3.00	3.12	0.6657	0.0137	3.0	0.041	1.4
2	8.3	10	0.61	2.52	2.06	0.6657	0.0407	3.0	0.122	4.4
3	6.6	10	0.91	2.00	2.31	0.6657	0.0870	3.0	0.261	9.2
4	5.0	10	1.22	1.52	2.97	0.6657	0.1400	3.0	0.420	14.8
5	3.3	10	1.52	1.00	3.63	0.6657	0.2704	3.0	0.811	28.7

Flow Through a Rock Ditch Check Example:

Given: A Rock Ditch Check with the following characteristics:

Dimension	Standard Units	Metric Conversion
Bottom Width	3 feet	0.91 meters
Side Slopes	3:1	3:1
Depth	2 feet	0.61 meters
Top Width	15 feet	4.57 meters
Top Flow Length	3 feet	0.91 meters
Bottom Flow Length	7 feet	2.13 meters
Rock Fill Diameter	6 inches	0.15 meters

Find: Stage discharge relationship for Rock Ditch Check.

Solution:

1. To properly apply the rock fill flow equation all values must be converted to **metric units.**

2. Determine the number of desired stage elevations for computations.

For this example calculations will be made every 0.5 ft.

3. Based on the rock size and the flow lengths, an appropriate value for the exponent *b* must be selected from Table 5.

   – Linear interpolation can be used to find b when the rock diameter = 0.15 m.

   b = 0.6651 + [(.15 - .10) / (.20-.10)] * (0.6662 – 0.6651)
   b = 0.6657

4. Based on a rock size of 0.15 meters and the flow lengths at different stages, the appropriate values for the coefficient a can be selected from Table 5 by using linear interpolation.

Stage (ft)	Stage (m)	Flow Length (m)	Coefficient a
0.0	0.00	2.13	2.26
0.5	0.15	1.83	2.55
1.0	0.31	1.52	3.00
1.5	0.46	1.22	3.37
2.0	0.61	0.91	3.67

Table 5. Values for Rock Check Flow Coefficient and Exponent

		dl= 1m	dl = 2m	dl = 3m
Stone Diameter(m)	Exponent b	Coefficient a	Coefficient a	Coefficient a
0.01	0.6371	9.40	6.05	4.60
0.02	0.6540	7.40	4.65	3.55
0.03	0.6589	6.40	4.08	3.08
0.04	0.6609	5.85	3.65	2.80
0.05	0.6624	5.40	3.35	2.60
0.06	0.6635	5.05	3.15	2.40
0.08	0.6644	4.50	2.85	2.20
0.09	0.6648	4.28	2.70	2.10
0.10	0.6651	4.13	2.60	2.05
0.20	0.6662	3.20	2.05	1.57
0.30	0.6664	2.80	1.75	1.30
0.40	0.6665	2.50	1.55	1.16
0.50	0.6666	2.30	1.40	1.08

5. Determine the total flows for each staging using the values determined above. The total flow is computed by multiplying the unit flow by the flow width.

Stage (m)	Flow Length (m)	Unit Flow (cms/m)	Flow Width (m)	Total Flow (cms)	Stage (ft)	Total Flow (cfs)
0.00	2.13	0.000	0.91	0.000	0.0	0.0
0.15	1.83	0.006	1.83	0.011	0.5	0.4
0.31	1.52	0.018	2.74	0.048	1.0	1.7
0.46	1.22	0.037	3.66	0.136	1.5	4.8
0.61	0.91	0.078	4.57	0.355	2.0	12.5

DESIGN AID EXAMPLE PROBLEMS

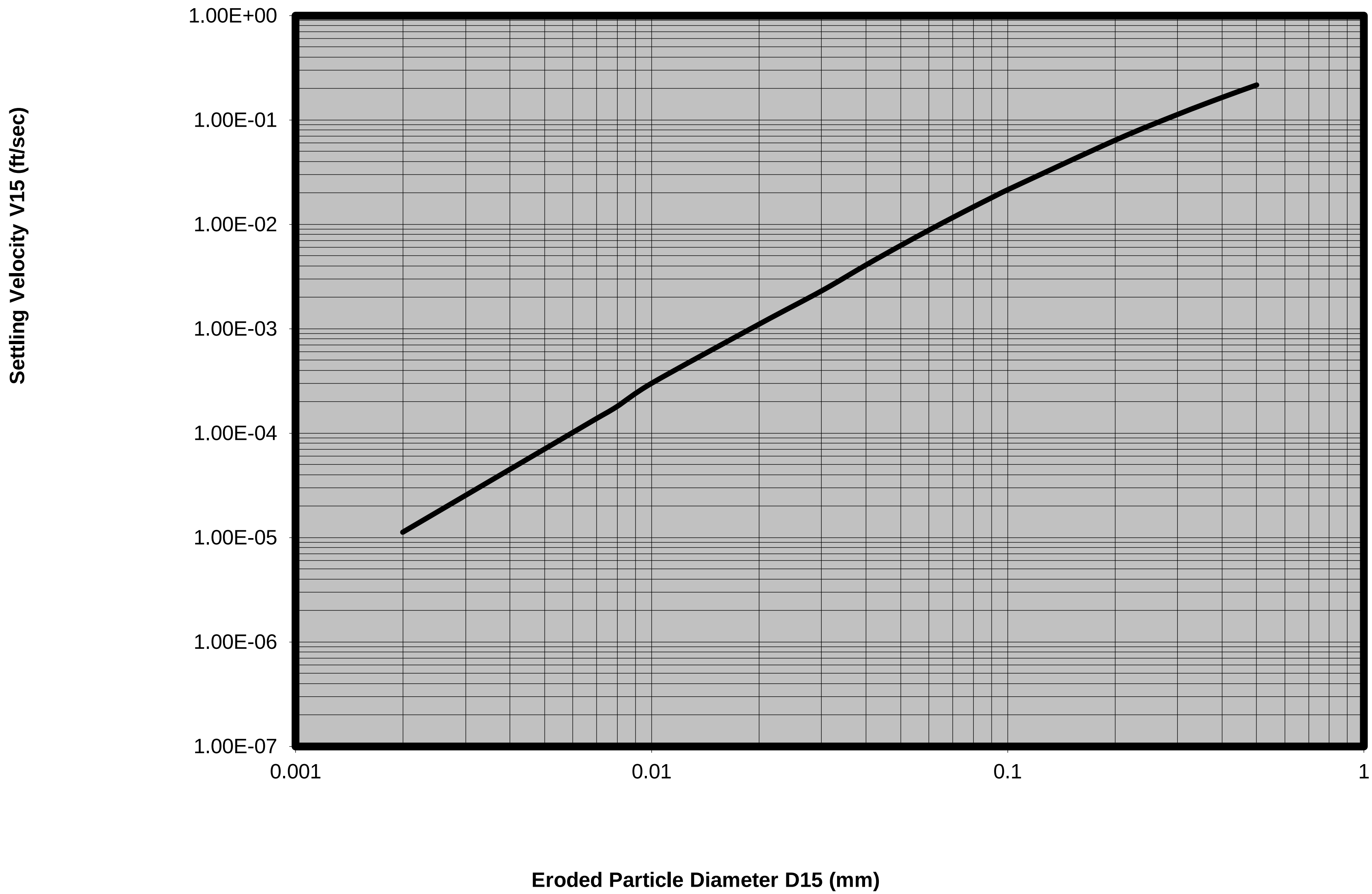
The example problems serve to illustrate the use of the design aids for calculation of trapping efficiency for various types of structures. Basic soils, hydrologic and hydraulic information are combined. Although the SCS TR-55 methods are recommended for estimating peak flow, other methods of estimating peak flows such as the Rational Method may be used. Site specific soils information can generally be found from soil surveys. On-site soil boring data may be used to generate this information as well. Hydraulic information is obtained by combining site and structural information.

In all cases, a ratio is calculated. The ratio is used to locate the point on a turning line for the specified conditions and structure. Trapping efficiency is found by reading the corresponding point on the x-axis estimating the trapping efficiency. These design aids are intended to be slightly conservative, but use of these methods should not replace the use of good engineering judgment. The engineer should investigate questionable results. Installation and maintenance should be considered. For example, it may be appropriate to add baffling to a pond in order to prevent short-circuiting between the inflow and outflow locations.

It must be emphasized that that these design aids are intended for “typical” structures. Extreme or critical conditions should require more detailed analyses be conducted. For example, sensitive areas in steep terrain or sensitive waters downstream would be examples of extreme situations. This document assumes that the user has a working knowledge of hydrology and hydraulics. Design techniques can best be illustrated using examples.

Settling Velocity for selected eroded particle D_{15} can be read from Figure 7.

Figure 7: Characteristic Settling Velocity as a Function of Eroded Particle Diameter



Example Problem 1: Sediment Basin.

$$\boldsymbol{Basin\ Ratio} = \frac{\boldsymbol{q_{po}}}{\boldsymbol{A \times V_{15}}}$$

q_{po} = Peak flow rate out of the basin (cfs)
V_{15} = Characteristic settling velocity (fps) of the characteristic D_{15} eroded particle (mm)
A = Surface area of the basin (acres)

Given:

A Sediment Basin will be used to control sediment runoff from a fully disturbed **10 acre** site with **Crider soils**.

Solution:

1) Solve for the settling velocity of the D_{15} particle for Crider soils from the MSD Training Manual.

- For particles less than 0.01mm, the settling velocity can be solved by $V_s = 2.81{D_{15}}^2$. Thus, from the MSD Training Manual, D_{15} for Crider Soils = 0.0054mm.

$$V_s = 2.81 \times 0.0054^2 = 8.2 \times 10^{-5}\ ft/s$$

2) Solve for the runoff upstream of the check using the rational method using the Newly Graded/Disturbed "c" factor in Exhibit 10-5 of the MSD Design Manual.

$$10\ ac \times .68 \times 5.3 \frac{in}{hr} = 36\ cfs$$

3) Solve for the required area of the basin

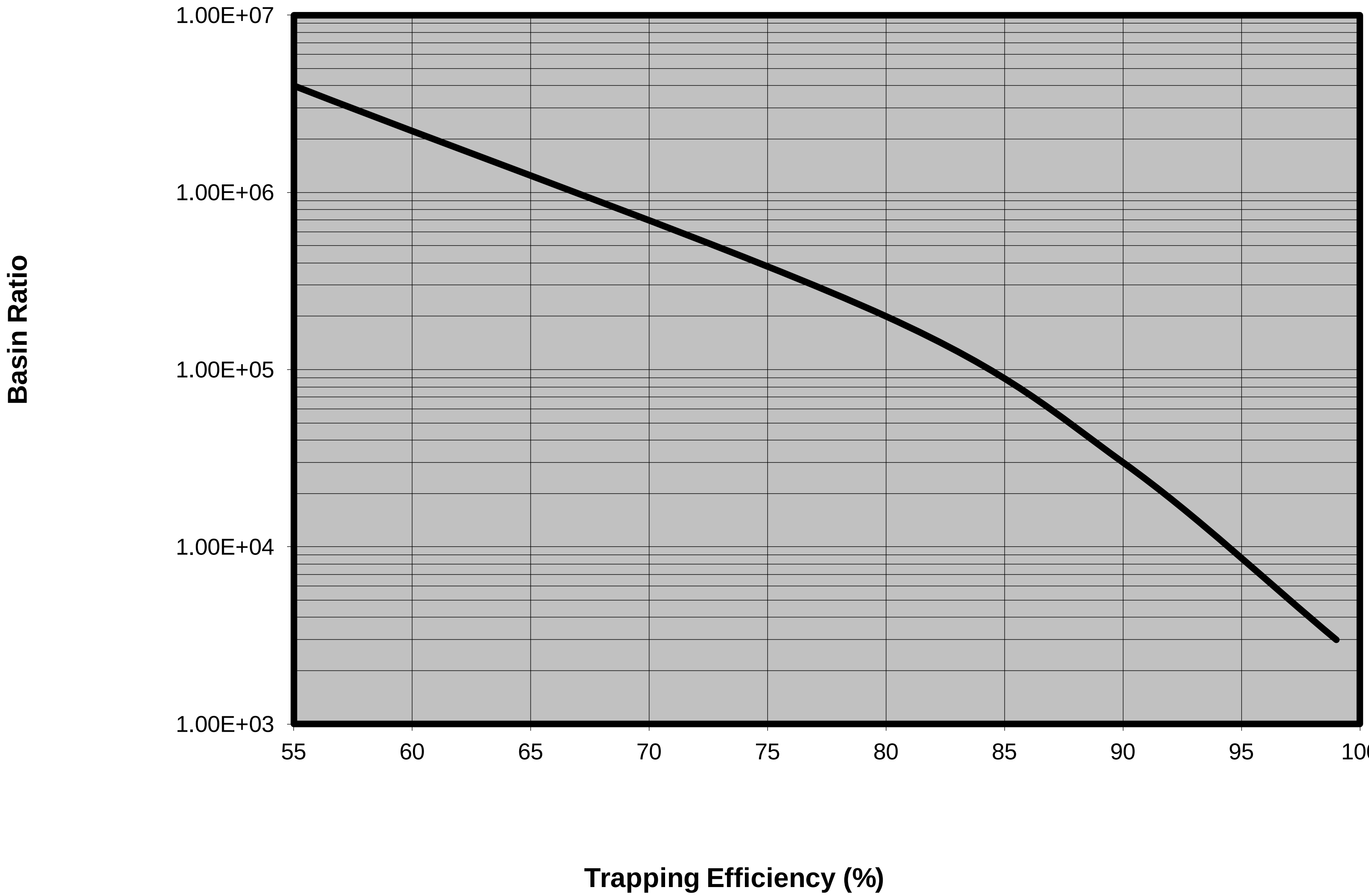
$$Basin\ Ratio = \frac{q_{po}}{A \times V_{15}}$$

According to the Sediment Basin Design Aid (Figure 8), the minimum Sediment Trap Ratio to achieve a trapping efficiency of 80% is $2x10^5$

$$2 \times 10^5 = \frac{36\ cfs}{A \times 8.2 \times 10^{-5}\ ft/s}$$

Thus, the required area of the trap is 2.2 acres

Figure 8: Design Aid for Estimating Trapping Efficiency of Sediment Basins.



Example Problem 2: Rock Ditch Check

$$\boldsymbol{Ditch\ Check\ Ratio} = \frac{\boldsymbol{Sq^{(1-b)}}}{\boldsymbol{aV_{15}}}$$

S = Channel slope (%)
q = flow per unit width through the check (cfs/ft)
V_{15} = Characteristic settling velocity (fps) of the characteristic D_{15} eroded particle (mm)
Coefficient a and exponent b can be interpolated from table 5 on pg 35.

Given:

A rock ditch check will be used to control sediment runoff on the down gradient end of a fully disturbed **2 acre** site with **Crider soils**. The check will be installed on a channel with a **bottom width of 5ft, slope of 1%**, and **3:1 side slopes**. The check will be faced with KYTC #57 stone which has an **average rock diameter of 1"**.

Solution:

1) Solve for the settling velocity of the D_{15} particle for Crider soils from the MSD Training Manual.

- For particles less than 0.01mm, the settling velocity can be solved by $V_s = 2.81 {D_{15}}^2$. Thus, from the MSD Training Manual. D_{15} for Crider Soils = 0.0054mm.

$$V_s = 2.81 \times 0.0054^2 = 8.2 \times 10^{-5}\ ft/s$$

2) Solve for the runoff upstream of the check using the rational method using the Newly Graded/Disturbed "c" factor in Exhibit 10-5 of the MSD Design Manual.

$$2\ ac \times .68 \times 5.3 \frac{in}{hr} = 7.21\ cfs$$

3) Compute the flow rate per unit width of the check.

- The average width of the check is 11' thus, the flow per unit width is 0.66 cfs/ft

4) Solve for the Ditch Check ratio.

$$Ditch\ Check\ Ratio = \frac{Sq^{(1-b)}}{aV_{15}}$$

From table 5, with an average stone diameter of 1" (0.2m), a = 7.4 and b = .66

$$Ditch\ Check\ Ratio = \frac{1 \times 0.66^{(1-.66)}}{7.4 \times (8.2 \times 10^{-5})} = 1.43 \times 10^3$$

Using Figure 10, the trapping efficiency for this check is 95%

5) Check for overtopping.

Using the Stage Discharge Equations for Rock Structures on pg. 30, the maximum flow through this check without overtopping is 8.68 cfs, which is greater than the 10 yr flow calculated above thus, the check will not overtop.

Figure 9: **Design Aid for Estimating Trapping Efficiency of Rock Ditch Checks with Fine Texture Soils.**

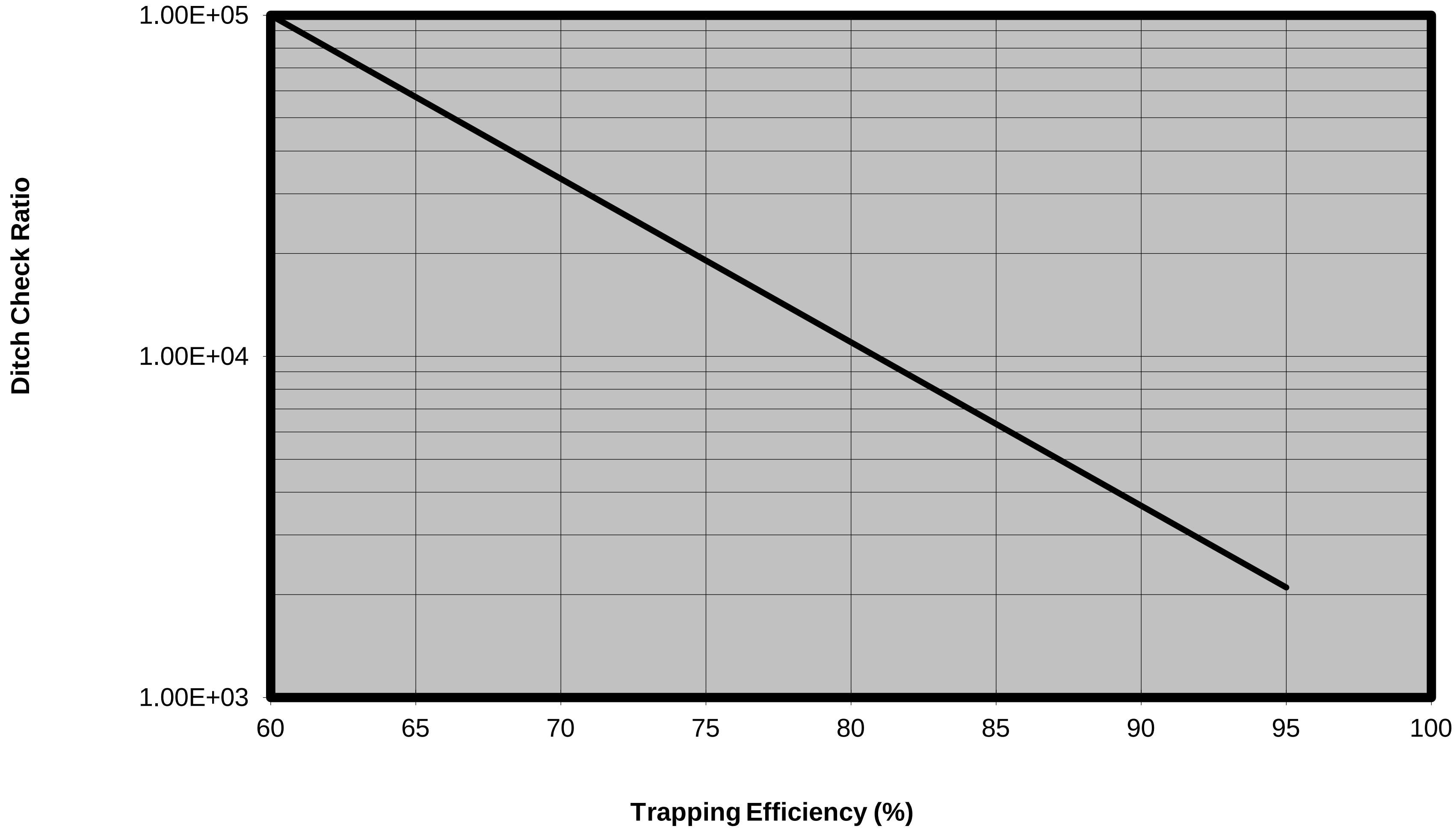


Figure 10: Design Aid for Estimating Trapping Efficiency of Rock Ditch Checks with Medium Texture Soils.

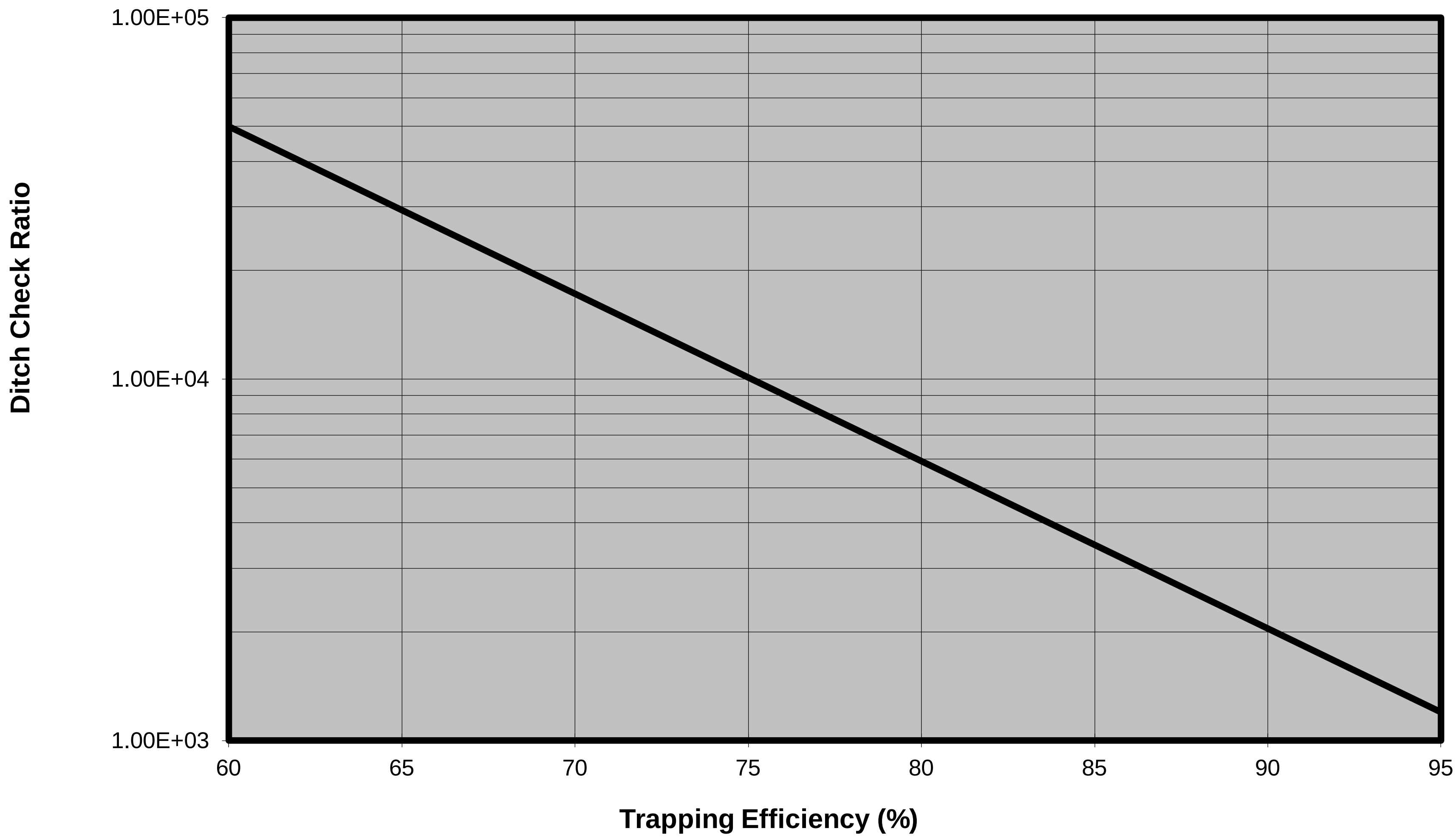
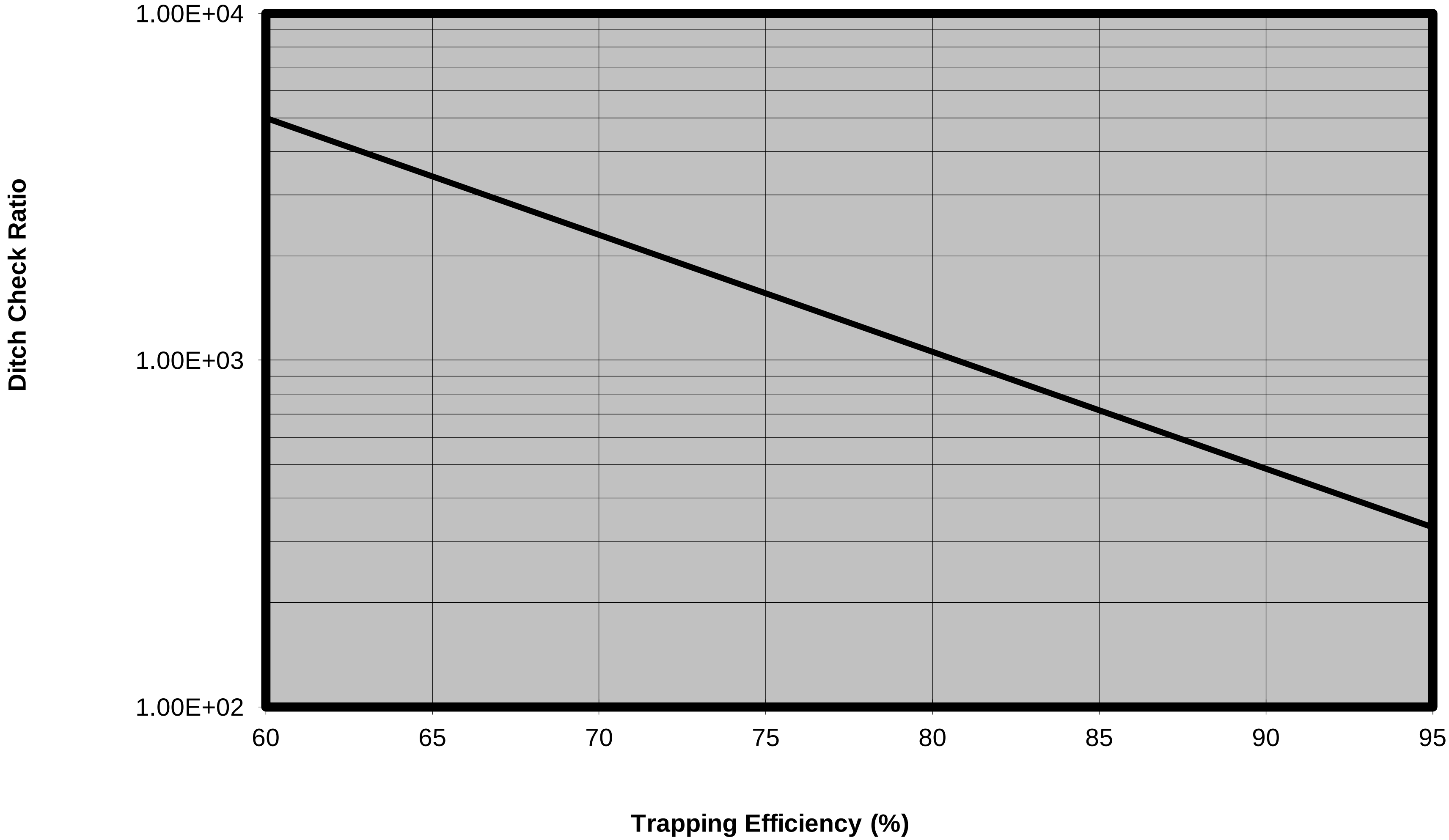


Figure 11: Design Aid for Estimating Trapping Efficiency of Rock Ditch Checks with Coarse Texture Soils.



Example Problem 3: Silt Fence.

$$\boldsymbol{Silt\ Fence\ Ratio} = \frac{\boldsymbol{q_0}}{\boldsymbol{V_{15} \times P_{area}}}$$

q_0 = Peak flow through silt fence (cfs)
V_{15} = Characteristic settling velocity (fps) of the characteristic D_{15} eroded particle (mm)
P_{area} =Ponding area up slope of the fence (ft^2)

Given:

A **500ft** long silt fence will be used to control erosion and sediment from a fully disturbed **0.5 acre** site with **Crider soils** and a **1% slope** towards the fence. The silt fence will be **2 feet tall** and has a slurry flow rate through the filter fabric of **10 gmp/ft^2**

Solution:

1) Solve for the settling velocity of the D_{15} particle for Crider soils from the MSD Training Manual.
- For particles less than 0.01mm, the settling velocity can be solved by $V_s = 2.81{D_{15}}^2$. Thus, from the MSD Training Manual. D_{15} for Crider Soils = 0.0054mm.

$$V_s = 2.81 \times 0.0054^2 = 8.2 \times 10^{-5}\ ft/s$$

2) Solve for the runoff upstream of the silt fence using the rational method using the Newly Graded/Disturbed "c" factor in Exhibit 10-5 of the MSD Design Manual.

$$.5ac \times .68 \times 5.3 \frac{in}{hr} = 1.8\ cfs$$

3) Solve for the ponding area above the silt fence

$0.01 = \frac{2ft}{x}$ Solving for x yields 200 ft

Thus, $P_{Area} = 200ft \times 500ft = 100{,}000ft^2$

4) Solve for the Silt Fence Ratio

$$Silt\ Fence\ Ratio = \frac{1.8cfs}{8.2 \times 10^{-5}\ ft/s \times 100000ft^2} = .22$$

Using the Silt Fence Design Aid (Figure 12), the trapping efficiency is **80%**

5) Check for overtopping of the SF

- Convert flow from cubic feet per second to gallons per minute

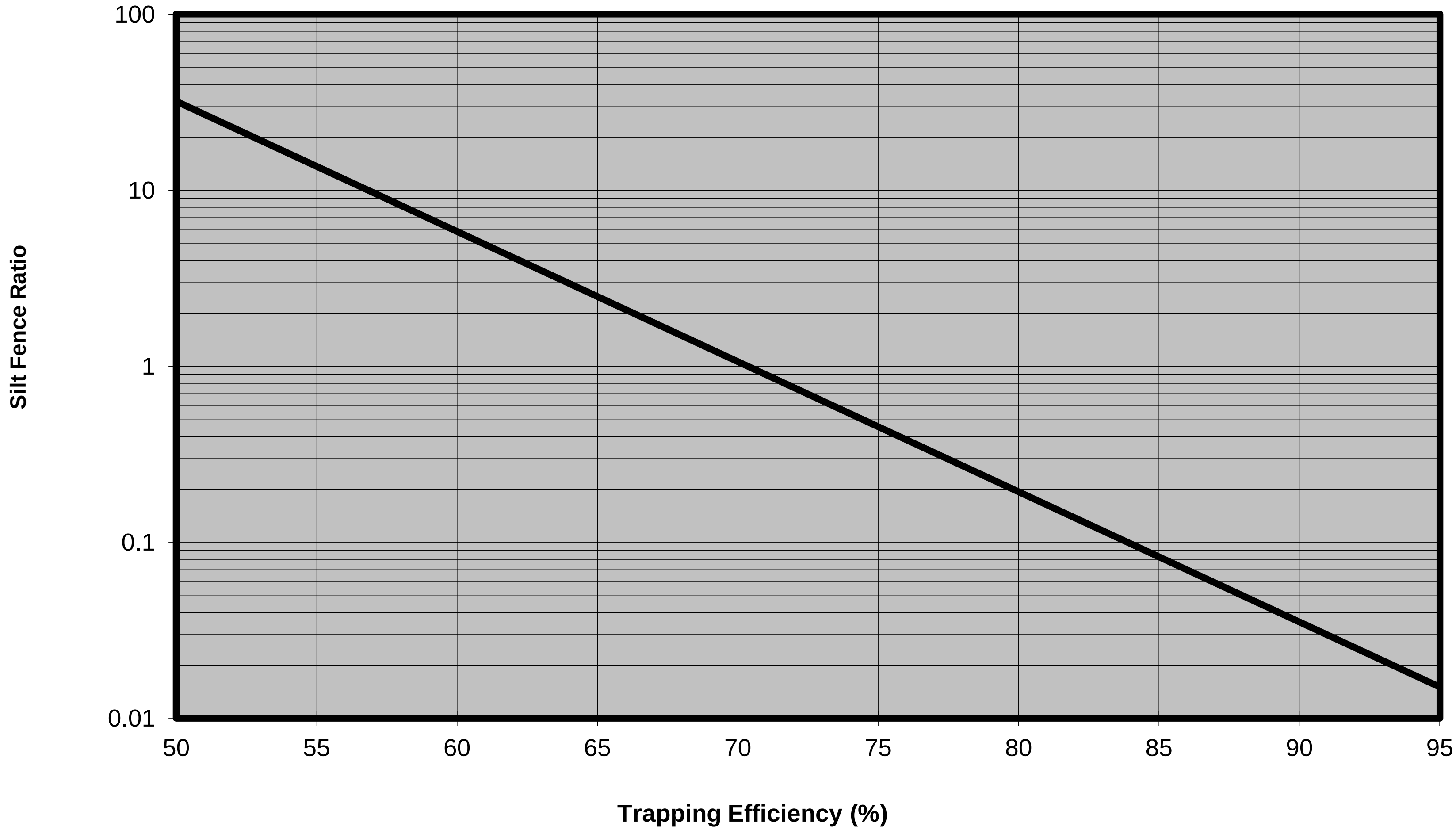
$$q_{po} = 1.8\ cfs \times 7.48gal/ft^2 \times 60 \frac{sec}{min} = 808\ gpm$$

- The required length of the SF is the flow rate in gpm divided by the slurry flow rate multiplied by the fence height.

$$\text{Thus, } L = 808\ gpm \div \left(2\ ft \times 10\,\frac{gpm}{ft^2}\right) = 40.4\ ft$$

Since the required length is less than the actual length (500ft), the fence will not overtop.

Figure 12: Design Aid for Estimating Trapping Efficiency of Silt Fence



Example Problem 4: Sediment Trap.

$$\textbf{Sediment Trap Ratio} = \frac{q_{po}}{A} / V_{15}$$

q_{po} = Peak flow rate through the trap (cfs)
V_{15} = Characteristic settling velocity (fps) of the characteristic D_{15} eroded particle (mm)
A = Settling area of the trap (acres)

Given:

A settling area with a rock dam will be used to control sediment runoff from a fully disturbed **5 acre** site with **Crider soils**. The check will be installed on a channel with a **bottom width of 5 ft** and **3:1 side slopes**. The dam will be faced with KYTC #57 stone which has an **average rock diameter of 1"**.

Solution:

1) Solve for the settling velocity of the D_{15} particle for Crider soils from the MSD Training Manual.
- For particles less than 0.01mm, the settling velocity can be solved by $V_s = 2.81{D_{15}}^2$. Thus, from the MSD Training Manual. D_{15} for Crider Soils = 0.0054mm.

$$V_s = 2.81 \times 0.0054^2 = 8.2 \times 10^{-5}\ ft/s$$

2) Solve for the runoff upstream of the check using the rational method using the Newly Graded/Disturbed "c" factor in Exhibit 10-5 of the MSD Design Manual.

$$5\ ac \times .68 \times 5.3 \frac{in}{hr} = 18\ cfs$$

3) Solve for the required settling area

According to the Sediment Trap Design Aid on pg. 53, the minimum Sediment Trap Ratio to achieve a trapping efficiency of 80% is $9 \mathrm{x} 10^4$

Thus,

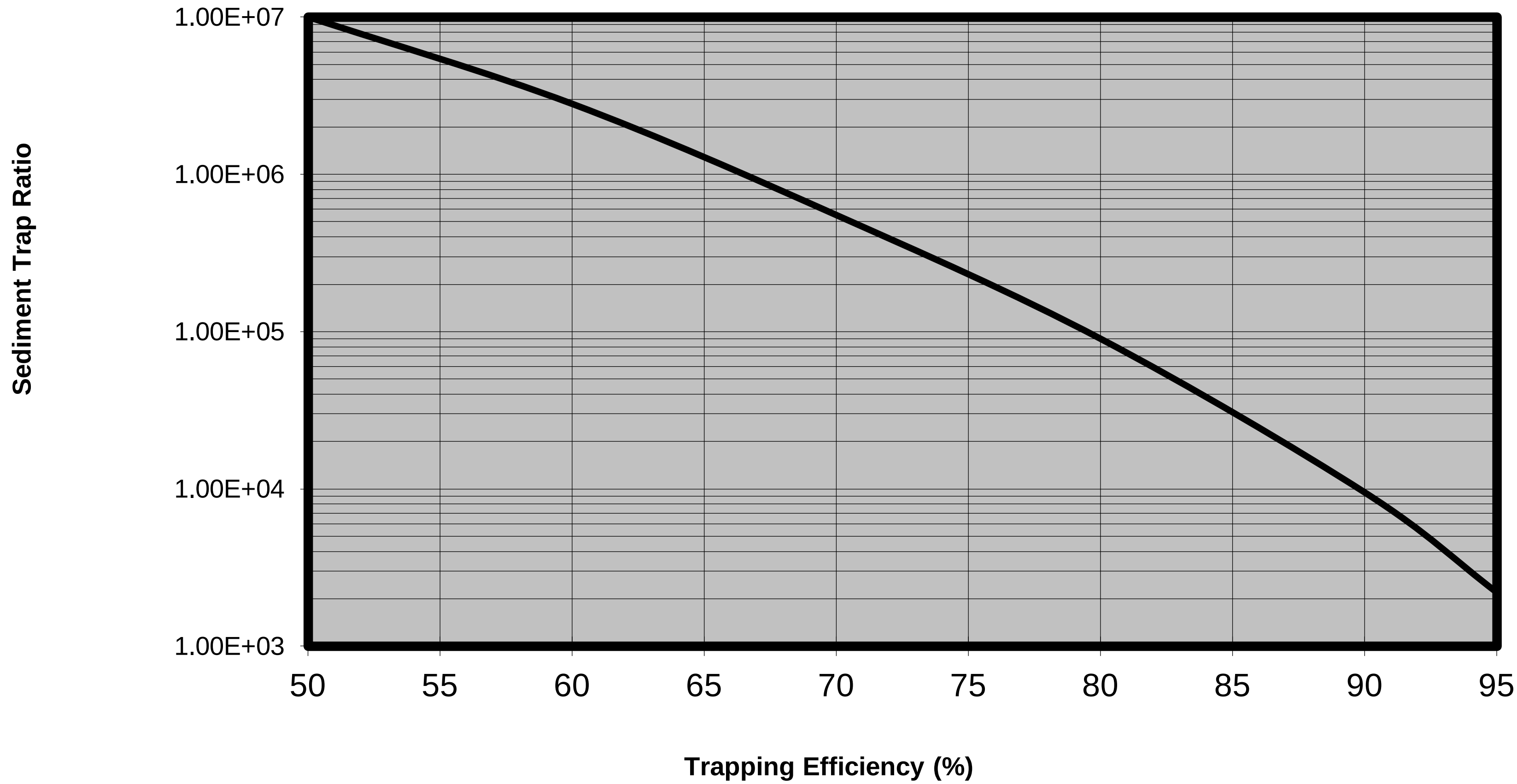
$$9 \times 10^4 = \frac{18\ cfs}{A} /\ 8.2 \times 10^{-5}\ ft/s$$

A 2.44 acre settling area is required to achieve an 80% trapping efficiency.

4) Design the Stone Dam and check for overtopping

Using the Stage Discharge Equations for Rock Structures on pg. 30 and the minimum design specifications for the stone dam, a five foot tall dam, five feet thick at the top, and in a five foot wide channel will allow 27.8 cfs discharge through the rock without overtopping which is more than the ten year storm runoff as calculated above.

Figure 13. Design Aid for Estimating Trapping Efficiency of Sediment Traps



VEGETATED FILTER STRIP EXAMPLE

Vegetate Filter Strips (VFS) are zones of vegetation through which sediment and pollutant-laden runoff are directed before being discharged to a concentrated flow channel. This sediment control measure may take the form of grass filters, grass filter strips, buffer strips, vegetated buffer zones, riparian vegetated buffer strips, and constructed filter strips.

When and Where to Use It

This practice applies to land undergoing development where filters are needed to reduce sediment damage to adjacent properties, streams or sinkholes. VFS are used to remove sediment from overland sheet flow but are not effective in removing sediment from concentrated flows.

There are two main classifications of VFS:

- Constructed filter strips: Constructed and maintained to allow for overland flow through vegetation that consists of grass-like plants with densities approaching that of tall lawn grasses.

- Natural vegetative strips: An area where sediment-laden flow is directed in an overland manner, including riparian vegetation around drainage channels. Vegetation ranges from grass-like plants to brush and trees with ground cover.

VFS remove solids primarily by three mechanisms:

1. Deposition of bedload material and its attached chemicals as a result of decreased flow velocities and transport capacity. This deposition takes place at the leading edge of the filter strip.

2. Trapping of suspended solids by the vegetation at the soil vegetation interface. When suspended solids settle to the bed, they are trapped by the vegetated litter at the soil surface instead of being re-suspended as would occur in a concentrated flow channel. When the liter becomes inundated with sediment, trapping no longer occurs by this mechanism.

3. Trapping of suspended materials by infiltrating water. This is the primary mechanism by which dispersed clay sized particles are trapped.

The effectiveness of VFS can fluctuate considerably depending on the type of vegetation, the height and density of the vegetation, season of the year, eroded particle characteristics, size of disturbed area, and site topography.

Factors Affecting Trapping of Vegetated Filter Strips

Flow Rate	Trapping is inversely related to flow rate.
Size Distributions	Trapping is directly related to eroded particle size distributions. Sand particles can be trapped with short filters on steeper slopes, while clay sized particles are trapped only by infiltration that takes in long flat strips.
Slope	Trapping inversely related to slope.
Type of Vegetation	Vegetation that grows in clumps trends to trap particles less effectively than uniform growth.
Density of Vegetation	Trapping is directly related to the vegetation density.
Stiffness of Vegetation	Vegetation must remain erect under storm flow conditions because trapping is greatly reduced when vegetation lays flat.
Height of Vegetation	Tall vegetation does not naturally remain dense near the ground, and tends to lie flat during storm flows.
Infiltration Rate	Trapping of suspended sediment, particularly silt particles, is directly proportional to infiltration rate.
Mass of Litter	Trapping is directly related to the mass of litter.
Degree of Channelization	Trapping is inversely related to the degree to which flow is channelized. Channelized flow is deeper with higher velocities, resulting in higher transport capacities and reduced trapping efficiency.

Source: Design Hydrology and Sedimentology for Small Catchments, Hann et. al.

Design Criteria

In the design of VFS, the designer must select a vegetation type, a ground slope, and a filter strip width and strip length. To be effective, the vegetated filter strip should be located on the contour perpendicular to the general direction of flow. Vegetation should be selected to be dense, lawn-like grass in order to minimize water channelization. The designer should never assume that natural vegetation is adequate for a VFS. A ponding area shall be constructed at the leading edge of the VFS for bedload deposotion.

The design process for vegetative filter strips requires a series of detailed equations. An explanation of these equations can be found in Design Hydrology and Sedimentology for Small Catchments, Hann et. al. pages 359-375. Software packages such as SEDIMOTII, or SEDCAD should be utilized to determine trapping efficiencies for VFS.

- The General Design Criteria to Design Filter Length are:

  a) Select a vegetation type .

  b) Select the design life and maximum allowable sediment deposition. A design life of 10-years, a deposition of 0.5 ft. (15-cm), and a bulk density of 1.5 is recommended (Hayes and Dillaha, 1991).

  c) Estimate the long-term sediment yield entering the filter strip and a 10-year 24-hour design single-storm sediment yield using the Universal Soil Loss Equation.

  d) Determine desired Trapping Efficiency- 80% design removal efficiency goal of the total suspended solids (TSS) in the inflow.

  e) Estimate the filter length necessary to prevent deposition within the filter greater than 0.5 feet. (Assume filter width is equal to disturbed area width but no smaller than 15 ft.)

  f) Use the filter length to calculate Trapping Efficiency for the design storm.

  g) Repeat (d) and (e) until the lengths match.

     - Minimum Ground Slope = 1%
     - Maximum Ground Slope = 10%

Vegetated Filter Strip Example

Estimate the required length (Lt) in feet of a VFS needed in Louisville to reduce the long term sediment yield to meet the design removal goal of 80% TSS from the following site.

(Lt) Length of VFS in feet
(SY) Sediment Yield = 5/tons/acre
(EPSD) Eroded Particle Size Distribution Shown in Figure 14.
(ADFL) Average disturbed area flow length = 200 ft
(S) Average VFS Slope = 8%
(BD) Soil Bulk Density = 93.6 lb/ft^3
(qw) Flow rate for the site calculated to be 0.074 cfs/ft

Solution

Select a vegetation type.

Choose KY 31 Fescue, which is acceptable for the growing conditions in Louisville

Select the recommended design life (DL).

DL = 10-years

Calculate the long-term sediment yield to the VFS using the Universal Soil Loss Equation.

SY = 5/tons/acre/year for this example

a) Determine desired Trapping Efficiency.

   - TE = 80% removal efficiency of total suspended solids (TSS).

b) Estimate filter length based on 15-cm depth (0.49 ft) of deposition (DD), and a bulk density of 1.5 (BD).

   - Calculate the total sediment to be trapped (TT in lb/ft of filter width)
     TT = DL * SY * TE * ADLF
     TT = (10-years)*(5 tons/acre/year)*(0.8)*(200 ft) * (1 acre/ 43,560 ft^2) * (2000 lb/ton)
     TT = 367 lb/ft of filter width

   - Calculate Lt based on Depth of Deposition
     Depth = TT/(Lt *BD)
     0.49 = (367 lb/ft) /(Lt *93.6 lb/ft^3)
     0.49 = 3.92/Lt

     Lt 〈 8 ft.

c) Calculate Trapping Efficiency using Lt.

- Determine FFi Values, Average Diameters (mm), and Fall Velocities (ft/sec)

  – Calculate the average diameter of coarse materials (ADC) entering the VFS
  ADC = Average Diameter of Coarse Materials
  FF1 = Fraction for Coarse (Sand) Particles
  FF0 = Percent Finer than 0.037mm

  ADC = FF1/2 + FF0
  FF1 = Fraction of Coarse (Sand) Particles (Percent Greater than 0.037mm)
  = 1.0 – FF

  FF0 = 0.36 (read from Eroded Particle Size Percent Finer Curve)
  FF1 = 1.0 – 0.36 = 0.64

  ADC = 0.64/2 + 0.36 = 0.68

  – ADM = Average Diameter of Medium Materials = 0.012 for all calculations

  FF2 = Fraction of Medium (Silt) Particles
  = FF0 –FF3
  = 0.36 – 0.18
  = 0.18

  – ADF = Average Diameter of Fine Materials = 0.002 for all calculations

  FF3 = Fraction of Fine (Clay) Particles (Percent Finer than 0.004 mm)
  FF3 = 0.18 (read from Eroded Particle Size Percent Finer Curve)

Particle Class	Fraction FFi	Average Diameter (mm)	Fall Velocity (ft/sec)	Fall Velocity Equation
Coarse (Sand)	0.64	0.170	0.021	Stokes Law
Medium (Silt)	0.18	0.012	4.05×10^{-4}	$2.81d^2$
Fine (Clay)	0.18	0.002	1.124×10^{-5}	$2.81d^2$

- Determine Flow Depth (D) and Velocity (V)

Parameters for calculations bases on a good stand of KY31 tall fescue

Flow Depth (D)

Calibrated Mannings Roughness (xn) = 0.056

Ss = Vegetation Spacing = 0.63 inches = 0.0525 ft.

Sc = VFS Slope = 8%

qw = Flow Rate (cfs/ft) = 0.074 cfs/ft

Calculate velocity (V) and depth of flow

$$V = \frac{1.5}{xn} R^{2/3} Sc^{1/2}$$

Mannings Equation

$$R = \frac{Ss\,D}{2D + Ss}$$

Hydraulic Radius

$$qw = VD$$

Continuity Equation

Solve equations simultaneously to solve for D

$$f(d) = \frac{D^{5/3}}{(2D + Ss)^{2/3}} = \frac{(qw)(xn)}{1.5(Sc)^{1/2}(Ss)^{2/3}} = \frac{(0.074)(0.056)}{1.5(0.08)^{1/2}(0.0525)^{2/3}} = 0.069$$

Solve solution by trail and error.

Trial	Trial Depth (ft)	f(d) function	Evaluation
1	0.15	0.085	Too high
2	0.10	0.054	Too low
3	0.12	0.066	Too low
4	0.125	0.069	OK

Using

D = 0.125 ft

R = 0.022 ft

V = 0.594 ft/sec

Check Continuity with depth and flow values

(0.594 ft/sec) * (0.125 ft) = 0.074 cfs/ft checks with initial flow value.

Determine Reynolds Number Re (assuming $\nu = 1.0 \times 10^{-5}$ ft^2 /sec)

$$R_e = \frac{VR}{\upsilon} = \frac{(0.594)(0.022)}{10^{-5}} = 1306$$

Calculate Fall Number for Coarse, Medium and Fine materials based on a VFS length = 8 ft.

Nfc = Coarse Fall Number (Vs = 0.021 ft/sec)
Nfm = Medium Fall Number (Vs = 4.05×10^{-4} ft/sec)
Nff = Fine Fall Number (Vs = 1.124×10^{-5} ft/sec)
Vs = particle settling velocity

$$N_f = \frac{(Vs)L}{(VD)} = \frac{(Vs)\ 8}{(0.594)(0.125)} = 13.5*(8)*(Vs)$$

Nfc = 2.270
Nfm = 0.044
Nff = 0.001

Determine Trapping Efficiency (TEd) for each particle size

$$TEd = \exp\left[-1.05x10^{-3}\ R_e^{0.82}\ N_f^{-0.91}\right] = \exp\left[-1.05x10^{-3}\ (1306)^{0.82}\ N_f^{-0.91}\right]$$

$$TEd = \exp\left[-0.377\, N_f^{-0.91}\right]$$

TEdc = Coarse Trapping = 0.836
TEdm = Medium Trapping = 0.002
TEdf = Fine Trapping = 0.000

Determine Total Trapping Efficiency (TE)

$$TE = TEdc(1 - FF1) + TEdm(FF2) + TEdf(FF3)$$

TE = 0.836(0.64) + 0.002(0.18) + 0.0 (0.18)

TE = 0.535 = 53.5%

This efficiency is not sufficient, and a new length must be determined.

Calculate the length required for 80% Trapping Efficiency

The length must be greater than 8ft to obtain the desired trapping efficiency

Using the following equation knowing that TE = 0.80, the length can be calculated

$$TE \quad = \quad TEdc(1-FF1)+TEdm(FF2)+TEdf\,(FF3)$$

It can be assumed the TEdf will be zero for calculations, because these particles are small and have a very slow settling velocity.
It can be assumed that TEdc will approach 1 by making the VFS length much greater than 8 ft.
TEdm can then be solved for

$$0.80 \quad = \quad 1.0(1-64)+TEdm(0.18)+0(0.18)$$

$$TEdm \quad = \frac{0.80-0.64}{0.18} \quad = \quad 0.889$$

Solving back, TEdm is calculated from

$$TEdm = \exp\left[-1.05x10^{-3}\, R_e^{\ 0.82}\, N_f^{\ -0.91}\right] \ = 0.889$$

therefore,

$$N_{fm} \ = \ \left[\frac{\ln(TEdm)}{-1.05x10^{-3}\, R_e}\right]^{\frac{-1}{0.91}} \ = \ \left[\frac{\ln(0.889)}{-0.377}\right]^{\frac{-1}{0.91}} \ = \ 3.595$$

Solving back, Nfm is calculated from

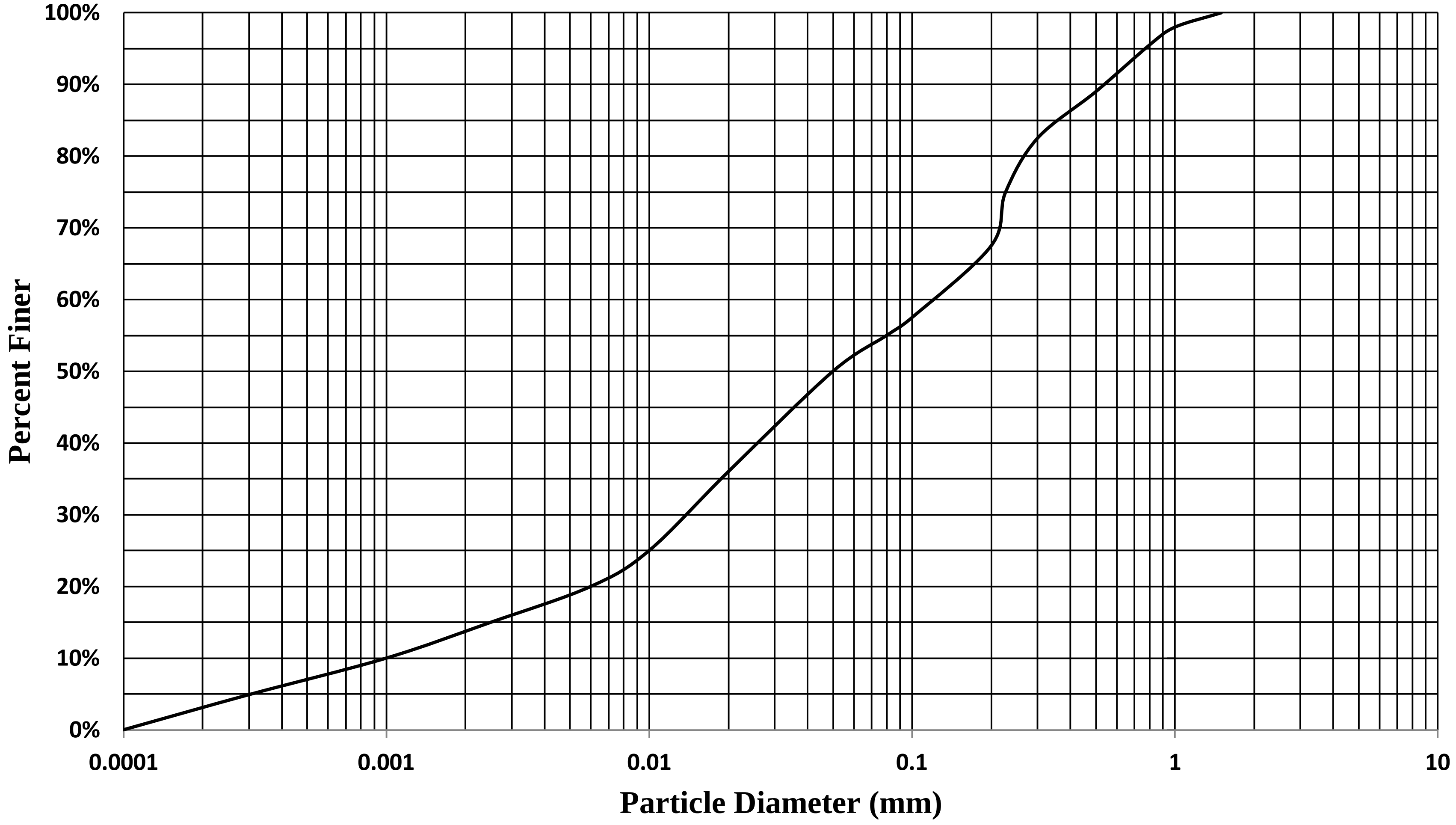
$$N_f \ = \ \frac{(Vs)L}{(VD)} \ = \ 13.5*(L)*(Vs)$$

and L is calculated from

$$L \ = \ \frac{N_f}{13.5*(Vs)} \ = \frac{3.595}{13.5*\left(4.05x10^{-4}\right)} \ = \ 657\,ft.$$

Therefore a Vegetated Filter Strip made of KY 31 fescue would need to be 657 ft. long, and be the width of the disturbed area to meet the trapping efficiency goal of 80% TSS.

FIGURE 14: EXAMPLE EPSD



APPENDIX A

BMP GUIDELINES, BMP SUGGESTED USES, BMP SELECTION FLOWCHART

BMP Guidelines

Erosion Prevention and Sediment Control Measures					
BMP	**Definition**	**Purpose**	**Where Applicable**	**Planning**	**Design Criteria**
Construction Sequence and Scheduling	A specified work schedule that coordinates the timing of land-disturbing activities and the installation of erosion and sedimentation control measures. The objective is to disturb only the immediate work areas.	To reduce on-site erosion and off-site sedimentation by performing land-disturbing activities and installing erosion and sediment control practices in accordance with a planned schedule.	All land-development projects that will disturb more than one contiguous acre.	The general order of construction and planning is: • Plan disturbances to coincide with work progress, • Order materials to avoid delays, • Build construction site access, • Implement sediment traps and barriers, • Apply runoff control (diversions), • Implement main runoff conveyance system, • Build stream crossings, • Land clearing and grading, • Surface stabilization, • Building construction, • Landscaping and final stabilization.	At a minimum, the construction sequence should include: • Erosion and sedimentation control practices to be installed, • Principal development activities, • What measures should be in place before other activities begin, • Compatibility with the general construction schedule of the contract. When changes in construction activities are needed, amend the sequence schedule as necessary to fit the changes.

BMP Guidelines

Erosion Prevention Measures					
BMP	**Definition**	**Purpose**	**Where Applicable**	**Planning**	**Design Criteria**
Surface Roughening	Preparing the soil topography for the designed construction purpose.	To prepare the site according to the plans while taking erosion and sedimentation factors into consideration.	All construction sites that require land disturbing activities.	Site preparation includes: • Land Clearing • Land Grading • Surface Roughening	Soil disturbances that will cause much erosion should not be done or other BMP's should be implemented before clearing occurs.
Bench Terracing	Erosion control accomplished by constructing benches or large steps across the land slope.	Reduce severity and length of land slope for erosion control.	On steeps slopes where erosive factors are very high and gully erosion is likely to take place.	Terrace spacing and slope maintenance need to be considered.	Reduce slope length proportional to the steepness of the slope. Control outlets from terraces so erosion is eliminated.
Temporary Seeding	Planting fast growing vegetation to provide temporary erosion control.	To provide stabilization on bare soil areas that will not be brought to final grade for a period of more than 30 working days.	May be used on cleared unvegetated areas where temporary erosion control is needed.	Selection of appropriate plant species, use of quality seed, proper bed preparation, and seed application method are important.	The area to be seeded should be uniform and loosened to a minimum depth of 3 inches. The area should be cleared of stones, roots, and other debris.
Mulching	Use of a protective blanket of straw, hay, wood chips, wood fibers, gravel, or synthetic materials on the soil surface.	To protect the soil surface from the erosive forces of raindrop impact and overland or sheet flows.	Use on beds for temporary or permanent seeding and on areas of bare soil when seeding or planting must be delayed.	The choice of mulch used should be based on season, type of vegetation, soil condition, and size of area to be covered.	Organic mulches are most effective when uniformly spread and secured to the soil structure.
Erosion Control Blankets (ECBs)	Porous fabrics manufactured by weaving or bonding the fabric together. Designed to be biodegradable.	To protect the soil surface from the erosive forces of raindrop impact and overland or sheet flows.	• On recently planted slopes to protect seedlings until they become established • To prevent undermining of the soil particles.	The types of available geotextiles are vast, therefore the selected fabric should match its purpose and the manufacturers recommendation.	Effective netting and matting requires firm, continuous contact between the materials and the soil. If there is no contact, the material will not hold the soil and erosion will take place underneath the material.

BMP Guidelines

Erosion Prevention Measures

BMP	Definition	Purpose	Where Applicable	Planning	Design Criteria
Turf Reinforcement Mats (TRMs)	Porous fabrics manufactured by weaving or bonding the fabric together. Made of synthetic material.	To protect the soil surface from the erosive forces of raindrop impact and overland or sheet flows.	• To stabilize flow on channels and swales. • As separators such as between riprap and the underlying soil.	The types of available geotextiles are vast, therefore the selected fabric should match its purpose and the manufacturers recommendation.	Effective netting and matting requires firm, continuous contact between the materials and the soil. If there is no contact, the material will not hold the soil and erosion will take place underneath the material.
Topsoiling	Stripping off, storing, and spreading fertile topsoil over disturbed areas.	To provide a suitable medium for vegetative growth to take place.	Used in areas where other methods will not produce or maintain a desirable stand of vegetation.	Recommended for soils that do not have a deep rooting zone to support plants, contain material toxic to plant growth, and exposed subsoil not suitable to produce adequate vegetation.	Should be applied on slopes 2:1 or flatter. Apply lime and fertilizer as appropriate.
Permanent Seeding Planting of Grasses	Control of runoff and erosion with permanent vegetation.	To economically control erosion and sedimentation.	Used on graded or cleared areas where soil is unstable because of texture, structure, high water table, or slope.	Selection of appropriate plant species, use of quality seed, and proper bed preparation are important.	Planting should occur within 14 days of final grading.
Permanent Ground Cover Plants	Control of runoff and erosion with trees, vines and shrubs by stabilizing soils in areas where vegetation other than grasses or legumes is preferred.	To economically control erosion and sedimentation.	Used on steep banks, graded cleared areas, and shady areas where turf maintenance is difficult. Also, can be used between terraces.	Selection of species should match soil characteristics. Quality stock should be selected and kept moist from time of receipt and planted as soon as possible.	Usually more effective when planted in clumps or blocks. Competitive vegetation should be pulled out of the area where the plants are to be planted.

BMP Guidelines

Erosion Prevention Measures					
BMP	**Definition**	**Purpose**	**Where Applicable**	**Planning**	**Design Criteria**
Sodding	Use of grass sod to permanently stabilize an area.	To rapidly prevent erosion and sedimentation.	May be used in areas requiring immediate and permanent vegetative cover.	More costly than seeding, but can be established during times of the year when grass seed may fail. Irrigation will need to be applied.	On slopes, sod should be applied with the long dimension perpendicular to the slope.
Riprap or Aggregate	Permanent layers of loose angular stones or aggregate with a filter fabric or granular underlining placed over an erodible soil surface.	To protect the soil surface from the erosive flow of water, slow the water flow velocity, and stabilize slopes.	Used when soil may erode under design flow conditions and cannot be protected by vegetative cover or other means. Riprap can be used at: • Storm drain outlets, • Channel banks and bottoms, • Roadside ditches, • Drop structures, • Toe of slopes, • Channel transitions.	Graded riprap contains a mixture of stone sizes while uniform riprap is made up of stones of similar sizes. The size of stone used is directly related to the design flow velocity of the channel. Typically should be used for velocities in excess of 15 ft/sec.	The minimum riprap thickness is 2 times the maximum stone diameter but not less than 6 inches. The specific gravity of the individual stones should be at least 2.5. Maxim bank slope for application should not be steeper than 1.5:1.

BMP Guidelines

Erosion Prevention Measures					
BMP	**Definition**	**Purpose**	**Where Applicable**	**Planning**	**Design Criteria**
Outlet Protection	Structurally lined aprons or other acceptable energy dissipation devices placed at the outlets of pipes or paved channel sections.	To protect the soil surface from the erosive flow of water, slow the water flow velocity, and stabilize slopes.	Used where the flow velocity at the design capacity will exceed the velocity of the receiving channel or area.	Geotextile Fabrics in conjunction with vegetation create a natural outlet protection. Riprap aprons are relatively low cost and easy to install. Riprap stilling basins or plunge pools are used where overfalls exit the ends of pipes where high flows would require excessive apron lengths.	Capacity: 10-year peak runoff or design discharge of conveyance, whichever is greater. Geotextile Fabrics should be designed to handle peak flow rates and tractive forces. The depth of a riprap apron should 2 times the maximum stone diameter but not less than 6 inches.

BMP Guidelines

Erosion Prevention Measures

BMP	Definition	Purpose	Where Applicable	Planning	Design Criteria
Dust Control	Reducing the erosive effects of wind on dry soils.	To prevent soil particles in the form of dust from becoming airborne.	Used where open dry areas of soil, particularly in dryer climates or during the dry season, are exposed to the erosive factors of the wind.	The direction of the prevailing winds and careful planning of clearing activities are important.	Minimize the period of soil exposure through use of temporary ground cover and other temporary stabilization practices. Some of the possible dust control measures are: • Vegetative cover, • Mulch, • Spray-on-adhesive, • Calcium chloride, • Sprinkling, • Stone, and • Barriers.

Temporary Sediment Control Measures

BMP	Definition	Purpose	Where Applicable	Planning	Design Criteria
Sediment Basins	A suitably located temporary or permanent earthen embankment, barrier, dam, or excavated basin designed to capture sediment.	To retain sediment on the construction site and prevent sedimentation in offsite waterbodies, properties etc.	Used where erosion control measures are not adequate to prevent offsite sedimentation on sites with disturbed area of 5 acres or more.	Hazard class must be considered so failure does not jeopardize property or lives. The location of the basin must be able to collect all of the site runoff.	Drainage area is between 5 and 150 acres. The flow length through the basin length to width ratio should be 2:1 or greater. (See Design Aids section 12.8.2 of Chapter 12)
Temporary Sediment Trap	A small temporary ponding basin formed by constructing an embankment across a drainage swale, by excavating a pond or by rock fill.	To detain sediment-laden runoff from small, disturbed areas long enough to allow the majority of the sediment to settle out.	Used at the outlets of drains, diversions, channels, and other runoff conveyances. May be installed during early site development.	Access to trap must be maintained to periodically remove sediment for proper disposal. Structure life is limited to 18 months.	Used for drainage areas of 5 acres or less. Minimum storage area is fixed to meet 80% removal efficiency. Side slopes of the excavated trap should be 2:1 or flatter. Maximum height is 5 ft. (See Design Aids section 12.8.5)

BMP Guidelines

Temporary Sediment Control Measures					
BMP	**Definition**	**Purpose**	**Where Applicable**	**Planning**	**Design Criteria**
Silt Fence	Sediment barrier consisting of synthetic filter fabric stretched across supporting posts with the bottom of the fabric being entrenched. In most cases the fabric should be reinforced with the support of a wire fence.	To catch and hold small amounts of sediment from disturbed areas by reducing the velocity of sheet flow to allow sediment deposition.	Used below small, disturbed areas less than ¼ acre per 100 ft. of fence, and where runoff can be stored behind the fence without damaging the fence or the area behind it.	Should be located where only shallow pools can be formed. Sediment deposition should be periodically removed and properly disposed of. Turnouts or breaks in the fence should be used to minimize drainage areas.	Fence should be stable for the 10-yr storm. The slope should be no longer than 100 ft. and have a gradient of 2:1 or flatter. The minimum fabric height is 18 inches while the maximum is 24 inches. Maximum post spacing is 6 ft. Minimum post burial depth is 12 inches. (See Design Aids section 12.8.4)
Rock Ditch Checks	Small temporary dams constructed across a swale or drainage ditch to reduce the velocity of concentrated storm flows.	To reduce erosion of the channel by restricting the velocity of flow in the channel. Not to be installed min live channels or waters of the commonwealth.	Used as a temporary or emergency measure to limit erosion by reducing flow in a small open channel.	Ditch checks should not be used in live streams but are intended for temporary ditches and swales. Checks in grass channels may kill the vegetation. Ditch checks shall be promptly removed when their useful life has been completed.	Drainage area should not exceed 10 acres. The maximum height is 2 ft. at the center. The center should be at least 6 inches lower than the outer edges. The maximum spacing between checks should be such that the toe of the upstream check is at the same elevation as the top of the downstream check. The maximum size of stone used should be no greater than 8 inches in diameter. (See Design Aids section 12.8.3)
Stabilized Construction Entrance	A gravel driveway or pad located at a point where vehicles enter and exit a construction site.	To reduce the amount of mud and soil transported onto public roads by traffic leaving the construction site.	Used wherever traffic leaves a construction site and enters a public right -of- way, street, alley, sidewalk, parking lot, or other paved area.	Construction plans should limit all traffic to properly constructed entrances and exits.	Stone should be KTC #3 or larger. Pad thickness has a 6-inch minimum with a required geotextile fabric underling the stone. The minimum width of the entrance shall be 24 ft. while the minimum length shall be 100 ft.

BMP Guidelines

Temporary Sediment Control Measures					
BMP	**Definition**	**Purpose**	**Where Applicable**	**Planning**	**Design Criteria**
Storm Drain Inlet Filters	A sediment filter or an excavated impounding area surrounding a storm drain inlet.	To retain sediment on the construction site by slowing and filtering runoff before it enters the storm drainage system.	Used where storm drain inlets are to be made operational before permanent stabilization of the disturbed area occurs.	Must not be used near the edge of fill material and must not divert water over cut or fill slopes. • Filter Fabric Inlet Protection • Stone Bag inlet Protection • Block and Gravel Drop Inlet Protection • Gravel and Wire Mesh Inlet Sediment Filter	The drainage area must be no greater than 1 acre with a slope less than 5%.
Vegetated Filter Strips	Zones of vegetation through which sediment and pollutant-laden runoff are directed before being discharged to a concentrated flow channel.	Filter strips are used to remove sediment from overland sheet flow but are not effective in removing sediment from concentrated flows	Used where runoff from land undergoing development needs to be filtered to reduce sediment damage to adjacent properties, streams or sinkholes.	Effectiveness can very depending vegetation, height, type and density, season of the year, soil eroded particle size characteristics, size of disturbed area, and site topography.	The General Design Criteria are: Minimum Width = 15 feet. Minimum Ground Slope = 1% Maximum Ground Slope = 10%

BMP Guidelines

Temporary Flow Control and Conveyance Measures					
BMP	**Definition**	**Purpose**	**Where Applicable**	**Planning**	**Design Criteria**
Temporary Pipe Slope Drains	Flexible tubing or conduit extending temporarily from the top to the bottom of a cut or fill slope.	To convey concentrated runoff down the face of a cut or fill slope to a protected stable area without causing erosion.	Used on sites before permanent stormwater drainage structures are installed and where stormwater runoff above a cut or fill slope will cause severe erosion if allowed to flow over the slope.	Must be sized, installed, and maintained properly because failure results in slope gully erosion. The entrance must be securely entrenched with watertight connections, with securely staked conduit.	Should handle peak runoff from the 10-year storm. The maximum drainage area per pipe is 10 acres. The entrance should be constructed of a standard flared end section of pipe or equivalent. Reinforced hold-down garments should be spaced at 10 ft. or less intervals.
Temporary Stream Crossing	Bridge or culvert constructed across a stream for the purpose of providing access to construction vehicles or heavy equipment.	To protect the banks of streams from tire damage, permanent degradation, and erosion.	Used only when permanent stream crossings are not unavailable.	The use of a bridge is preferred over a culvert because a bridge provides the least obstruction to flow and fish migration.	The selection of the type and size of the pipe to be used as a culvert shall be determined by the design engineer. Culvert applications require as many pipes to be placed across the width of the channel as possible. The minimum pipe diameter to be used is 24-inches.

BMP Guidelines

Temporary Flow Control and Conveyance Measures					
BMP	**Definition**	**Purpose**	**Where Applicable**	**Planning**	**Design Criteria**
Runoff Control Measures	A temporary ridge, excavated channel, or combination ridge and channel constructed across sloping land at a pre-determined grade.	To divert clean water around work sites to stable outlets and to divert sediment-laden water to sediment control structures such as sediment traps and basins.	• Above slopes to prevent clean runoff from flowing over unprotected soil, • Across unprotected slopes to reduce flow lengths, • Below slopes to divert runoff to a stable outlet, and • Within and below disturbed areas to direct sediment-laden water to control structures.	Design as a stable channel with a mild bed slope. Use of either uniform or a gradually increasing grade is preferred over sudden decreases or increases in grade. A permanent vegetative covering is required where the channel grade is between 0.2% and 3%.	Design drainage area is 5 acres or less based on the peak runoff from the 10-year storm. A channel lining is required if the average velocity is greater than 2 ft/sec. Channel side slopes are 2:1 or flatter. The berm must have side slopes of 2:1 or flatter with a minimum top width of 2 ft. and a designed freeboard of at least 4 inches.
Construction De-watering	Removal of standing stormwater or groundwater from excavated pits.	Used to drain excavated pits and trenches or low spots of standing water.	Used in pits, trenches or other open excavations where ground water may accumulate and a pump is able to remove standing water and discharge it appropriately.	Sediment laden or contaminated water must be discharged in an area suitable to handle the particles carried with the water. Direct pumping to lakes and streams is prohibited.	The following de-watering measures are recommended: • Pump directly to existing sediment control structures. • Pump or conveying water to infiltration trenches • Pump water to a buffer zone through a designed outlet structure.

BMP Guidelines

Permanent Flow Control and Conveyance Measures					
BMP	**Definition**	**Purpose**	**Where Applicable**	**Planning**	**Design Criteria**
Subsurface Drains	A perforated pipe or conduit placed beneath the surface of the ground at a designated depth and grade.	Used to drain saturated soils by lowering the water table.	Used in areas free from tree roots where the soil layer depth is deep enough to allow proper installation.	Not recommended in areas where the drain will pass under heavy vehicle crossings.	Should be designed for required capacity. The minimum diameter should be 6 inches. The line should be graded to achieve at least a velocity of 2.4 ft/sec to prevent silting.
Level Spreader	Structure that converts sediment-free channel flow into sheet flow and uniformly releases it over a stabilized area.	Provides stable outlets for diversion channels, basins, dikes and other structures.	Used where sediment free storm runoff can be released as sheet flow over a stable area.	Install in areas where the level lip can be constructed without using fill material. The discharge area should have a maximum 10% slope and be well-vegetated and stable for design flow conditions. There should be no traffic across a level spreader.	Capacity determined by peak flow from the 10-year storm. The maximum desirable flow into the spreader should not exceed 30 cfs. Spreader length, width and depth are designed based on flow. There should be a 20-ft. long transition section between the channel entrance and the design width of the spreader. The grade of the spreader invert and lip must be 0.

BMP SUGGESTED USES
Erosion Prevention Measures

BMP	Design Manual Section	Slope Protection	Waterway Protection	Surface Protection	Enclosed Drainage	Large Flat Areas	Borrow Areas	Adjacent Properties
Erosion Prevention Measures	12.5	X	X	X	X	X	X	X
Surface Roughening	12.5.1	X		X				
Bench Terracing	12.5.2	X		X				
Temporary Seeding	12.5.3	X		X		X	X	X
Mulching	12.5.4	X				X	X	
Erosion Control Blankets and Turf Reinforcement Mats	12.5.5	X	X	X			X	
Final Stabilization	12.5.6	X		X		X		X
Topsoiling	12.5.6.1			X		X		
Permanent Seeding and Planting of Grasses	12.5.6.2	X		X		X		X
Sodding	12.5.6.3	X		X		X		X
Riprap or Aggregate	12.5.7	X	X	X				
Outlet **Stabilization**	12.5.8		X		X			X
Dust Control	12.5.9					X	X	X

BMP SUGGESTED USES
Temporary Sediment Control Measures

BMP	Design Manual Section	Slope Protection	Waterway Protection	Surface Protection	Enclosed Drainage	Large Flat Areas	Borrow Areas	Adjacent Properties
Temporary Sediment Control Measures	12.6	X	X	X	X	X	X	X
Storage Volumes and Maintenance Schedules	12.6.1		X		X			X
Temporary Sediment Basin	12.6.2		X	X	X			X
Multipurpose Basin	12.6.3		X	X	.X			X
Temporary Sediment Trap	12.6.4		X	X				X
Silt Fence	12.6.5	X	X					X
Rock Ditch Check	12.6.6			X				X
Stabilized Construction Entrance	12.6.7					X		X
Storm Drain Inlet Protection	12.6.8		X		X			X
Vegetated Filter Strips	12.6.9		X					X

BMP Suggested Uses
Runoff Control and Conveyance Measures

BMP	**Design Manual Section**	**Slope Protection**	**Waterway Protection**	**Surface Protection**	**Enclosed Drainage**	**Large Flat Areas**	**Borrow Areas**	**Adjacent Properties**
Pipe Slope Drains	12.7.1	X		X				
Temporary Stream Crossing	12.7.2		X	X				X
Runoff Conveyance Measures	12.7.3	X					X	X
Construction Dewatering	12.7.4		X		X	X	X	
Stone Bag Check Dam in Small Ditch	12.7.**5**		X	X				X

APPENDIX B

JEFFERSON COUNTY SOILS INFORMATION

SOILS INFORMATION AND ERODED SIZE DISTRIBUTIONS FOR JEFFERSON COUNTY, KENTUCKY.

PERCENT FINER FOR SPECIFIED PARTICLE DIAMETERS

SOIL SERIES -HYDROLOGIC SOIL GROUP

DEPTH (in)	K	D15 (mm)	1.4	1.0	0.063	0.044	0.038	0.004	0.003	0.001
			Percent Finer Than (mm)							
ASHTON –HSG B										
0-9	0.32	0.0063	100.0	91.9	73.5	56.0	53.1	5.5	3.4	0.0
9-44		0.0053	100.0	91.9	73.4	64.9	62.9	8.0	5.1	0.0
44-80		0.0065	100.0	85.2	51.5	42.5	42.5	7.5	4.9	0.0
BEASLEY –HSG C										
0-7	0.43	0.0048	100.0	87.4	58.6	53.8	52.7	11.7	8.0	0.0
7-29		0.0043	100.0	85.3	51.6	48.2	47.5	13.9	9.8	0.0
29-50		0.0046	100.0	80.9	37.3	35.5	35.5	13.7	9.8	0.0
CAPTINA –HSG C										
0-9	0.43	0.0066	100.0	93.3	78.0	55.6	51.8	4.4	2.7	0.0
9-25		0.0055	100.0	89.1	64.2	57.0	56.1	8.4	5.4	0.0
25-39		0.0063	100.0	83.9	47.2	39.7	39.7	8.7	5.8	0.0
39-58		0.0079	100.0	81.5	39.1	30.3	30.3	8.5	5.8	0.0
58-80		0.0754	100.0	72.9	11.0	8.0	8.0	12.9	9.8	0.0
CORYDON –HSG D										
0-9	0.43	0.0052	100.0	87.3	58.4	53.2	52.6	9.9	6.5	0.0
9-15		0.0048	100.0	84.9	50.5	47.6	47.4	12.1	8.3	0.0
CRIDER –HSG B										
0-12	0.32	0.0054	100.0	93.1	77.4	67.1	64.4	7.3	4.6	0.0
12-38		0.0052	100.0	91.5	72.0	64.2	62.1	9.0	5.8	0.0
38-50		0.0239	100.0	75.1	18.1	15.5	15.5	13.1	9.8	0.0
50-96		0.0037	100.0	80.7	36.7	35.6	35.6	16.2	11.7	0.0
DICKSON -HSG C										
0- 7	0.43	0.0058	100.0	92.4	74.9	61.5	58.8	6.4	4.0	0.0
7-25		0.0054	100.0	92.4	75.1	65.4	63.1	7.5	4.7	0.0
25-45		0.0054	100.0	91.3	71.4	63.1	61.4	8.0	5.1	0.0
45-65		0.0052	100.0	82.1	41.3	38.6	38.6	11.8	8.3	0.0
DUNNING -HSG D										
0-15	0.37	0.0050	100.0	89.3	64.9	58.7	57.1	10.5	7.0	0.0
15-72		0.0045	100.0	83.7	46.4	44.5	44.5	13.3	9.3	0.0
ELK -HSG B										
0-9	0.37	0.0053	100.0	88.8	63.3	56.8	55.8	9.1	5.9	0.0
9-42		0.0054	100.0	91.3	71.4	63.1	61.4	8.0	5.1	0.0
42-69		0.0061	100.0	85.4	51.9	44.7	44.7	8.2	5.4	0.0

SOIL SERIES -HYDROLOGIC SOIL GROUP

DEPTH (in)	K	D15 (mm)	1.4	1.0	0.063	0.044	0.038	0.004	0.003	0.001
			Percent Finer Than (mm)							
ENNIS -HSG B										
0-10	0.24	0.0083	100.0	85.6	52.7	34.7	34.6	5.7	3.6	0.0
10-60		0.0080	100.0	83.3	45.3	32.6	32.6	7.3	4.9	0.0
FAIRMOUNT -HSG D										
0-11	0.24	0.0044	100.0	83.1	44.4	43.0	43.0	13.9	9.8	0.0
11-17		0.0045	100.0	83.7	46.4	44.5	44.5	13.3	9.3	0.0
GINAT -HSG D										
0-9	0.43	0.0058	100.0	89.4	65.2	54.8	53.7	7.2	4.5	0.0
9-23		0.0054	100.0	88.3	61.7	55.4	54.6	9.0	5.8	0.0
23-48		0.0052	100.0	90.0	67.0	60.0	58.5	9.3	6.0	0.0
48-74		0.0052	100.0	90.0	67.0	60.0	58.5	9.3	6.0	0.0
74-80		0.0056	100.0	90.9	70.1	60.1	58.4	7.3	4.6	0.0
GUTHRIE -HSG D										
0-8	0.43	0.0059	100.0	94.3	81.1	64.8	60.6	5.5	3.4	0.0
8-32		0.0054	100.0	92.4	75.1	65.4	63.1	7.5	4.7	0.0
32-53		0.0055	100.0	90.4	68.6	60.2	59.0	7.8	4.9	0.0
53-68		0.0055	100.0	89.5	65.6	57.9	56.9	8.2	5.2	0.0
HOLSTON -HSG B										
0-8	0.28	0.0079	100.0	87.1	57.5	37.7	37.3	5.4	3.4	0.0
8-44		0.0071	100.0	83.7	46.3	35.9	35.9	7.7	5.2	0.0
44-75		0.0073	100.0	81.2	38.1	31.0	31.0	9.1	6.3	0.0
HUNTINGTON -HSG B										
0-11	0.32	0.0057	100.0	89.6	65.9	56.6	55.6	7.5	4.7	0.0
11-64		0.0057	100.0	89.6	65.9	56.6	55.6	7.5	4.7	0.0
64-74		0.0079	100.0	84.2	48.0	34.0	34.0	6.7	4.4	0.0
LAKIN -HSG A										
0-11	0.17	0.0379	100.0	94.8	83.0	16.1	15.0	1.2	0.8	0.0
11-60		0.0441	100.0	92.9	76.6	14.5	14.1	1.7	1.1	0.0
60-80		0.0449	100.0	97.1	90.5	10.7	9.8	0.6	0.4	0.0
LAWRENCE -HSG C										
0-10	0.43	0.0057	100.0	93.7	79.2	65.0	61.4	6.1	3.8	0.0
10-25		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
25-50		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
50-75		0.0049	100.0	87.9	60.3	55.1	53.9	11.2	7.6	0.0
LINDSIDE -HSG C										
0-8	0.32	0.0052	100.0	90.0	67.0	60.0	58.5	9.3	6.0	0.0
8-44		0.0054	100.0	90.0	67.1	59.3	58.1	8.2	5.2	0.0
44-60		0.0065	100.0	84.7	49.7	41.0	41.0	7.9	5.2	0.0

SOIL SERIES -HYDROLOGIC SOIL GROUP

DEPTH (in)	K	D15 (mm)	1.4	1.0	0.063	0.044	0.038	0.004	0.003	0.001
			Percent Finer Than (mm)							
LITZ -HSG C										
0-12	0.32	0.0093	100.0	84.9	50.5	30.9	30.9	5.6	3.6	0.0
12-24		0.0461	100.0	79.7	33.1	12.4	12.4	6.0	4.4	0.0
LORING -HSG C										
0-7	0.49	0.0061	100.0	96.4	88.0	67.8	61.9	4.1	2.5	0.0
7-28		0.0053	100.0	93.3	78.0	69.0	66.5	7.8	4.9	0.0
28-50		0.0054	100.0	93.9	80.0	68.8	65.5	7.0	4.4	0.0
50-65		0.0060	100.0	93.3	78.1	61.2	57.6	5.5	3.4	0.0
LOWELL -HSG B										
0-11	0.37	0.0050	100.0	90.6	69.1	62.0	60.1	9.9	6.5	0.0
11-23		0.0044	100.0	87.3	58.2	53.3	52.0	13.3	9.3	0.0
23-53		0.0043	100.0	85.3	51.6	48.2	47.5	13.9	9.8	0.0
MARKLAND -HSG C										
0- 7	0.43	0.0051	100.0	89.8	66.6	59.9	58.3	10.0	6.6	0.0
7-28		0.0044	100.0	87.3	58.2	53.3	52.0	13.3	9.3	0.0
28-60		0.0048	100.0	86.3	55.1	51.1	50.4	12.1	8.3	0.0
MCGARY -HSG C										
0-11	0.43	0.0052	100.0	87.9	60.1	54.7	53.8	10.0	6.6	0.0
11-39		0.0046	100.0	89.2	64.4	58.1	56.4	12.1	8.3	0.0
39-60		0.0047	100.0	88.5	62.1	56.4	54.9	12.1	8.3	0.0
MELVIN -HSG D										
0-9	0.43	0.0052	100.0	90.0	67.0	60.0	58.5	9.3	6.0	0.0
9-30		0.0055	100.0	92.3	74.8	64.7	62.3	7.3	4.6	0.0
30-62		0.0057	100.0	90.1	67.6	57.7	56.3	7.3	4.6	0.0
MEMPHIS -HSG B										
0-9	0.49	0.0060	100.0	95.8	86.3	68.0	62.7	4.7	2.9	0.0
9-23		0.0052	100.0	92.7	76.0	67.5	65.0	8.4	5.4	0.0
23-77		0.0057	100.0	94.9	83.3	68.3	64.0	5.8	3.6	0.0
MUSKINGUM -HSG C										
0-5	0.28	0.0072	100.0	88.3	61.6	42.0	41.4	5.5	3.4	0.0
5-26		0.0074	100.0	84.7	49.8	37.2	37.2	6.8	4.4	0.0
NEWARK -HSG C										
0-7	0.43	0.0059	100.0	89.6	65.8	54.8	53.6	7.0	4.4	0.0
7-38		0.0054	100.0	90.0	67.1	59.3	58.1	8.2	5.2	0.0
38-60		0.0053	100.0	90.5	68.8	61.5	60.8	8.3	5.2	0.0
OTWAY –HSG D										
0-18	0.43	0.0046	100.0	87.9	60.1	54.9	53.4	12.7	8.8	0.0
18-36		0.0052	100.0	90.0	67.0	60.7	60.1	9.0	5.7	0.0

SOIL SERIES -HYDROLOGIC SOIL GROUP

DEPTH (in)	K	D15 (mm)	1.4	1.0	0.063	0.044	0.038	0.004	0.003	0.001
			Percent Finer Than (mm)							
PURDY -HSG D										
0-9	0.43	0.0052	100.0	92.9	76.8	68.1	65.6	8.2	5.2	0.0
9-42		0.0048	100.0	84.9	50.5	47.6	47.4	12.1	8.3	0.0
42-60		0.0048	100.0	85.6	52.8	49.4	48.9	12.1	8.3	0.0
ROBERTSVILLE -HSG D										
0-6	0.43	0.0058	100.0	93.2	77.6	63.2	59.9	6.1	3.8	0.0
6-21		0.0054	100.0	92.2	74.2	65.5	63.5	7.8	4.9	0.0
21-45		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
45-65		0.0054	100.0	88.3	61.7	55.4	54.6	9.0	5.8	0.0
ROCKCASTLE -HSG D										
0-6	0.43	0.0044	100.0	83.1	44.4	43.0	43.0	13.9	9.8	0.0
6-28		0.0045	100.0	83.7	46.4	44.5	44.5	13.3	9.3	0.0
SCIOTOVILLE -HSG C										
0-13	0.37	0.0059	100.0	91.2	71.0	58.1	56.0	6.6	4.1	0.0
13-34		0.0055	100.0	89.6	65.7	57.9	56.9	8.0	5.1	0.0
34-59		0.0053	100.0	90.6	69.2	61.6	60.9	8.2	5.1	0.0
59-69		0.0071	100.0	84.2	48.2	37.4	37.4	7.4	4.9	0.0
SEQUATCHIE -HSG B										
0-12	0.24	0.0087	100.0	85.9	53.5	33.5	33.4	5.4	3.4	0.0
12-46		0.0060	100.0	87.4	58.5	49.5	49.2	7.4	4.7	0.0
46-72		0.0098	100.0	84.7	49.9	29.4	29.4	5.5	3.6	0.0
SHELBYVILLE -HSG B										
0-9	0.32	0.0058	100.0	94.5	81.8	66.6	62.5	5.8	3.6	0.0
9-38		0.0053	100.0	92.3	74.9	66.3	64.1	8.2	5.2	0.0
38-65		0.0043	100.0	83.8	46.8	44.8	44.5	13.9	9.8	0.0
TAFT -HSG C										
0-9	0.43	0.0060	100.0	93.3	78.1	61.2	57.6	5.5	3.4	0.0
9-24		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
24-64		0.0054	100.0	91.6	72.4	63.8	62.0	7.8	4.9	0.0
64-80		0.0066	100.0	84.4	48.8	39.6	39.6	7.8	5.2	0.0
TYLER -HSG C										
0-14	0.43	0.0058	100.0	92.5	75.5	61.5	58.6	6.2	3.9	0.0
14-18		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
18-59		0.0055	100.0	89.7	66.2	58.2	57.2	7.9	5.0	0.0
59-70		0.0061	100.0	89.6	65.9	52.9	51.5	6.6	4.1	0.0
WEINBACH -HSG C										
0-15	0.43	0.0059	100.0	89.6	65.8	54.8	53.6	7.0	4.4	0.0
15-23		0.0055	100.0	89.9	66.7	58.5	57.5	7.8	4.9	0.0
23-40		0.0055	100.0	89.9	66.7	58.5	57.5	7.8	4.9	0.0
40-52		0.0053	100.0	90.6	69.2	61.6	60.0	8.7	5.6	0.0
52-65		0.0071	100.0	84.2	48.2	37.4	37.4	7.4	4.9	0.0

SOIL SERIES -HYDROLOGIC SOIL GROUP

DEPTH (in)	K	D15 (mm)	1.4	1.0	0.063	0.044	0.038	0.004	0.003	0.001
			Percent Finer Than (mm)							
WESTMORELAND -HSG ZZ										
0-7	0.99	0.0058	100.0	90.1	67.6	56.5	55.1	7.0	4.4	0.0
7-36		0.0062	100.0	85.0	50.6	42.9	42.9	8.2	5.4	0.0
36-49		0.0081	100.0	82.7	43.3	31.2	31.2	7.6	5.2	0.0
WHEELING -HSG B										
0-14	0.37	0.0069	100.0	90.8	69.7	48.9	46.6	5.0	3.1	0.0
14-60		0.0067	100.0	85.1	50.9	40.7	40.7	7.2	4.7	0.0
60-72		0.0255	100.0	87.5	59.1	17.5	17.5	3.4	2.2	0.0
WOOLPER -HSG C										
0-6	0.37	0.0052	100.0	90.0	67.0	60.0	58.5	9.3	6.0	0.0
6-15		0.0047	100.0	86.9	57.0	52.6	51.6	12.2	8.4	0.0
15-65		0.0043	100.0	85.3	51.6	48.2	47.5	13.9	9.8	0.0
ZANESVILLE -HSG C										
0-7	0.43	0.0052	100.0	90.6	69.1	61.8	60.0	9.3	6.0	0.0
7-28		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
28-39		0.0055	100.0	89.7	66.2	58.2	57.2	7.9	5.0	0.0
39-60		0.0079	100.0	81.5	39.1	30.3	30.3	8.5	5.8	0.0
ZIPP -HSG D										
0-6	0.28	0.0047	100.0	88.5	62.1	56.4	54.9	12.1	8.3	0.0
6-36		0.0044	100.0	87.3	58.2	53.3	52.0	13.3	9.3	0.0
36-60		0.0046	100.0	85.7	53.1	49.6	48.9	12.7	8.8	0.0

APPENDIX C

RAINFALL AND USLE DATA

RAINFALL AND USLE DATA

Table 1. Distribution of Rainfall Erosion Index (EI Curves) for Jefferson County

Date	EI Curve Number
January 1	0.0
January 15	1.0
February 1	3.0
February 15	6.0
March 1	9.0
March 15	12.0
April 1	16.0
April 15	21.0
May 1	26.0
May 15	31.0
June 1	37.0
June 15	43.0
July 1	50.0
July 15	57.0
August 1	64.0
August 15	71.0
September 1	77.0
September 15	81.0
October 1	85.0
October 15	88.0
November 1	91.0
November 15	93.0
December 1	95.0
December 15	97.0
January 1	100.0

Minimum Value to be used is 50
Average Annual R Factor = 175

Table 2. Rainfall Data

Duration	Return Period (in years) 1	2	5	10	25	50	100
1 hr.	1.2	1.5	1.8	2.0	2.4	2.6	2.8
6 hr.	1.9	2.3	2.8	3.2	3.6	4.0	4.5
12 hr.	2.3	2.7	3.4	3.8	4.4	4.8	5.2
24 hr.	2.7	3.2	4.0	4.5	5.2	5.7	6.2

All values are in inches

Table 3. Universal Soil Loss Equation CP Factors

Condition	*CP Factor*
Bare Soil	1.0
Compacted Root Raked Soil	1.2
Compacted Bulldozer Scraped Soil	1.2
Fresh Unprepared Seedbed	0.64
Temporary Seeding 0-60 Days	0.40
Temporary Seeding After 60 Days	0.05
Permanent Seeding 2-12 Months	0.05
Brush	0.35
Erosion Control Blankets	0.01-0.10

Table 4. Universal Soil Loss Equation LS Factors

% Slope	*Slope Length in Feet*																	
	20	**50**	**75**	**100**	**120**	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**	**600**	**700**	**800**	**900**	**1000**
0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.11	0.114	0.12	0.12	0.13	0.13	0.13	0.137	0.141	0.145	0.148	0.152
1.0	0.1	0.11	0.12	0.13	0.14	0.14	0.15	0.15	0.17	0.18	0.19	0.20	0.20	0.22	0.23	0.24	0.25	0.25
2.0	0.12	0.16	0.18	0.20	0.21	0.22	0.24	0.26	0.27	0.29	0.0	0.31	0.32	0.34	0.36	0.37	0.38	0.40
3.0	0.17	0.23	0.26	0.28	0.30	0.32	0.35	0.37	0.38	0.41	0.43	0.45	0.46	0.49	0.51	0.53	0.55	0.57
4.0	0.21	0.30	0.35	0.40	0.43	0.47	0.52	0.57	0.62	0.66	0.69	0.73	0.76	0.81	0.87	0.91	0.96	1.00
5.0	0.23	0.37	0.46	0.53	0.58	0.65	0.75	0.84	0.92	1.00	1.07	1.13	1.19	1.31	1.41	1.51	1.60	1.69
6.0	0.30	0.47	0.58	0.67	0.73	0.82	0.95	1.06	1.16	1.25	1.34	1.42	1.50	1.64	1.78	1.90	2.01	2.12
7.0	0.36	0.58	0.71	0.82	0.90	1.01	1.16	1.30	1.42	1.54	1.65	1.75	1.84	2.02	2.18	2.33	2.47	2.60
8.0	0.44	0.70	0.85	0.99	1.08	1.21	1.40	1.56	1.71	1.85	1.98	2.10	2.21	2.42	2.62	2.80	2.97	3.13
9.0	0.52	0.82	1.01	1.17	1.28	1.43	1.65	1.85	2.03	2.19	2.34	2.48	2.62	2.87	3.10	3.31	3.52	3.71
10.0	0.61	0.96	1.18	1.36	1.50	1.67	1.93	2.16	2.37	2.56	2.74	2.90	3.06	3.35	3.62	3.87	4.10	4.33
11.0	0.70	1.11	1.36	1.58	1.73	1.93	2.23	2.49	2.73	2.95	3.16	3.35	3.53	3.87	4.18	4.46	4.74	4.99
12.0	0.80	1.27	1.56	1.80	1.97	2.21	2.55	2.65	3.12	3.37	3.60	3.82	4.03	4.42	4.77	5.10	5.41	5.70
13.0	0.91	1.44	1.76	2.04	2.23	2.50	2.88	3.23	3.53	3.82	4.08	4.33	4.56	5.00	5.40	5.77	6.12	6.46
14.0	1.02	1.62	1.98	2.29	2.51	2.81	3.24	3.62	3.97	4.29	4.58	4.86	5.13	5.62	6.07	6.49	6.88	7.25
15.0	1.14	1.81	2.21	2.56	2.80	3.13	3.62	4.04	4.43	4.79	5.12	5.43	5.72	6.27	6.77	7.24	7.68	8.09
16.0	1.26	2.00	2.45	2.83	3.11	3.47	4.01	4.48	4.91	5.31	5.67	6.02	6.34	6.95	7.51	8.02	8.51	8.97
17.0	1.40	2.21	2.71	3.13	3.42	3.83	4.42	4.94	5.42	5.85	6.26	6.64	7.00	7.66	8.28	8.85	9.39	9.89
18.0	1.53	2.42	2.97	3.43	3.76	4.20	4.85	5.43	5.94	6.42	6.86	7.28	7.68	8.41	9.08	9.71	10.3	10.9
19.0	1.67	2.65	3.24	3.75	4.10	4.59	5.30	5.93	6.49	7.01	7.50	7.95	8.38	9.18	9.92	10.6	11.3	11.9
20.0	1.82	2.88	3.53	4.07	4.46	4.99	5.76	6.45	7.06	7.63	8.15	8.65	9.12	10.0	10.7	11.5	12.2	12.9
25.0	2.63	4.16	5.1	5.89	6.45	7.21	8.33	9.31	10.2	11.0	11.8	12.5	13.2	14.4	15.6	16.7	17.7	18.6
33.3	4.22	6.67	8.17	9.44	10.3	11.6	13.4	14.9	16.4	17.7	18.9	20.0	21.1	23.1	25.0	26.7	28.3	29.9
40.0	5.65	8.94	8.94	12.7	13.9	15.5	17.9	20	21.9	23.7	25.3	26.8	28.3	31.0	33.5	35.8	38.0	40.0
50.0	7.97	12.6	12.6	17.8	19.5	21.8	25.2	28.2	30.9	33.3	35.6	37.8	39.9	43.7	47.2	50.4	53.5	56.4
66.6	11.9	18.9	18.9	26.7	29.2	32.7	37.7	42.2	46.2	49.9	53.3	56.6	59.6	65.3	70.5	75.4	80.0	84.3
100.0	18.9	29.9	29.9	42.2	46.3	51.7	59.7	66.8	73.2	79.0	84.5	89.6	94.5	103.	112	120	126	134

APPENDIX D

MSD APPROVED ECBS AND TRMS

Erosion Control Blankets

A list of ECB products for each of the following classes and types is given in the MSD Standard Specifications.

Temporary Erosion Control Blanket (ECB) -Class I & II

For any ECB that has netting attached, the netting shall be photodegradable and/or biodegradable as specified for that Class and type of ECB. The weight of the netting shall not exceed 15% of the total blanket weight.

- **Class I:** Short-term Degradable Products – Defined as products composed primarily of biologically, photochemically or otherwise degradable constituents with longevity of approximately 1 year. Non-organic, photodegradable or biodegradable netting is allowed.

  Urban- Either netted with biodegradable material or non-netted, used in urban and residential areas where the slopes do not exceed 4H:1V. No minimum shear stress required, but the minimum mat thickness allowed is 9mm (3/8 inch). The product should be capable of withstanding moderate foot traffic without tearing or puncturing. Not to be used in channels.

  Type A- Maximum Product Permissible Shear Stress (0 - 1.0 lb/ft^2):

    A netted product for use on slopes 2.5H:1V and flatter where the calculated design shear stress is 1.0 lb/ft^2 or less. Not to be used in channels.

  Type B- Maximum Product Permissible Shear Stress (1.0 - 2.0 lb/ft^2):

    Double netted, used on slopes 2H:1V or flatter or, in channels where the calculated design shear stress is 2.0 lb/ft^2 or less.

- **Class II:** Long-term Degradable Products- defined as products composed primarily of biologically, photochemically or otherwise degradable constituents with a longevity of up to 5 years.

  Type A-Maximum Product Permissible Shear Stress (0 - 1.0 lb/ft^2):
    For use on slopes 3H:1V or, in channels where the calculated design shear stress is 1.0 lb/ft^2 or less flatter Jute fabric used

for erosion mats shall be a woven fabric of a uniform open weave of single jute yarn.

Type B- Maximum Product Permissible Shear Stress (0 - 2.0 lb/ft^2):

For use on slopes 2H:1V or flatter or, in channels where the calculated design shear stress is 2.0 lb/ft^2 or less. Non-organic, photodegradable or biodegradable netting is allowed.

Type C- Maximum Product Permissible Shear Stress (0 - 2.0 lb/ft^2):

For use in environmentally sensitive areas on slopes 2H:1V or flatter or, in channels where the calculated design shear stress is 2.0 lb/ft^2 or less. Only organic fiber woven mats are allowed with a maximum opening of 12 mm (1/2 inch).

Turf Reinforcement Mats

MSD Class III TRM physical properties are identified in the MSD Standard Specifications.

- **Class III:** Non-degradable Products- defined as products composed of non-degradable constituents with an unlimited longevity.

Type A- Maximum Product Permissible Shear Stress (0 – 6.0 lb/ft^2):

A TRM mat for use on slopes 2H:1V or flatter or, in channels where the calculated design shear stress is 6.0 lb/ft^2 or less.

Type B- Maximum Product Permissible Shear Stress (6.0 - 8.0 lb/ft^2):

A TRM mat for use on slopes 1H:1V or flatter or, in channels where the calculated design shear stress is 8.0 lb/ft^2 or less.

Type C- Maximum Product Permissible Shear Stress (8.0 - 10.0 lb/ft^2):

A TRM mat for use on slopes 1H:1V or steeper or, in channels where the calculated design shear stress is 10.0 lb/ft^2 or less.

MSD Approved ECB Products, Class I, Urban

Products	Manufacturer
Earth-Guard	Earth-Guard
HP90	Bon Terra
ENC2	Bon Terra
ENCS2	Bon Terra
ENS2	Bon Terra
ECS 1000-01	Erosion Control Systems
S150BN	North American Green
SC150BN	North American Green

MSD Approved ECB Products, Class I, Type A

Products	Manufacturer
Curex Excelsior	American Excelsior
Curex Excelsior II	American Excelsior
Curex High Velocity	American Excelsior
QuickGrass	American Excelsior
CS2	Bon Terra
S1	Bon Terra
S2	Bon Terra
ECS High Velocity Excelsior	Erosion Control Systems
ECS High Velocity Straw	Erosion Control Systems
ECS High Standard Straw	Erosion Control Systems
Earth-Lock IB	Erosion Control Systems
C125BN	North American Green
S75	North American Green
S75BN	North American Green
S150	North American Green
S150BN	North American Green
SC150	North American Green
SC150BN	North American Green
Excesior	PPS
XCEL Regular R1	PPS
XCEL Regular S1	PPS
EXCEL Super Duty SD3	PPS
Verdyol High Velocity ERO-MAT	Verdyol Alabama, Inc.
Verdyol High Velocity Excesior	Verdyol Alabama, Inc.
Verdyol Standard ERO-MAT	Verdyol Alabama, Inc.
Verdyol Standard Excelsior	Verdyol Alabama, Inc.

MSD Approved ECB Products, Class I, Type A

Products	Manufacturer
Curex Excelsior II	American Excelsior
Curex High Velocity	American Excelsior
CS2	Bon Terra
S2	Bon Terra
ECS High Velocity Excelsior	Erosion Control Systems
ECS High Velocity Straw	Erosion Control Systems
ECS Earthlock	Erosion Control Systems
Earth-Lock IB	Erosion Control Systems
S150	North American Green
SC150	North American Green
XCEL Superior S2	PPS
EXCEL Super Duty SD3	PPS
Verdyol High Velocity ERO-MAT	Verdyol Alabama, Inc.
Verdyol High Velocity Excesior	Verdyol Alabama, Inc.

MSD Approved ECB Products, Class I, Type B

Products	Manufacturer
C2	Bon Terra
CP2	Bon Terra
S125	North American Green
C350	North American Green

MSD Approved ECB Products, Class II, Type C

Products	Manufacturer
Dekowee 700	Beton Industries
Dekowee 900	Beton Industries
CF7	Bon Terra
CF9	Bon Terra
Bio-Mat	RoLanka

MSD Approved TRM Products, Class III, Type A Physical Properties

PROPERTY	TEST METHOOD	ENGLISH VALUES[1] *MARV*
Mechanical		
Tensile Strength	ASTM D5035[2]	145 x 110 lb/ft
Tensile Elongation	ASTM D5035[2]	50% (max)
Tensile Strength @ 10% Elongation	ASTM D5035[2]	100 x 70 lb/ft
Endurnace		
UV Resistance @ 1000 hrs	ASTM D4355	80%
Physical		
Mass Per Unit Area	ASTM D5261	8.0 oz/yd^2
Thickness[3]	ASTM D1777	0.35 in
Moisture Absorption	ASTM D570	0.01% (max)
Ground Cover Factor[4]	Light Projection Analysis	60%

Notes:

1.Values for machine and cross machine directions, respectively, under dry or saturated condition. Minimum averal roll values are calculated as the typical minus two standard deviations. Statistically, it yeilds a 97.7% degree of confidence that any samples taken from quality assurance testing will exceed the value reported

2. Formerly test method ASTM D1682

3. Modified ASTM D1777 using 6" Pressure Plate 0.2 kPA

4. Ground Cover Factor represents "% shade" from Lumite Light Projection Test

MSD Approved TRM Products, Class III, Type A

Products	Manufacturer
Pec Mat	American Excelsior
Tensar TB 1000	Tensar Earth Technologies, Inc.
Mirafi TM-8	Nicolon Mirafi
P300	North American Green
Contech C-45	Synthetic Industries
Landlock TRM 435	Synthetic Industries
Cenkamat 7010	Akzo Industrial Systems Co.

MSD Approved TRM Products, Class III, Type B Physical Properties

PROPERTY	TEST METHOOD	ENGLISH VALUES[1] *MARV*
Mechanical		
Tensile Strength	ASTM D5035[2]	170 x 130 lb/ft
Tensile Elongation	ASTM D5035[2]	50% (max)
Tensile Strength @ 10% Elongation	ASTM D5035[2]	180 x 80 lb/ft
Endurnace		
UV Resistance @ 1000 hrs	ASTM D4355	80%
Physical		
Mass Per Unit Area	ASTM D5261	10.0 oz/yd^2
Thickness[3]	ASTM D1777	0.50 in
Moisture Absorption	ASTM D570	0.01% (max)
Ground Cover Factor[4]	Light Projection Analysis	74%

Notes:

1.Values for machine and cross machine directions, respectively, under dry or saturated condition. Minimum averal roll values are calculated as the typical minus two standard deviations. Statistically, it yeilds a 97.7% degree of confidence that any samples taken from quality assurance testing will exceed the value reported. Typical indicates mean or average of all test data.

2. Formerly test method ASTM D1682

3. Modified ASTM D1777 using 6" Pressure Plate 0.2 kPA

4. Ground Cover Factor represents "% shade" from Lumite Light Projection Test

MSD Approved TRM Products, Class III, Type B

Products	Manufacturer
Enkamat 7018	Akzo Industrial Systems Co.
Tensar TM3000	Earth Technologies, Inc.
Miramat TM8	Nicolon Mirafi
LANDLOCK TRM 450	Synthetic Industries

MSD Approved TRM Products, Class III, Type C Physical Properties

PROPERTY	TEST METHOOD	ENGLISH VALUES[1] *MARV*
Mechanical		
Tensile Strength	ASTM D5035[2]	3,100 x 2,000 lb/ft
Tensile Elongation	ASTM D5035[2]	55% (max)
Tensile Strength	ASTM D4595[2]	3,200 x 2,200 lb/ft
Tensile Elongation	ASTM D4595[2]	65% (max)
Tensile Strength @ 10% Elongation	ASTM D4595[2]	7,500 x 6,750 lb/ft
Endurnace		
UV Resistance @ 1000 hrs	ASTM D4355	80%
Physical		
Mass Per Unit Area	ASTM D5261	10.0 oz/yd^2
Thickness[3]	ASTM D1777	0.50 in
Ground Cover Factor[4]	Light Projection Analysis	75%

Notes:

1.Values for machine and cross machine directions, respectively, under dry or saturated condition. Minimum averal roll values are calculated as the typical minus two standard deviations. Statistically, it yeilds a 97.7% degree of confidence that any samples taken from quality assurance testing will exceed the value reported. Typical indicates mean or average of all test data.

2. Formerly test method ASTM D1682

3. Modified ASTM D1777 using 6" Pressure Plate 0.2 kPA

4. Ground Cover Factor represents "% shade" from Lumite Light Projection Test

MSD Approved TRM Products, Class III, Type B

Products	Manufacturer
PYRAMAT	Synthetic Industries
Enka S-55	Akzo Industrial Systems Co.

APPENDIX E

MSD STANDARD DRAWINGS

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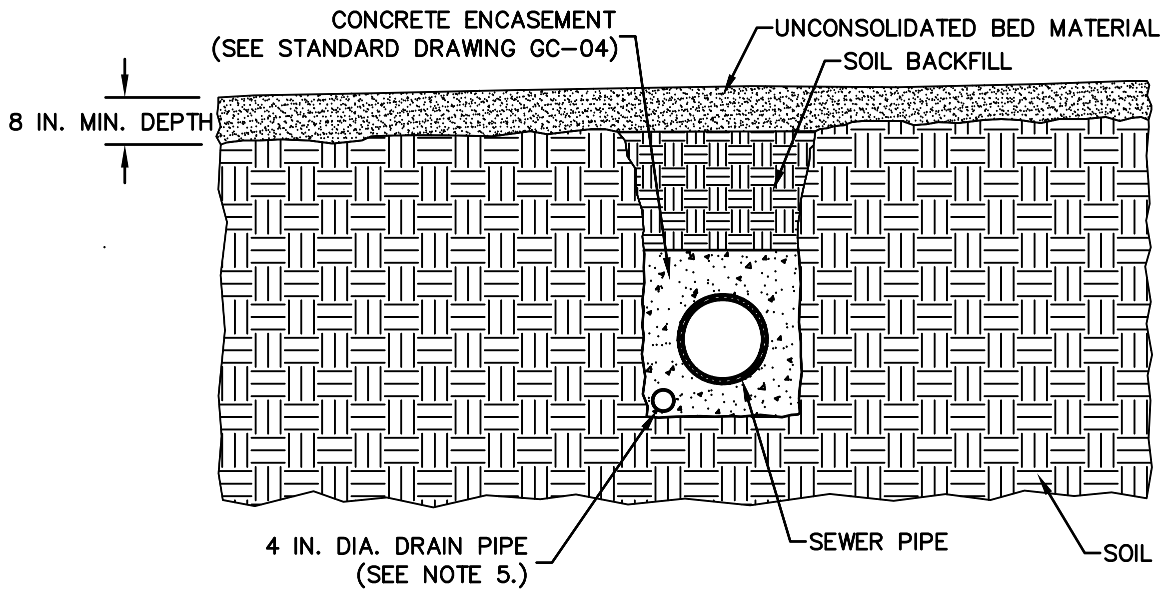
STANDARD DRAWINGS
SECTION INDEX

EFFECTIVE DATE: JUNE 17, 2013

EROSION CONTROL



CROSS SECTION

NOTES

1. UNCONSOLIDATED MATERIAL IS LOOSE STONE, GRAVEL, SAND, SOIL, OR MUCK NATURALLY DEPOSITED IN THE STREAM BED.
2. STOCKPILE BED MATERIAL AND SOIL IN SEPARATE STOCKPILES.
3. SOIL BACKFILL AND UNCONSOLIDATED BED MATERIAL SHALL BE SAME MATERIAL AS THAT REMOVED DURING EXCAVATION.
4. SOIL BACKFILL SHALL BE COMPACTED TO 95% OF STANDARD PROCTOR DENSITY.
5. EXTEND EACH END OF DRAIN PIPE TO A MINIMUM OF 24 INCHES INTO CRUSHED STONE ENCASEMENT.
6. 4" DRAIN IS OPTIONAL BASED ON SITE CONDITIONS.

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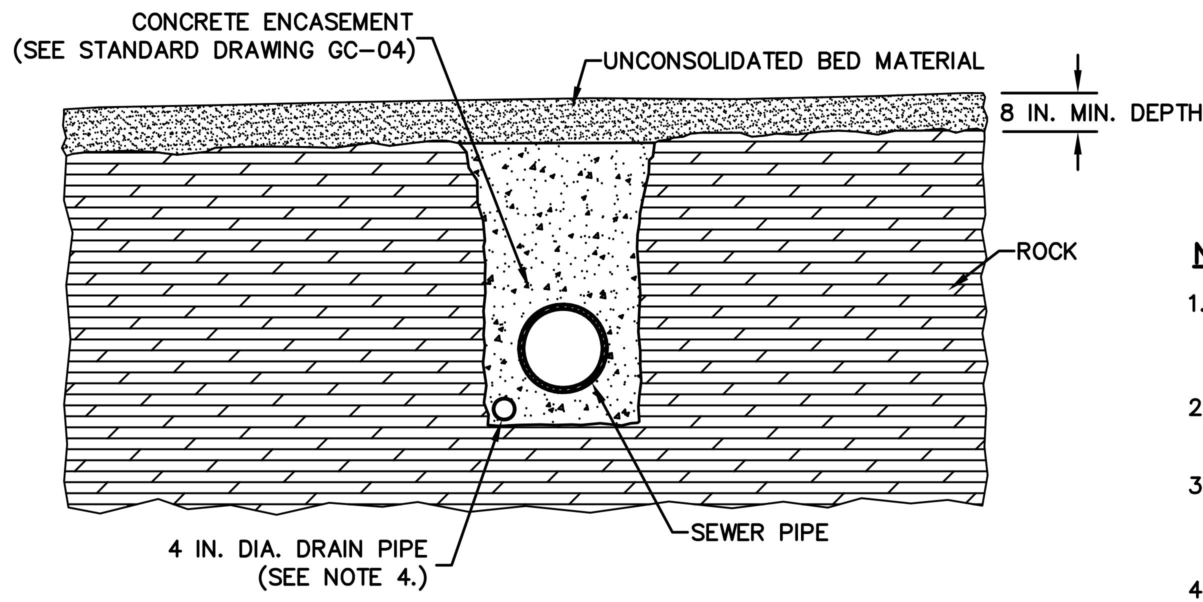
RESTORATION OF CHANNELS WITH UNCONSOLIDATED BEDS OVER SOIL

STANDARD DRAWING NO. EC-01-01

APPROVED BY: DIRECTOR OF ENGINEERING 9/30/2009 DATE



CROSS SECTION

NOTES

1. UNCONSOLIDATED MATERIAL IS LOOSE STONE, GRAVEL, SAND, SOIL, OR MUCK NATURALLY DEPOSITED IN THE STREAM BED.
2. STOCKPILE BED MATERIAL SEPARATE FROM SPOIL MATERIAL.
3. UNCONSOLIDATED BED MATERIAL SHALL BE SAME MATERIAL AS THAT REMOVED DURING EXCAVATION.
4. EXTEND EACH END OF DRAIN PIPE TO A MINIMUM OF 24 INCHES INTO CRUSHED STONE ENCASEMENT.
5. 4" DRAIN IS OPTIONAL BASED ON SITE CONDITIONS.

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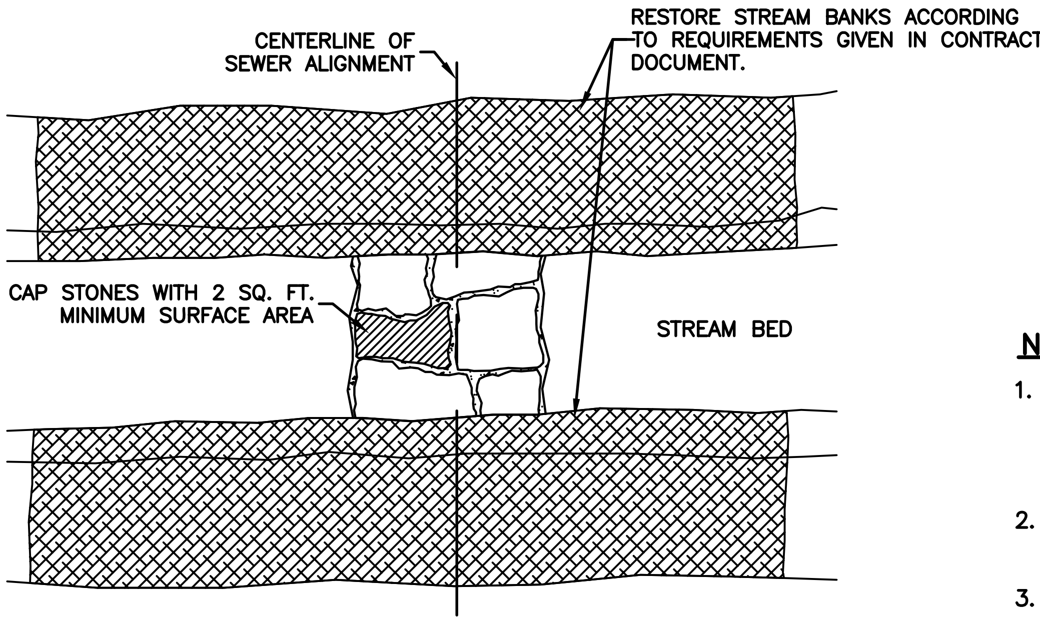
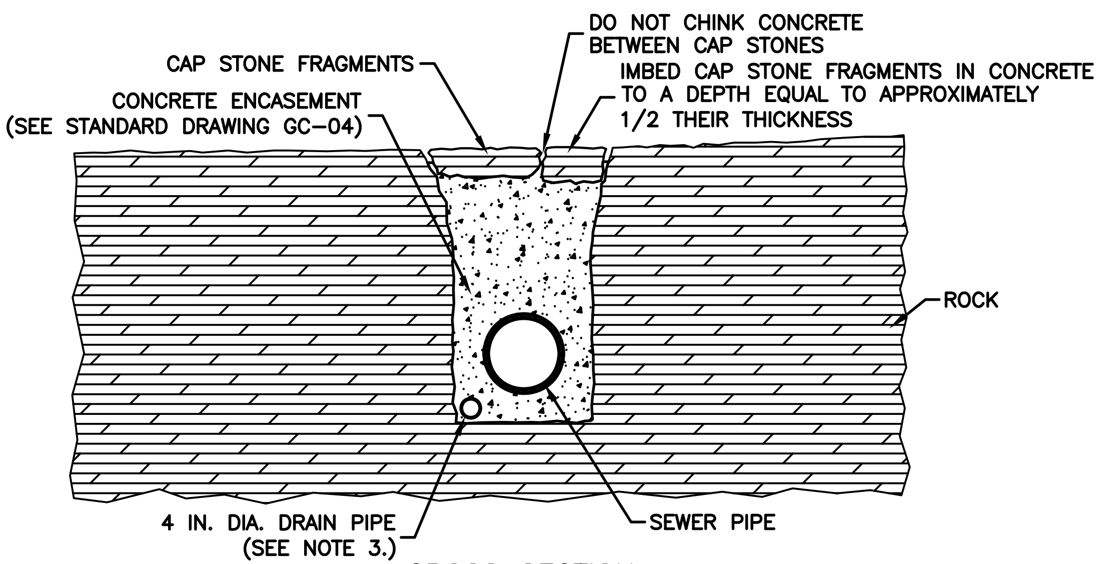
RESTORATION OF CHANNELS WITH UNCONSOLIDATED BEDS OVER ROCK

STANDARD DRAWING NO. EC-02-01

APPROVED BY: DIRECTOR OF ENGINEERING 9/30/2009 DATE



PLAN



CROSS SECTION

NOTES

1. USE THIS RESTORATION METHOD ON EXPOSED MONOLITHIC ROCK BEDS AND THOSE WITH LESS THAN 4 INCHES OF UNCONSOLIDATED BED MATERIAL DEPOSITED OVER A MONOLITHIC ROCK BED.
2. MINIMUM THICKNESS OF CAP STONE SHALL BE 8 INCHES.
3. EXTEND EACH END OF DRAIN PIPE A MINIMUM OF 24 INCHES INTO CRUSHED STONE ENCASEMENT.
4. 4" DRAIN IS OPTIONAL BASED ON SITE CONDITIONS.

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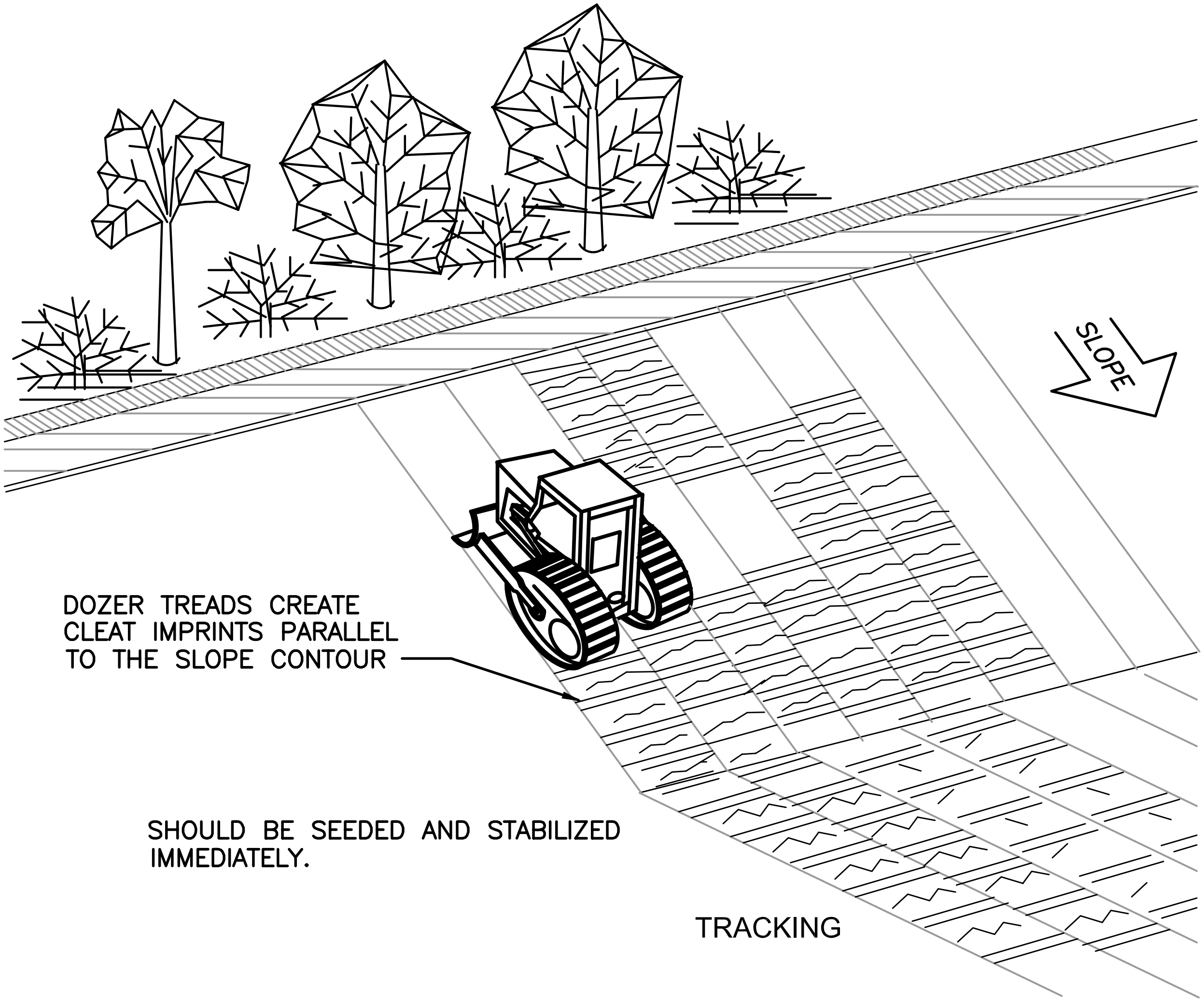
RESTORATION OF CHANNELS WITH ROCK BED

STANDARD DRAWING NO. EC–03–01

APPROVED BY: DIRECTOR OF ENGINEERING 9/30/2009 DATE



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SURFACE ROUGHENING
METHOD 1 OF 3

STANDARD DRAWING NO. EC-04-01

APPROVED BY: DIRECTOR OF ENGINEERING 9/30/2009 DATE

TRACKING

Tracking is defined as driving tracked machinery up and down slopes, leaving the cleat imprints parallel to the slope contour.

When and Where to Use It:

To slow erosion, surface roughening by tracking should be done as soon as possible after the vegetation has been removed from the slope.

Tracking can be used with seeding, planting and temporary mulching to stabilize an area.

Tracking should be performed immediately after grading activities have ceased (temporarily or permanently) in an area.

Installation:

It is important to avoid excessive compacting of the soil surface when tracking because soil compaction inhibits vegetation growth and causes higher runoff rates. As few passes as possible should be made with the machinery in order to minimize compaction.

Surface roughened areas by the means of tracking should be seeded and mulched immediately.

Inspection and Maintenance:

Inspections should be made every seven (7) calendar days and within 24–hours after each rainfall event that produces ½–inches or more of precipitation.

If rills (small watercourses that have steep sides and are usually only a few inches deep) appear, they should be re–graded and re–seeded immediately.

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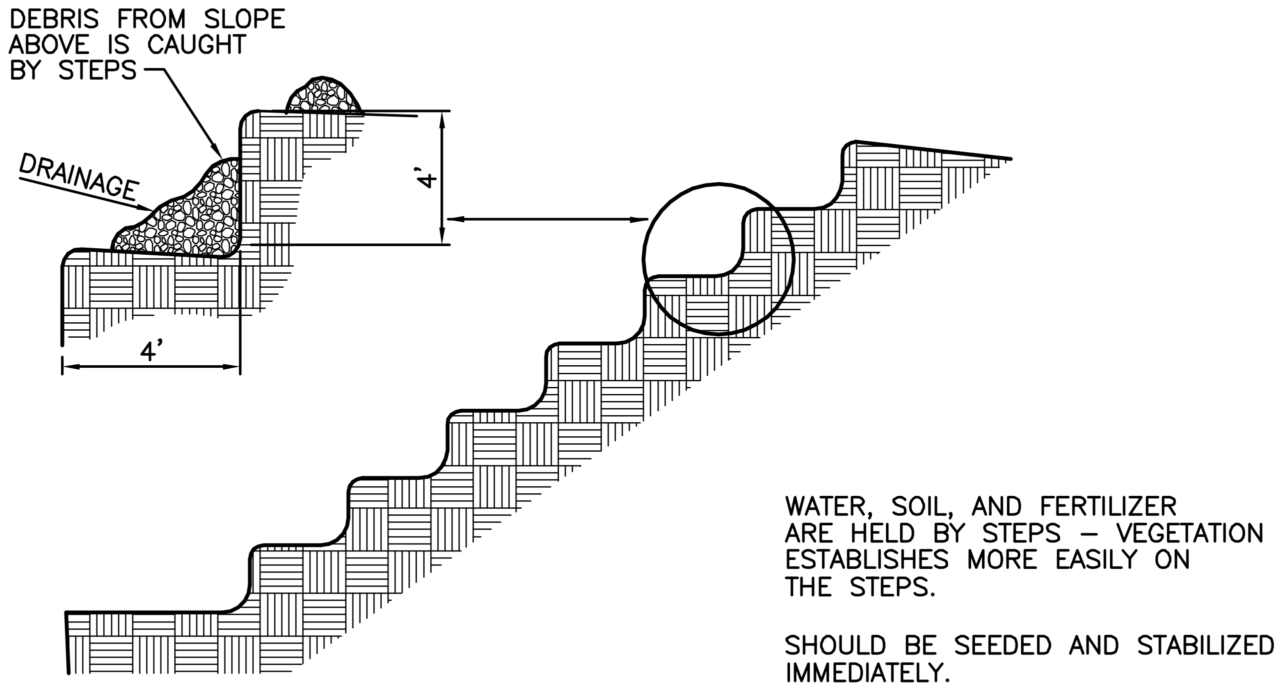
SURFACE ROUGHENING
METHOD 1 OF 3

APPROVED BY: DIRECTOR OF ENGINEERING 9/30/2009 DATE



STAIR STEPPING CUT SLOPES

SOURCE: VA. DSWC

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SURFACE ROUGHENING
METHOD 2 OF 3

STANDARD DRAWING NO. EC–05–02 Page 1 of 2

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4/30/2012
DATE

STAIR–STEP GRADING

Stair–Step Grading is defined as cutting stair–steps into slopes with each step having a maximum horizontal distance of 4–feet and a maximum vertical distance of 4–feet.

<u>When and Where to Use It</u>

To slow erosion, stair step grading should be done within 7 days after the vegetation has been removed from the slope.

Stair–step grading can be used with seeding, and planting to stabilize an area.

<u>Installation</u>:

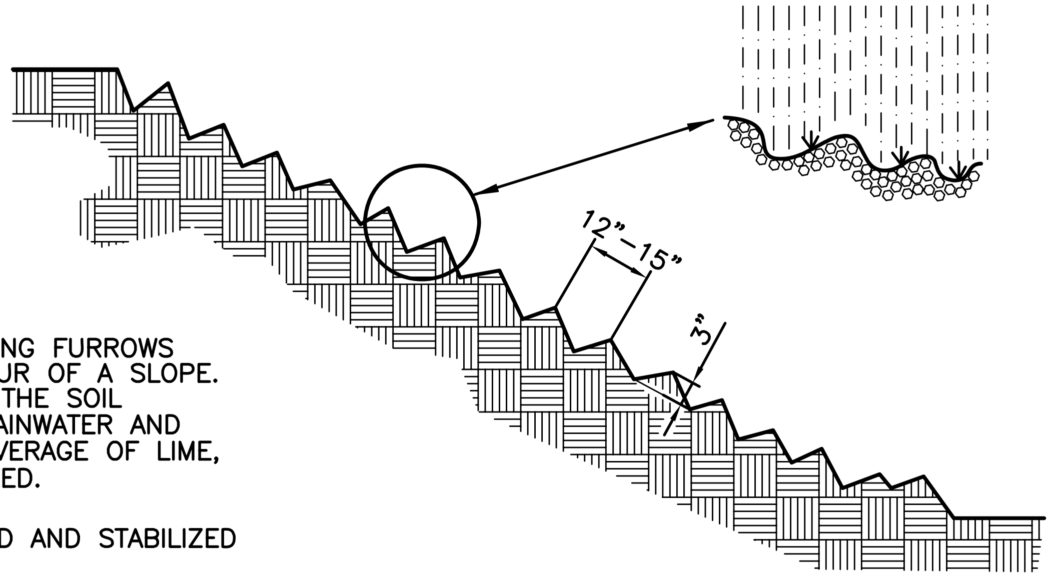
Stair–step grading may be carried out on any material soft enough to be moved with a bulldozer. The ratio of vertical cut distance to horizontal distance should not be steeper than 1:1 and the horizontal portion of the "step" should slope towards the vertical wall.

Areas that are graded in this manner should be seeded immediately.

<u>Inspection and Maintenance</u>:

Inspections should be made every seven (7) calendar days and within 24–hours after each rainfall event that produces ½–inches or more of precipitation.

If rills (small watercourses that have steep sides and are usually only a few inches deep) appear, they should be re–graded and re–seeded immediately.



GROOVING IS CUTTING FURROWS ALONG THE CONTOUR OF A SLOPE. IRREGULARITIES IN THE SOIL SURFACE CATCH RAINWATER AND PROVIDE SOME COVERAGE OF LIME, FERTILIZER AND SEED.

SHOULD BE SEEDED AND STABILIZED IMMEDIATELY.

GROOVING SLOPES

SOURCE: VA. DSWC

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SURFACE ROUGHENING METHOD 3 OF 3

STANDARD DRAWING NO. EC–06–01 Page 1 of 2

APPROVED BY: [signature] DIRECTOR OF ENGINEERING

9/30/2009
DATE

SLOPE GROOVING

Slope Grooving is defined by using machinery to create a series of ridges and depressions that run perpendicular to the slope on the contour.

When and Where to Use It:

To slow erosion, slope grooving should be done within 7 days after the vegetation has been removed from the slope.

Slope Grooving can be used with seeding and planting to stabilize an area.

Installation:

Slope Grooving may be installed with any appropriate implement that can be safely operated on the slope and will not cause undue compaction. Suggested implements include discs, chisel plows and the teeth on a front–end loader bucket. Such grooves should be a minimum of 3–inches deep and no further than 15–inches apart.

Areas that are graded in this manner should be seeded immediately.

Inspection and Maintenance:

Inspections should be made every seven (7) calendar days and within 24–hours after each rainfall event that produces ½–inches or more of precipitation.

If rills (small watercourses that have steep sides and are usually only a few inches deep) appear, they should be re–graded and re–seeded immediately.

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SURFACE ROUGHENING
METHOD 3 OF 3

STANDARD DRAWING NO. EC–06–01

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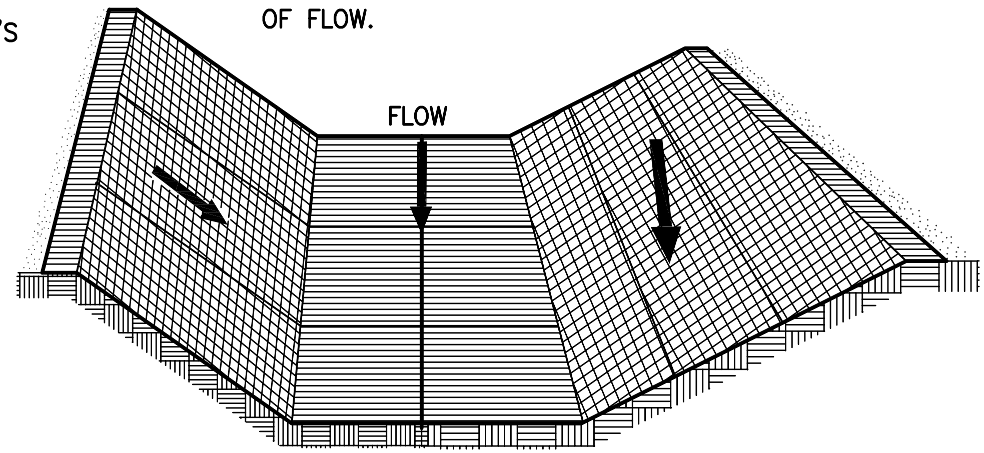
ON STEEP SLOPES, APPLY STRIPS OF NETTING PARALLEL TO THE DIRECTION OF FLOW AND ANCHOR AS PER MANUFACTURER'S SPECIFICATIONS.
(SLOPES GREATER THAN 1:1)

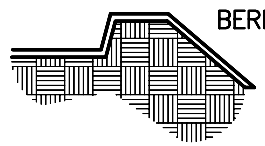
IN CHANNELS, APPLY NETTING PARALLEL TO THE DIRECTION OF FLOW.

LAY FROM BOTTOM UP W/ 4" LAP. KEY IN AT TOP OF SLOPE/BERM.

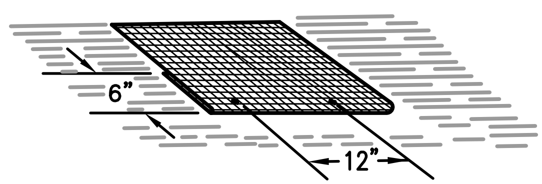


ON SHALLOW SLOPES, STRIPS OF NETTING MAY BE APPLIED ACROSS THE SLOPE.
(SLOPES UP TO 1:1)

WHERE THERE IS A BERM AT THE TOP OF THE SLOPE, BRING THE NETTING OVER THE BERM AND ANCHOR IT BEHIND THE BERM.



BRING NETTING DOWN TO LEVEL AREA BEFORE TERMINATING THE INSTALLATION.



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ORIENTATION OF NETTING AND MATTING

STANDARD DRAWING NO. EC-07-01 Page 1 of 2

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ORIENTATION OF NETTING AND MATTING

Installation:

The proper installation of netting and matting is different for each product, therefore the recommended installation procedure from the manufacturer should be followed.

Overlap the edges of each strip at least 4–inches and staple every 3–feet down the center of the overlap when overlapping separate strips of netting and matting,

Bring netting and matting down to a level area before terminating the installation. Turn the ends under at least 6–inches and staple the end of the matting at 12–inch intervals.

Netting and Matting must be applied so that it is in complete contact with the soil. If not, erosion will occur beneath it.

Netting should be securely anchored to the soil as recommended by the manufacturer guidelines.

Mulch binders should be applied at rates recommended by the manufacturer.

Inspection and Maintenance:

Areas protected by netting and matting should be checked for dislocation or failure every seven (7) calendar days and within 24–hours after each rainfall event that produces ½–inches or more of precipitation.

Regular inspections should take place until grasses are firmly established.

If washouts or breakage occurs, re–install netting and matting as necessary after repairing any slope damage.

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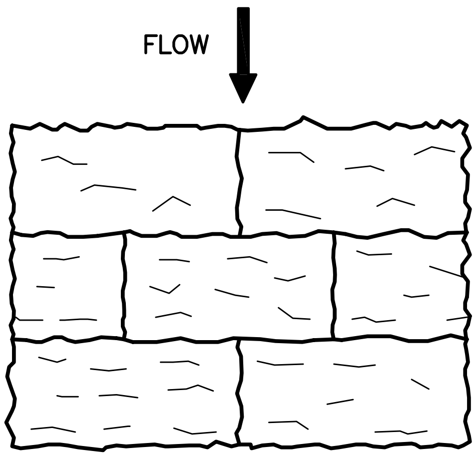
ORIENTATION OF
NETTING AND MATTING

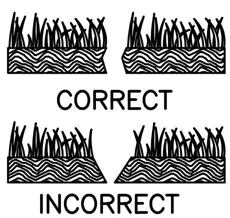
STANDARD DRAWING NO. EC–07–01 Page 2 of 2

APPROVED BY: DIRECTOR OF ENGINEERING 9/30/2009 DATE



SHAPE AND SMOOTH SOIL SURFACE TO FINAL GRADE. WORK PRESCRIBED LIME AND FERTILIZER INTO THE SOIL.

LAY SOD IN A STAGGERED PATTERN. BUTT THE STRIPS TIGHTLY AGAINST EACH OTHER. DO NOT LEAVE SPACES AND DO NOT OVERLAP. A SHARPENED MASON'S TROWEL IS A HANDY TOOL FOR TUCKING DOWN THE ENDS AND TRIMMING PIECES.



BUTTING – ANGLED ENDS CAUSED BY THE AUTO-MATIC SOD CUTTER MUST BE MATCHED CORRECTLY.

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SODDING

STANDARD DRAWING NO. EC–08–01 Page 1 of 2

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SODDING STANDARD

Installation:

Shape and smooth the soil surface to final grade in accordance with the approved grading plan.

Add lime to reach a soil pH value required by the specific grass. Fertilize according to a soil test or in the absence of a test use available nitrogen, phosphorous and potash as prescribed for permanent seeding. Work lime and fertilizer into the soil 3– to 6–inches deep and smooth the surface.

Clear the soil surface of trash, debris, roots, branches, stones and soil clods in excess of 2–inches of length or diameter. Rake soil surface to break crust just before laying sod, or irrigate soil lightly if the soil is dry. Do not install sod on hot, dry soil, compacted clay, frozen soil, gravel, or soil that has been treated with pesticides.

Sod should be harvested, delivered, and installed within a period of 36 hours. Store rolls of sod in the shade during installation. Sod should be free of weeds and be of uniform thickness (approximately 1–inch) and should have a dense root mat for mechanical strength.

Lay strips of sod beginning at the lowest area to be sodded with the longest dimension of the strip perpendicular to the slope, and stagger in a brick–like pattern. Wedge strips securely in place. Square the ends of each strip to provide for a close, tight fit. Match angled ends correctly to prevent voids.

Roll or compact immediately after installation to ensure firm contact with the underlying topsoil.

Irrigate the sod until the soil is wet to a depth of 4–inches, and keep moist until grass takes root.

If placed on steep slopes, sod should be laid with staggered joints and/or be pegged and stapled. In areas such as steep slopes or next to running waterways, chicken wire, jute, or other netting can be placed over the sod for extra protection against lifting.

Inspection and Maintenance:

Watering may be necessary after planting and during periods of intense heat and/or lack of rain (drought). Keep soil moist to a depth of 4–inches until sod is fully rooted.

Mow to a height of 2– to 3–inches after sod is well–rooted (2–3 weeks). Do not remove more than 1/3 of the shoot in any one mowing.

Permanent, fine turf areas require yearly applications of fertilizer and lime.

Inspect the sod every 7 days after it is first installed, especially within 24 hours of rain events that produce 0.5 inches ormore percipitation, until it has established a permanent cover.

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SODDING

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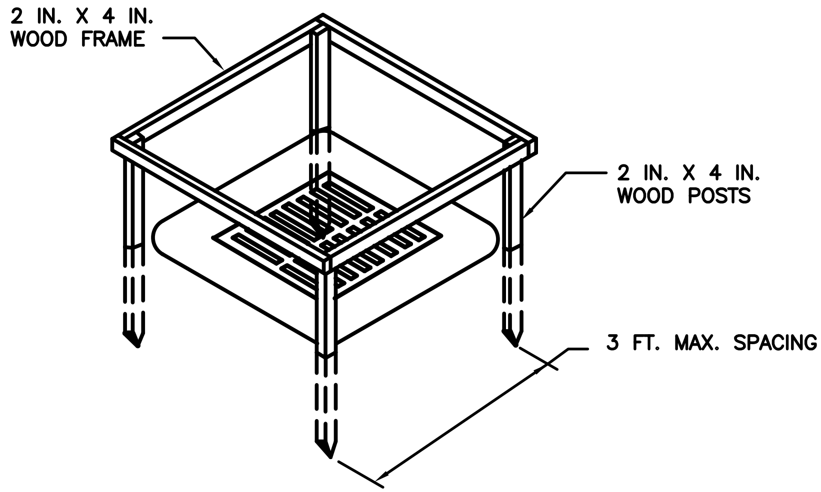
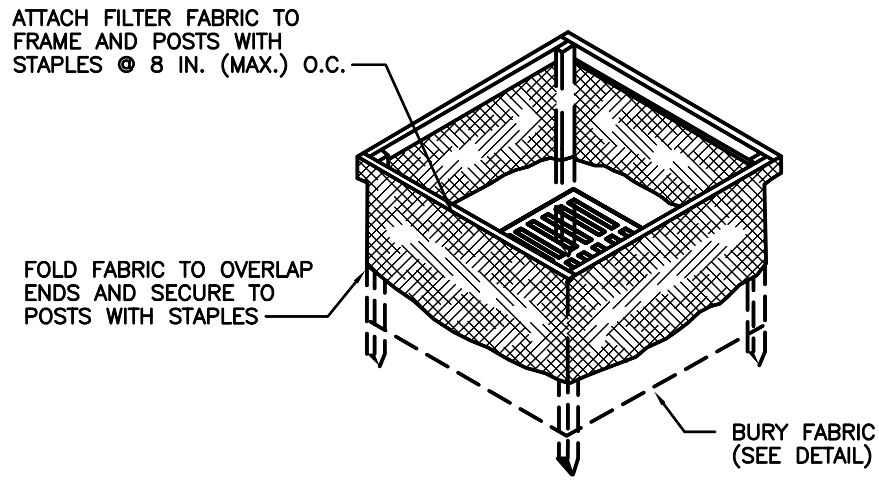
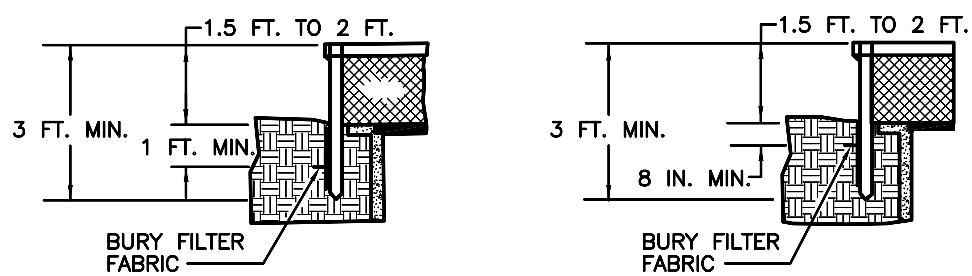


WOOD FRAME CONSTRUCTION DETAIL



FILTER FABRIC INSTALLATION DETAIL



FILTER FABRIC BURIAL OPTIONS

SOURCE:
INDIANA HANDBOOK FOR EROSION CONTROL IN DEVELOPING AREAS
NORTH CAROLINA SEDIMENT AND EROSION CONTROL PLANNING AND DESIGN MANUAL

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FILTER FABRIC INLET PROTECTION

STANDARD DRAWING NO. EF-01-02 Page 1 of 2

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FILTER FABRIC INLET PROTECTION

Installation:

Filter fabric is used for inlet protection when storm water flows are relatively small (0.5 cfs or less) with low velocities and where the inlet drains a relatively flat area (slopes no greater than 5%). This practice cannot be used where inlets are paved or where inlets receive concentrated flows such as in streets or highway medians.

Extra–strength filter cloth (50 pounds / linear inch minimum tensile strength) should be used. Filter fabric shall be cut from a continuous roll to avoid joints.

Stakes shall be 2–in. x 4–in. wood with a minimum length of 3–feet. The height of the filter barrier above grade shall be a minimum of 1.5–feet and shall not exceed 2–feet.

Stakes shall be spaced around the perimeter of the inlet a maximum of 3–feet apart and driven into the ground a minimum of 1.5 –feet.

A trench shall be excavated 4–inches wide and 8–inches deep around the outside perimeter of the stakes.

The filter fabric shall be stapled to the wooden stakes with staples made of heavy–duty wire at least ½–inch long.

The fabric shall be extended into the trench 8–inches.

The trench should backfilled with soil or crushed stone and compacted over the filter fabric.

Inspection and Maintenance:

Inspections should be made every seven (7) calendar days and within 24–hours after each rainfall event that produces ½–inches or more of precipitation. Any needed repairs should be made immediately.

If the fabric becomes clogged, it should be replaced.

Sediment should be removed when it reaches approximately 1/3 the height of the fence. If a sump is used, sediment should be removed when it fills approximately 1/3 the depth of the hole. Maintain the pool area, always providing adequate sediment storage volume for the next storm. Take care not to damage or undercut fabric when removing sediment.

Storm drain inlet protection structures should be removed only after the disturbed areas are permanently stabilized. Remove all construction material and sediment, and dispose of them properly. Grade the disturbed area to the elevation of the drop inlet structure crest. Use appropriate permanent stabilization methods to stabilize bare areas around the inlet.

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FILTER FABRIC INLET PROTECTION

STANDARD DRAWING NO. EF–01–02 Page 2 of 2

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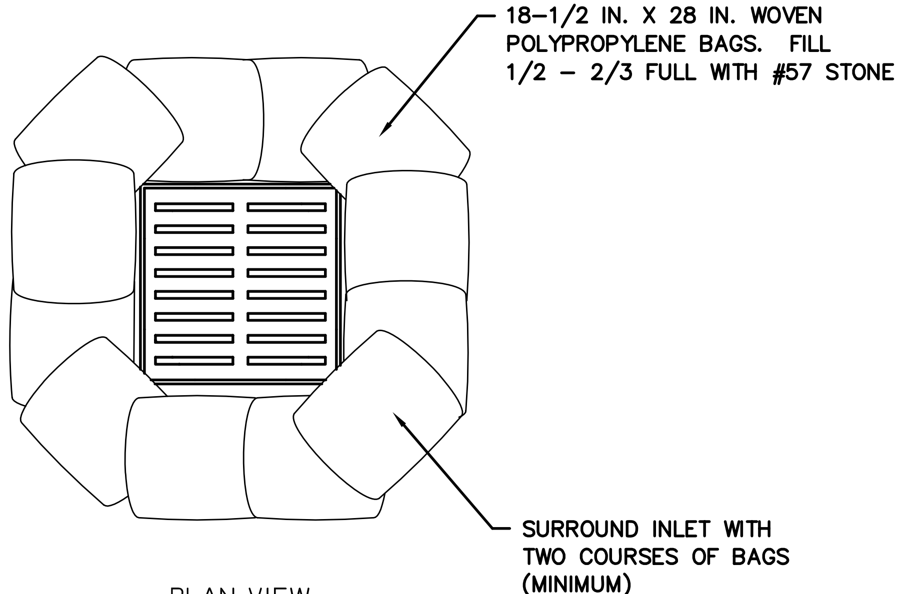
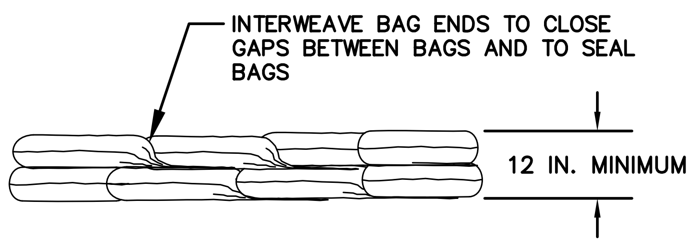


PLAN VIEW



ELEVATION

NOTE: THE 12-INCH HEIGHT REQUIREMENT IS WAIVED IN CASES WHERE IT WILL CAUSE FLOOD DAMAGE IF THE STONE BAGS ARE OVERTOPPED.

TYPE III STONE BAG SILT CHECK AT CATCH BASINS

NOT TO SCALE

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STONE BAG INLET PROTECTION

STANDARD DRAWING NO. EF-03-02 Page 1 of 2

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STONE BAG INLET PROTECTION

Installation:

Stone fill bags shall be be woven polypropylene bags with approximate dimensions of 18–1/2 inches by 28 inches.

The bags shall be filled ½ to 2/3 full with KTC #57 stone. Tie the ends of filled bags using either draw strings or wire ties.

Interweave the loose ends of the bags so that the gaps between bags are filled and the ends of the bags are sealed.

Completely surround the inlet with a minimum of two (2) rows of bags to a minimum of 12 inches in height.

Inspection and Maintenance:

Inspections should be made every seven (7) calendar days and within 24–hours after each rainfall event that produces ½–inches or more of precipitation. Any needed repairs should be handled immediately.

If sediment accumulates, remove it from the face of the bags before it accumulates to a height equal to 1/3 the structure height. Any needed repairs should be handled immediately. Take care not to damage or undercut the bags when removing sediment.

Remove and replace any damaged bags and dispose of them properly.

Storm drain inlet protection structures should be removed only after the disturbed areas are permanently stabilized. Remove all construction material and sediment, and dispose of them properly. Grade the disturbed area to the elevation of the drop inlet structure crest. Use appropriate permanent stabilization methods to stabilize bare areas around the inlet.

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STONE BAG INLET PROTECTION

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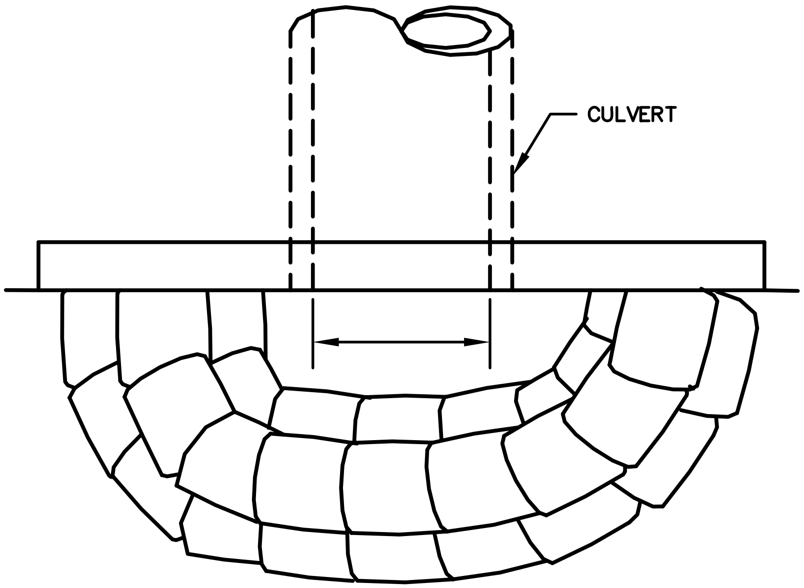
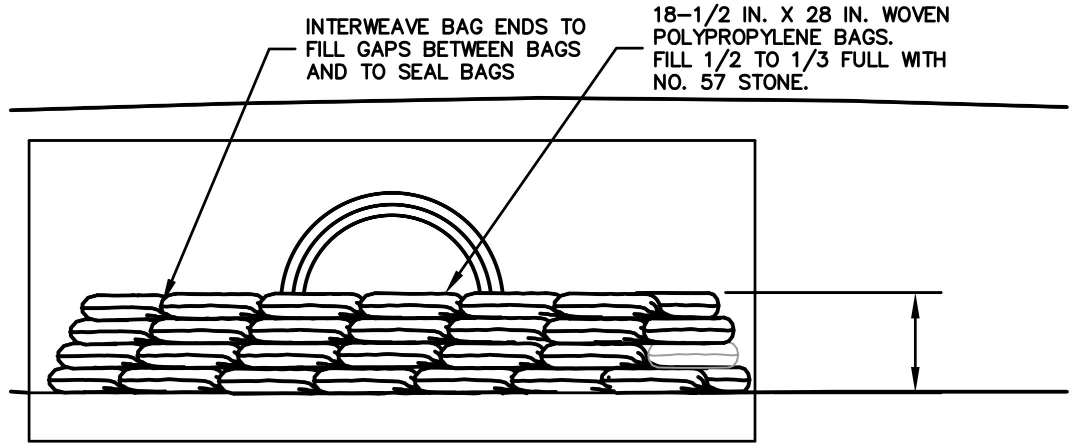


PLAN VIEW



UPSTREAM ELEVATION

Purpose:
Install stone bag protection at straight headwall inlets to pool water, providing opportunity for settling sediment before it enters headwall.

Design Criteria:
Bag specifications: Approximately 18 1/2-inch X 28-inch woven polypropylene bags.
Stone: Use KTC No. 5 7 Stone.
Height of stone bags above culvert inverts: Construct a minimum of two courses of bags. The stone-filled bags shall be stacked to a height equal to 1/2 the diameter of the culvert being protected.

Bid Units:
Installation: "Each"

Bid each stone bag inlet protection structure shown on the Erosion Prevention and Sediment Control Plan as a unit. Do not separate items such as stone and bags.

Maintenance: "Each"

Bid item provides for sediment removal and general upkeep for the life of the project. Replacement of inlet protection structures damaged by storm flows or natural deterioration will be reimbursed at the unit cost established for installation. Replacement of stone bag inlet protection that was damaged by activities incidental to construction will not be reimbursed. Inspect inlet protection every seven (7) days and after every storm event

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STRAIGHT HEADWALL INLET PROTECTION

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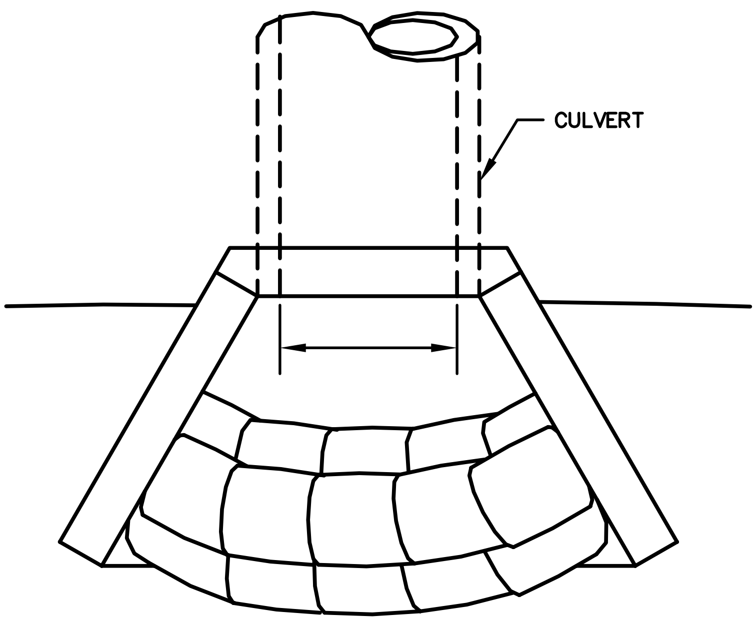
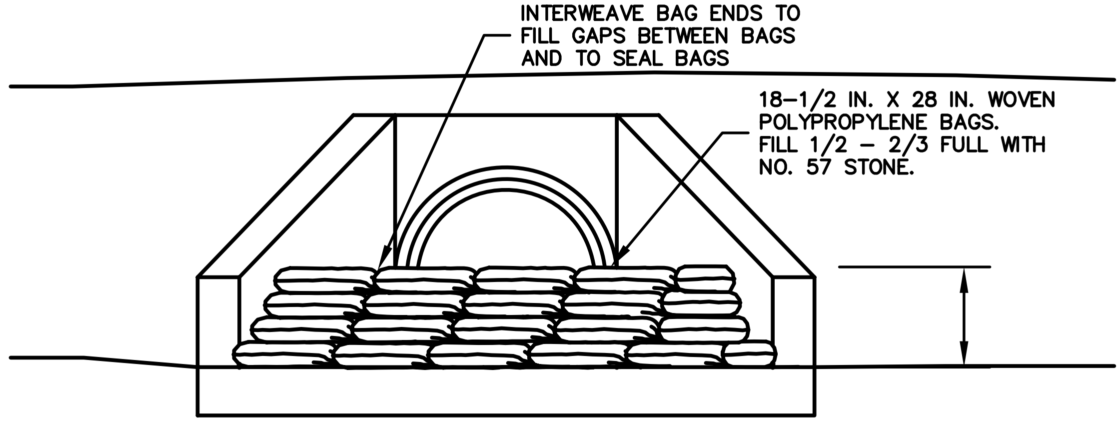


PLAN VIEW



UPSTREAM ELEVATION

Purpose:
Install stone bag protection at winged headwall inlets to pool water, providing opportunity for settling sediment before it enters headwall.

Design Criteria:
Bag specifications: Approximately 18 1/2-inch X 28-inch woven bags. Stone: Use KTC No. 57 Stone.
Height of stone bags above culvert inverts: Construct a minimum of two courses of bags. The stone-filled bags shall be stacked to a height equal to 1/2 the diameter of the culvert being protected.

Bid Units:
Installation: "Each"

Bid each stone bag inlet protection structure shown on the Erosion Prevention and Sediment Control Plan as a unit. Do not separate items such as stone and bags.

Maintenance: "Each"

Bid item provides for sediment removal and general upkeep for the life of the project. Replacement of inlet protection structures damaged by storm flows or natural deterioration will be reimbursed at the unit cost established for installation. Replacement of stone bag inlet protection that was damaged by activities incidental to construction will not be reimbursed. Inspect inlet protection every seven (7) days and after every storm event

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WINGED HEADWALL INLET PROTECTION

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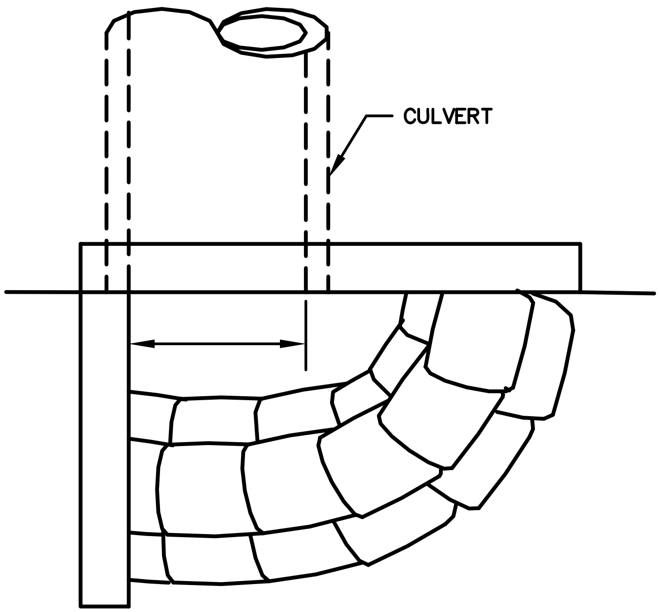
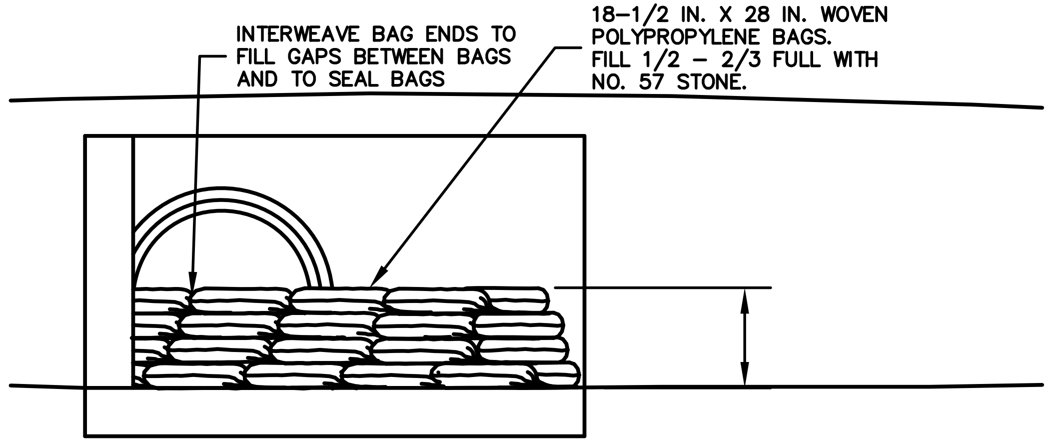


PLAN VIEW



UPSTREAM ELEVATION

Purpose:
Install stone bag protection at ell headwall inlets to pool water, providing opportunity for settling sediment before it enters headwall.

Design Criteria:
Bag specifications: Approximately 18 1/2-inch X 28-inch woven bags. Stone: Use KTC No. 57 Stone.
Height of stone bags above culvert inverts: Construct a minimum of two courses of bags. The stone-filled bags shall be stacked to a height equal to 1/2 the diameter of the culvert being protected.

Bid Units:
Installation: "Each"

Bid each stone bag inlet protection structure shown on the Erosion Prevention and Sediment Control Plan as a unit. Do not separate items such as stone and bags.

Maintenance: "Each"

Bid item provides for sediment removal and general upkeep for the life of the project. Replacement of inlet protection structures damaged by storm flows or natural deterioration will be reimbursed at the unit cost established for installation. Replacement of stone bag inlet protection that was damaged by activities incidental to construction will not be reimbursed. Inspect inlet protection every seven (7) days and after every storm event

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ELL HEADWALL
INLET PROTECTION

STANDARD DRAWING NO. EF-07-02

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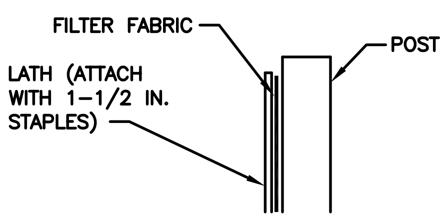
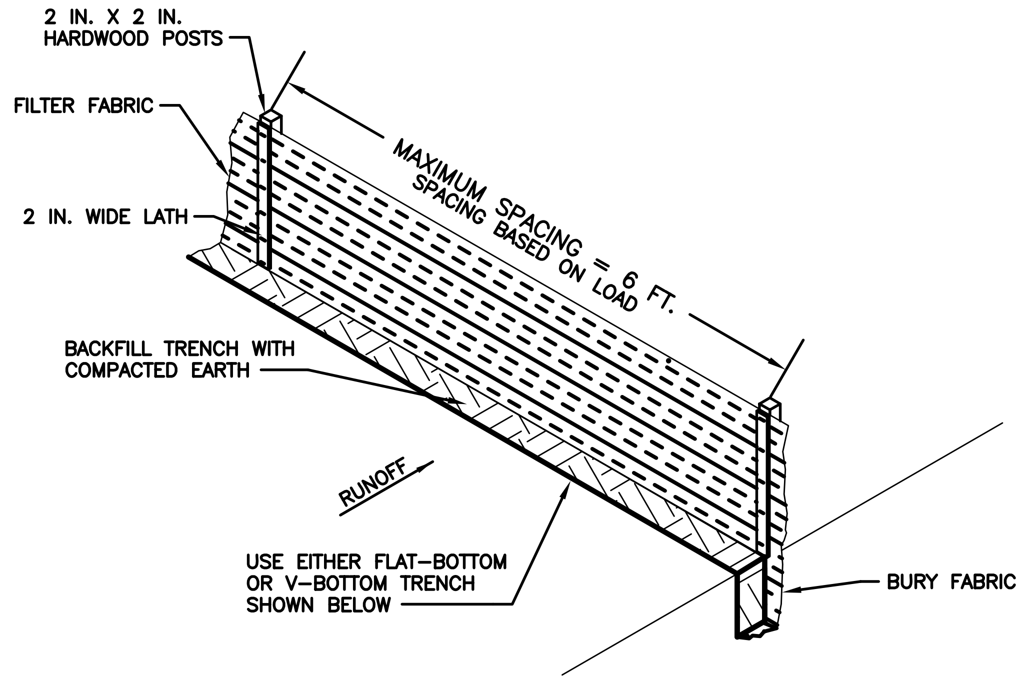
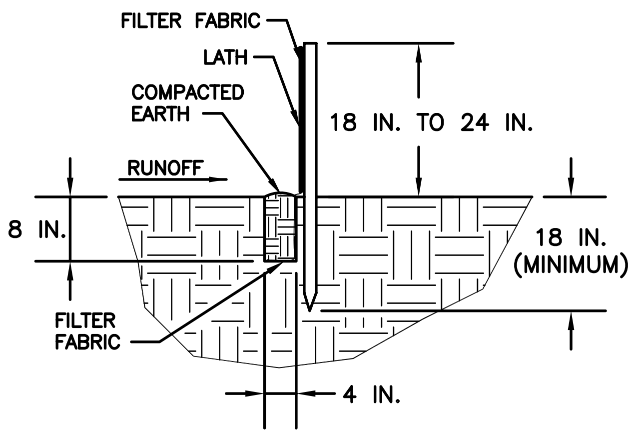


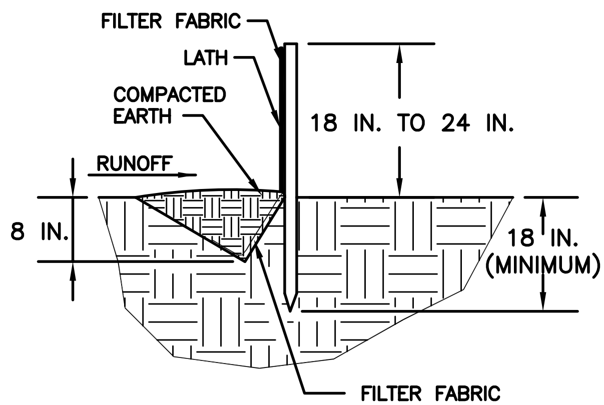
FABRIC ATTACHMENT DETAIL



SILT FENCE INSTALLATION



FLAT-BOTTOM TRENCH DETAIL



V-SHAPED TRENCH DETAIL

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SILT FENCE

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SILT FENCE DETAIL

Installation:

The fence should be placed across the slope along a line of uniform elevation (perpendicular to the direction of flow). The fence should be located at least 10–feet from the toe of steep slopes to provide sediment storage and access for maintenance and cleanout.

A flat–bottom trench approximately 4–inches wide and 8–inches deep, or a V–shaped trench 8–inches deep should be excavated. On the downslope side of the trench, drive the 2–in. X 2–in. wood posts at least 18–inches into the ground, spacing them no further than 6–feet apart.

Posts should be installed, with 1– to 2–inches of the post protruding above the top of the fabric and no more than 3–feet of the post should protrude above the ground. The minimum fence height (height of filter fabric above grade) shall be 18–inches. The maximum fence height (height of filter fabric above grade) shall be 24–inches.

The filter fabric should be purchased in a continuous roll and cut to the length of the barrier to avoid the use of joints. When joints are necessary, filter cloth should be wrapped together only at a support post with both ends securely fastened to the post, with a minimum 6–inch overlap.

Extra–strength filter cloth (50 pounds / linear inch minimum tensile strength) should be used. A 2–inch wide lathe shall be stapled over the filter fabric to securely fasten it the to the upslope side of the posts. The staples used should be 1.5–inch heavy–duty wire staples spaced a maximum of 8–inches apart.

Place the bottom 12–inches of the filter fabric into the 8–inch deep trench, extending the remaining 4–inches towards the up–slope side of the trench and backfill the trench with soil or gravel and compact.

Inspection and Maintenance:

Inspect silt fence every seven (7) calendar days and within 24–hours after each rainfall event that produces ½–inches or more of precipitation. Check for areas where runoff has eroded a channel beneath the fence, or where the fence was caused to sag or collapse by runoff overtopping the fence.

If the fence fabric tears, begins to decompose, or in any way becomes ineffective, replace the affected section of fence immediately.

Sediment must be removed when it reaches approximately 1/3 the height of the fence, especially if heavy rains are expected.

Silt fence should be removed within 30 days after final site stabilization is achieved or after temporary BMPs are no longer needed. Trapped sediment should be removed or stabilized on site. Disturbed areas resulting from fence removal shall be permanently stabilized.

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SILT FENCE	
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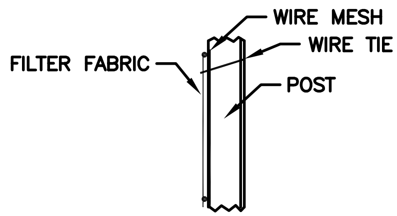

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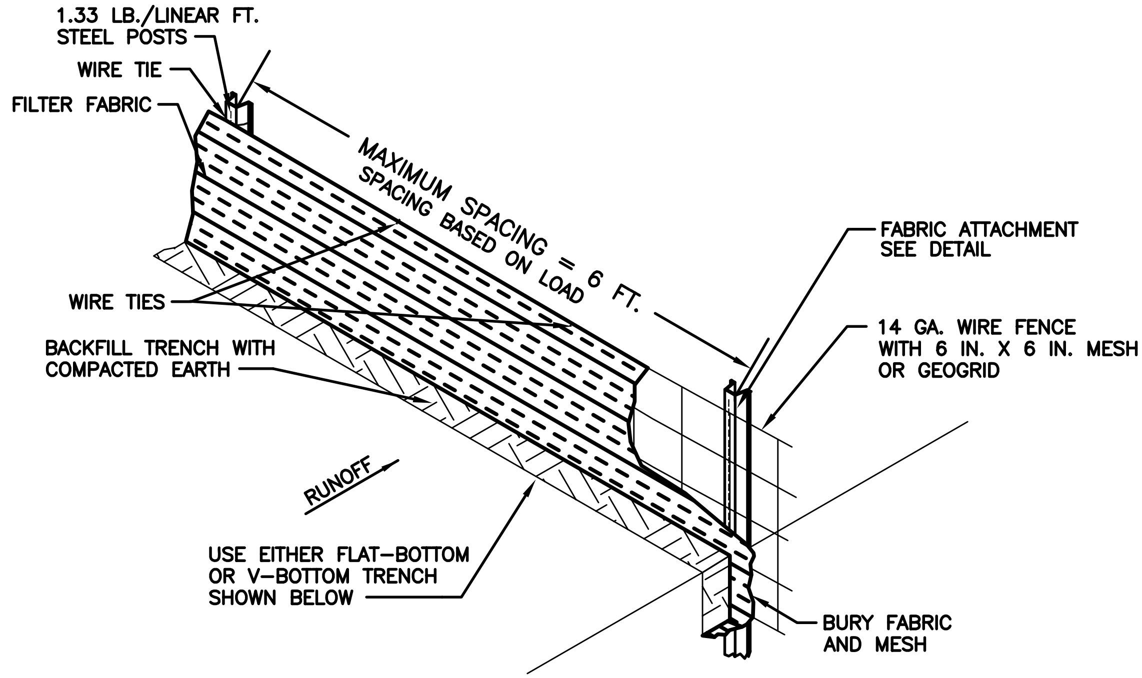
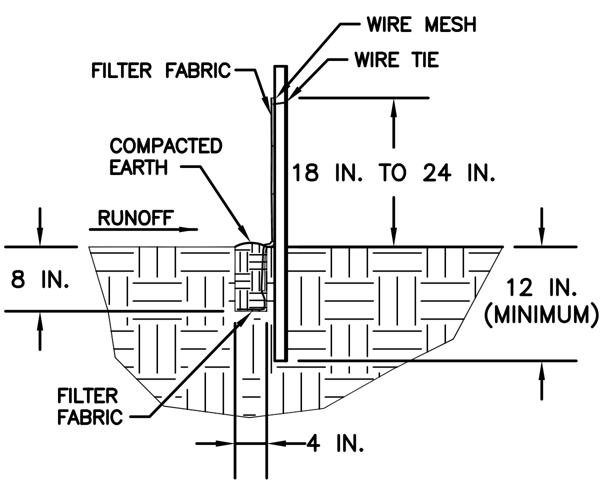
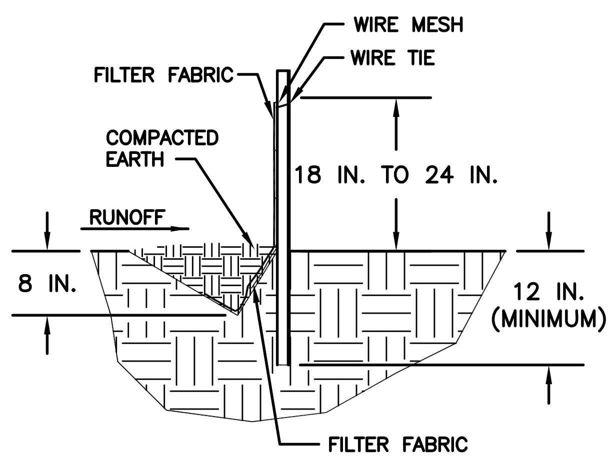


SILT FENCE INSTALLATION



FLAT-BOTTOM TRENCH DETAIL



V-SHAPED TRENCH DETAIL

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REINFORCED SILT FENCE

STANDARD DRAWING NO. EF-10-02 Page 1 of 2

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REINFORCED SILT FENCE

Installation:

The fence should be placed across the slope along a line of uniform elevation (perpendicular to the direction of flow). The fence should be located at least 10-feet from the toe of steep slopes to provide sediment storage and access for maintenance and cleanout.

A flat-bottom trench approximately 4-inches wide and 8-inches deep, or a V-shaped trench 8-inches deep should be excavated. On the downslope side of the trench, drive the 1.33 lb./linear foot steel posts at least 12-inches into the ground, spacing them no further than 6-feet apart.

Posts should be installed, with 1- to 2-inches of the post protruding above the top of the fabric and no more than 3-feet of the post should protrude above the ground. The minimum fence height (height of filter fabric) above grade shall be 18-inches. The maximum fence height (height of filter fabric) above grade shall be 24-inches.

Fasten the 6-inch by 6-inch 14 gage wire mesh to the upslope side of the posts using heavy duty wire staples at least 1-inch long, tie wires or hog rings. Extend the mesh 6-inches into the trench.

The filter fabric should be purchased in a continuous roll and cut to the length of the barrier to avoid the use of joints. When joints are necessary, filter cloth should be wrapped together only at a support post with both ends securely fastened to the post, with a minimum 6-inch overlap.

Extra-strength filter cloth (50 pounds / linear inch minimum tensile strength) should be used. Use plastic wire ties to attach the fabric to the post and wire. Extend 12-inches of the fabric into the trench.

Place the bottom 12-inches of the filter fabric into the 8-inch deep trench, extending the remaining 4-inches towards the up-slope side of the trench and backfill the trench with soil or gravel and compact.

Inspection and Maintenance:

Inspect silt fence every seven (7) calendar days and within 24-hours after each rainfall event that produces ½-inches or more or of precipitation. Check for areas where runoff has eroded a channel beneath the fence, or where the fence was caused to sag or collapse by runoff overtopping the fence.

If the fence fabric tears, begins to decompose, or in any way becomes in effective, replace the affected section of fence immediately.

Sediment must be removed when it reaches approximately 1/3 the height of the fence, especially if heavy rains are expected.

Reinforced silt fence should be removed 30 days after final site stabilization is achieved or after temporary BMPs are no longer needed. Trapped sediment should be removed or stabilized on site. Disturbed areas resulting from fence removal shall be permanently stabilized.

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REINFORCED SILT FENCE

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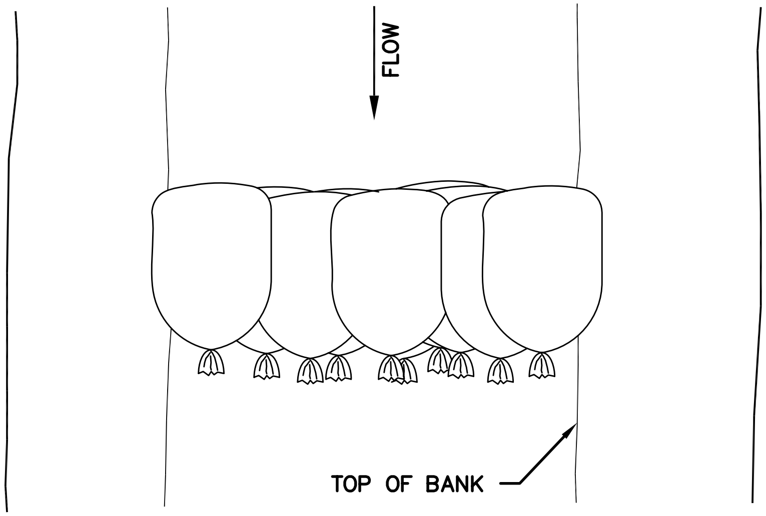
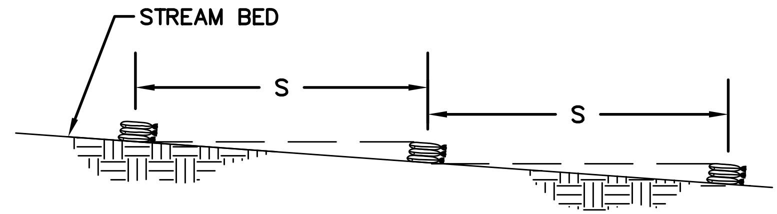
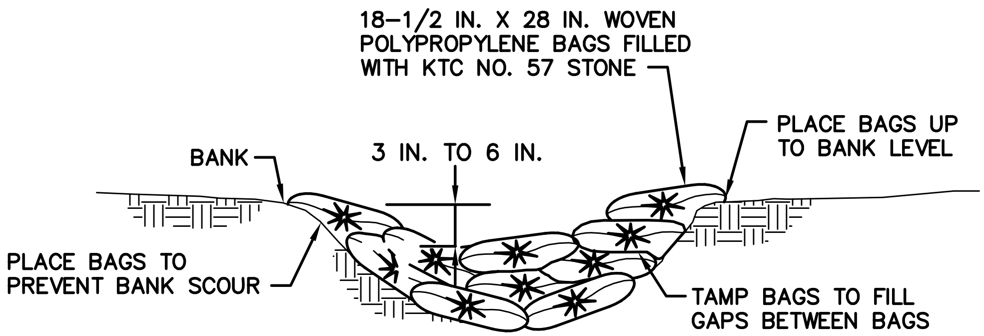


TYPICAL PLAN



NOTE: SPACE SERIES OF VELOCITY CHECKS ALONG STREAM REACH. USE SPACING "S" SUCH THAT THE CRESTS OF DOWNSTREAM CHECKS ARE THE SAME ELEVATION AS THE TOE OF UPSTREAM CHECKS.



TYPICAL CROSS SECTION

STONE BAG SILT / VELOCITY CHECK

NOT TO SCALE

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STONE BAG CHECK DAM IN SMALL DITCH

STANDARD DRAWING NO. EF–12–02 Page 1 of 2

APPROVED BY: [signature] DIRECTOR OF ENGINEERING

9/30/2009 DATE

STONE BAG CHECK DAM IN SMALL DITCH

When and Where to Use It:

Stone bag checks are to be placed in man-made swales and ditches only. Stone bag check dams should not be built in wetlands, any active or live streams, and in Waters of Commonwealth.

Stone bag check dams are applicable in situations where flow velocities are too high causing channel scour. They should not be used as a primary sediment-trapping device. They should be used as velocity checks only as a short-term temporary solution.

Specific conditions for use include new diversion ditches that will not or cannot be stabilized for several days, and temporary diversion channels that are eroding due to high flow rates or steep slopes.

Installation:

Stone fill bags shall be be woven polypropylene bags with approximate dimensions of 18-1/2 inches by 28 inches. The bags shall be filled with KTC No. 57 stone. Tie the ends of filled bags using either draw strings or wire ties.

Stone bag check dams shall span the banks of the ditch or swale.

The height of the dam at the stream centerline shall equal the height noted on the plans, or equal the approximate stage for normal storm flows.

Place bags at the banks to a height at least 6 inches above the center of the check.

Space stone bag ditch checks as shown on the plans, or such that the crest of the downstresm check is at the same elevation as the toe of the check located immediately upstream.

Inspection and Maintenance:

Inspect checks every seven (7) calendar days and within 24-hours after each rainfall event that produces ½-inches or more of precipitation. Check for structural damage, channel erosion and sediment deposition. If sediment accumulates, remove it from the upstream face of the check before it accumulates to a height equal to 1/3 the structure height. Make all necessary repairs immediately.

Split the spacing between existing checks with an additional check if stream erosion problems persist within a reach.

Reinforce checks with additional stone bags as required to maintain integrity. Remove and replace any damaged bags and dispose of them properly. Do not leave damaged or empty bags in the ditch at any time.

Remove checks as soon as they are no longer required to control flow velocities and the ditch can be stabilized according to the appropriate stabilization schedule or is taken out of service.

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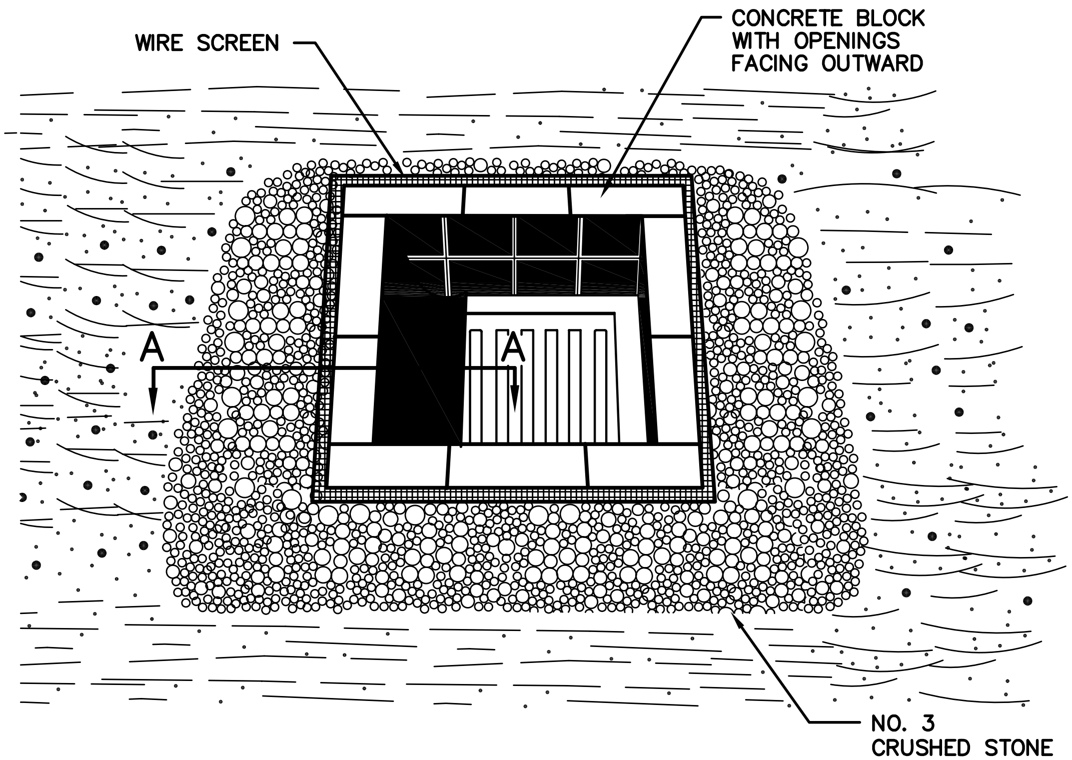
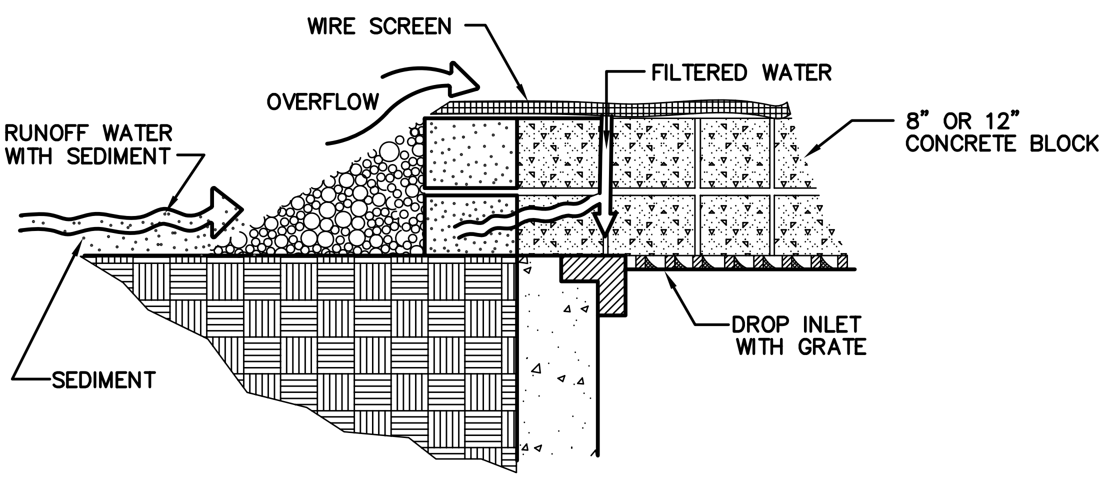
STONE BAG CHECK DAM
IN SMALL DITCH

STANDARD DRAWING NO. EF-12-02 Page 2 of 2

APPROVED BY: DIRECTOR OF ENGINEERING 9/30/2009 DATE





CROSS SECTION A-A

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BLOCK AND GRAVEL DROP INLET PROTECTION

STANDARD DRAWING NO. EF-13-01 Page 1 of 2

APPROVED BY: [signature] DIRECTOR OF ENGINEERING — 9/30/2009 DATE

BLOCK AND GRAVEL DROP INLET PROTECTION

Installation:

Block and gravel filters can be used where heavy flows and higher velocities are expected and where an overflow capacity is necessary to prevent excessive ponding around the structure.

Gravel shall consist of KTC #57 Crushed Stone.

Place concrete blocks lengthwise on their side so that the open end faces outward, not upward.

The height of the barrier can be varied, depending upon design needs by stacking a combination of blocks that are 8- and 12-inches wide.

Wire mesh should be placed over the outside vertical face of the concrete blocks to prevent stones from being washed through the holes in the blocks. Hardware cloth or comparable wire mesh with ½-inch openings should be used.

Inspection and Maintenance:

Inspections should be made every seven (7) calendar days and within 24-hours after each rainfall event that produces ½-inches or more of precipitation. Any needed repairs should be handled immediately.

Sediment should be removed when it reaches approximately 1/3 the height of the blocks. If a sump is used, sediment should be removed when it fills approximately 1/3 the depth of the hole.

If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.

Storm drain inlet protection structures should be removed only after the disturbed areas are permanently stabilized. Remove all construction material and sediment, and dispose of them properly. Grade the disturbed area to the elevation of the drop inlet structure crest. Stabilize all bare areas immediately.

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BLOCK AND GRAVEL DROP INLET PROTECTION

STANDARD DRAWING NO. EF-13-01 Page 2 of 2

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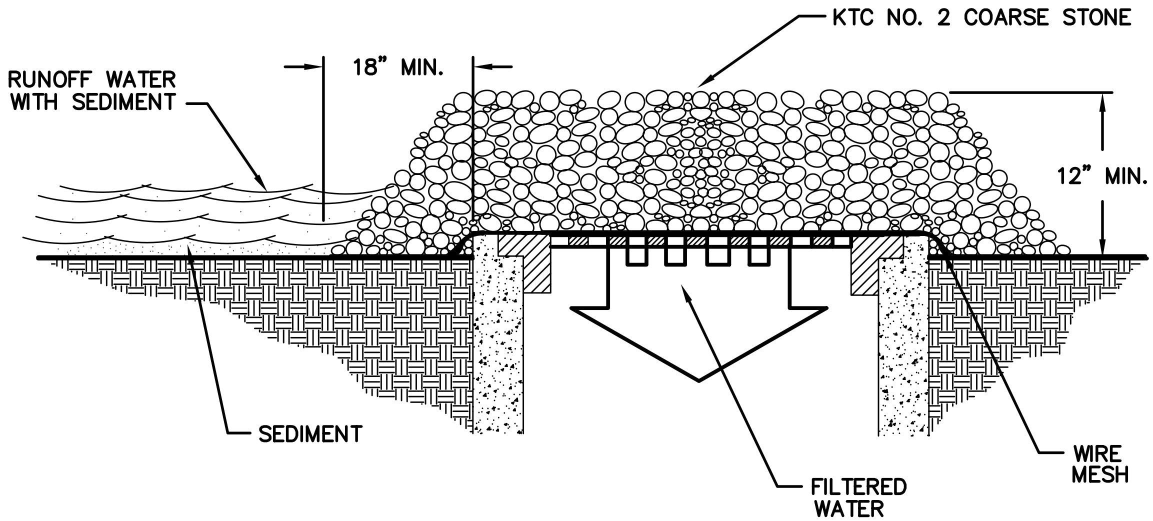

CROSS SECTION

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GRAVEL AND WIRE MESH INLET SEDIMENT FILTER

STANDARD DRAWING NO. EF-14-01 Page 1 of 2

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GRAVEL AND WIRE MESH INLET SEDIMENT FILTER

Installation:

Gravel and mesh filters can be used where heavy concentrated flows are expected and subject to disturbance by site traffic. Gravel and mesh filters should not be used where ponding around the structure might cause excessive inconvenience or damage to adjacent structures and unprotected areas. Gravel and mesh filters have no overflow mechanism, therefore ponding is likely especially if sediment is not removed regularly. Gravel and mesh filters must never be used where overflow may endanger an exposed fill slope.

Wire mesh shall be laid over the drop inlet so that the wire extends a minimum of 1–foot beyond each side of the inlet structure. Hardware cloth or comparable wire mesh with ½–inch openings shall be used. If more than one strip of mesh is necessary, the strips shall be overlapped.

KTC No. 2 Coarse Stone shall be placed over the wire mesh as indicated. The depth of stone shall be at least 12–inches over the entire inlet opening. The stone shall extend beyond the inlet opening at least 18–inches on all sides.

If the stone becomes clogged with sediment, the stones must be pulled away from the inlet, cleaned and replaced.

Inspection and Maintenance:

Inspections should be made every seven (7) calendar days and within 24–hours after each rainfall event that produces ½–inches or more of precipitation. Any needed repairs should be handled immediately.

Accumulated sediment must be removed after every rainfall event.

If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.

Storm drain inlet protection structures should be removed only after the disturbed areas are permanently stabilized. Remove all construction material and sediment, and dispose of them properly. Grade the disturbed area to the elevation of the drop inlet structure crest. Stabilize all bare areas immediately.

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GRAVEL AND WIRE MESH
INLET SEDIMENT FILTER

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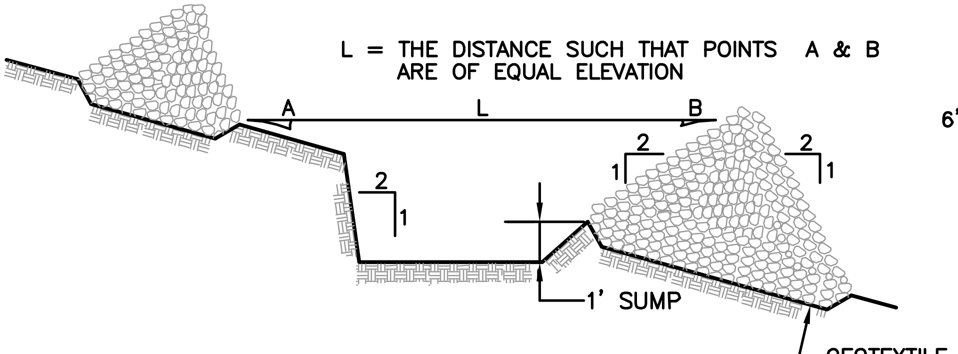
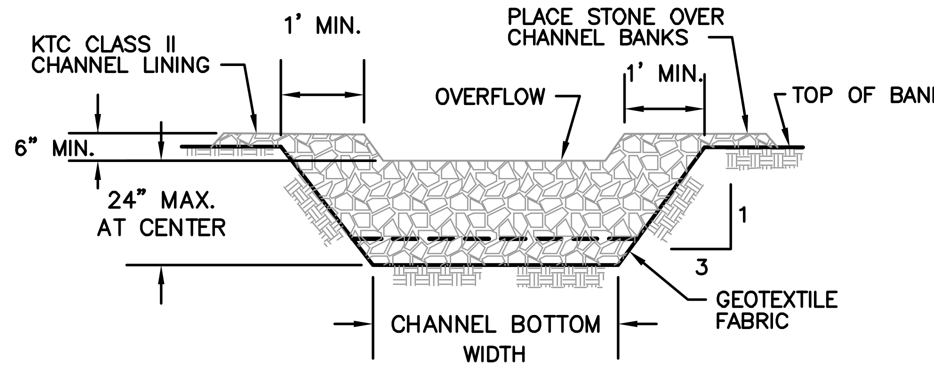
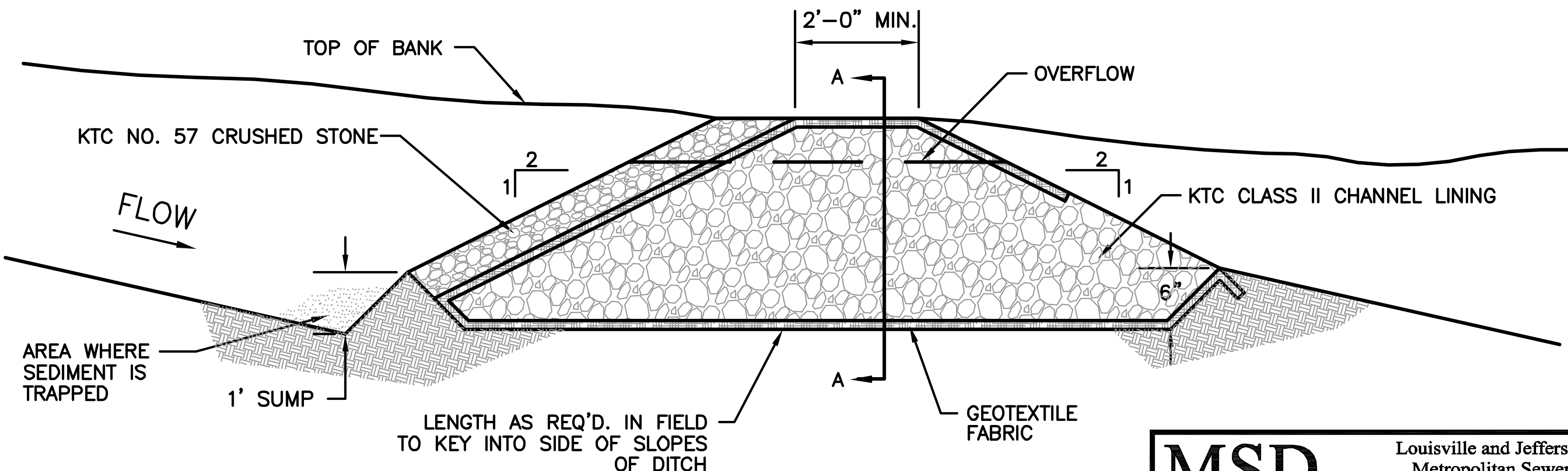


SPACING BETWEEN DITCH CHECK



CROSS SECTION A-A THRU STONE DITCH CHECK



NOTE:
STONE BERM TO BE REMOVED
BY GRADING CONTRACTOR AFTER
GRASSING IS ESTABLISHED

TYPICAL DITCH CHECK SECTION

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ROCK DITCH CHECK

STANDARD DRAWING NO. EB-03-03 Page 1 of 2

APPROVED BY: [signature] 7/13/2012
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ROCK DITCH CHECK

When and Where to Use It

A rock ditch check should be installed in steeply sloped swales, or in swales where adequate vegetation cannot be established. Rock ditch checks should be used only in small open channels. Rock ditch checks should not be placed in waters of the commonwealth (unless approved by state authorities).

Installation:

A geotextile fabric shall be installed over the soil surface where the rock ditch check is to be placed and laid under the KTC #57 crushed stone extending to the downstream slope of the rock check.

The body of the rock ditch check shall be composed of KTC Class II channel lining.

The upstream face of the rock ditch check shall be composed of KTC #57 crushed stone.

Rock ditch checks should not exceed a height of 2-feet at the centerline of the channel.

Rock ditch checks should have a minimum top flow length of 2-feet.

Stone should be placed over the channel banks prevent water from cutting around the ditch check.

The rock must be placed by hand or mechanical placement (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the check is lower than the edges.

The maximum spacing between the dams should be such that the toe of the upstream check is at the same elevation as the top of the downstream check.

Inspection and Maintenance:

Inspect rock ditch checks every seven (7) calendar days and within 24-hours after each rainfall event that produces ½-inches or more of precipitation. Inspect for sediment and debris accumulation. Inspect ditch check edges for erosion and repair promptly as required.

Sediment should be removed when it reaches 1/3 the original check height.

In the case of grass-lined ditches and swales, rock ditch checks should be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4%.

After construction is complete, all stone should be removed if vegetation will be used for permanent erosion control measures.

The area beneath the rock ditch checks should be seeded and mulched immediately after rock check dam removal.

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ROCK DITCH CHECK

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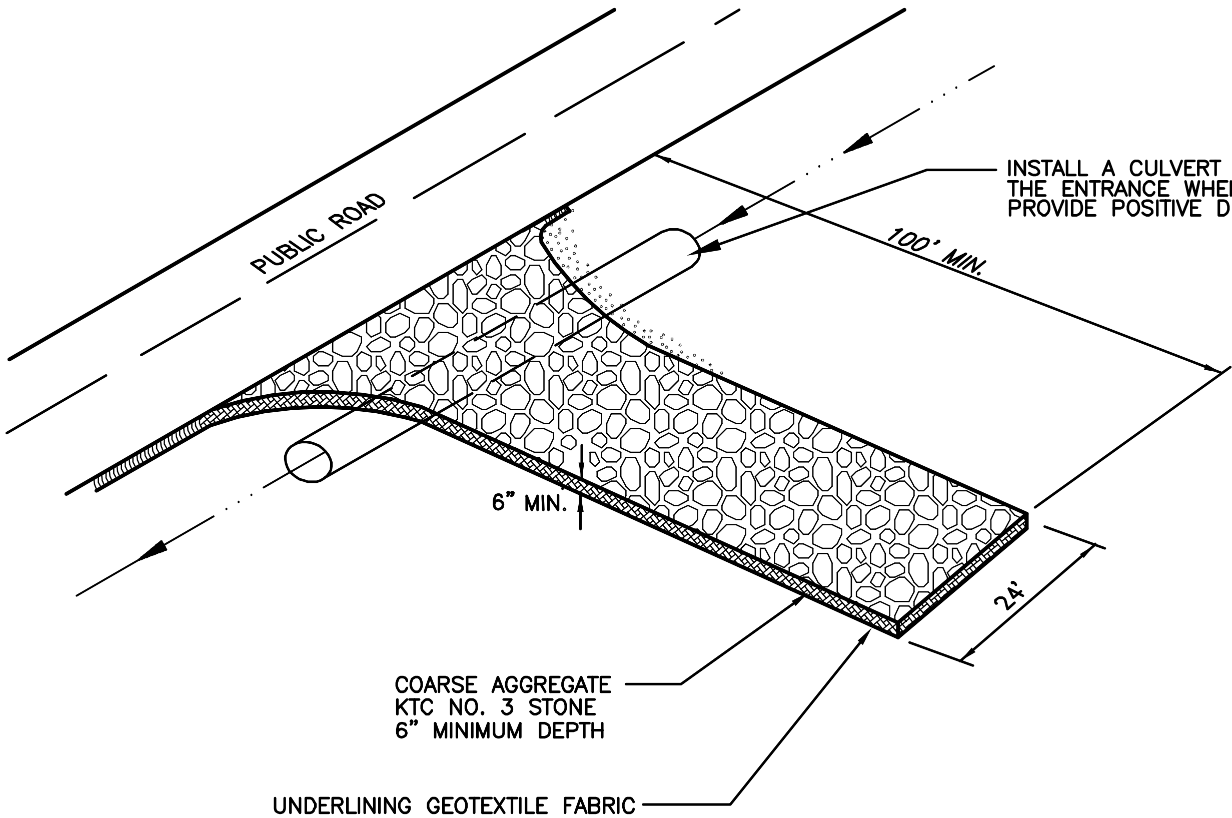

DIVERT ALL SURFACE RUNOFF AND DRAINAGE FROM THE STONE PAD TO A SEDIMENT TRAP OR BASIN OR OTHER SEDIMENT TRAPPING STRUCTURE.

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STABILIZED CONSTRUCTION ENTRANCE	
STANDARD DRAWING NO.	ER-01-03 Page 1 of 3
APPROVED BY: DIRECTOR OF ENGINEERING	4/30/2012 DATE

STABILIZED CONSTRUCTION ENTRANCE

When and Where to Use It

Stabilized construction entrances should be used at all points where traffic will be leaving a construction site and moving directly onto a public road.

Important Considerations

If washing is used, provisions must be made to intercept the wash water and trap the sediment before it is carried offsite. Washdown facilities shall be required as directed by MSD. Washdown areas in general must be established with crushed gravel and drain into a sediment trap or sediment basin. Construction entrances should be used in conjunction with the stabilization of construction roads to reduce the amount of mud picked up by vehicles.

Installation:

Remove all vegetation and any objectionable material from the foundation area.

Divert all surface runoff and drainage from stones to a sediment trap or basin.

Install a geotextile fabric prior to placing any stone.

Install a culvert pipe across the entrance when needed to provide positive drainage.

The entrance shall consist of KTC #3 stone with a minimum thickness of 6-inches.

Minimum dimensions of the entrance shall be 24-feet wide by 100-feet long, and may be modified as necessary to accommodate site constraints.

STABILIZED CONSTRUCTION ENTRANCE

Inspection and Maintenance:

Inspect entrances every seven (7) calendar days and within 24–hours after each rainfall event that produces ½–inches or more of precipitation, or after heavy use. Check for mud and sediment buildup and pad integrity. Make daily inspections during periods of wet weather. Maintenance is required more frequently in wet weather conditions. Reshape the stone pad as needed for drainage and runoff control.

Wash or replace stones as needed and as directed by the inspector. The stone in the entrance should be washed or replaced whenever the entrance fails to reduce mud being carried off–site by vehicles. Frequent washing will extend the useful life of stone.

Immediately remove mud and sediment tracked or washed onto public roads by brushing or sweeping. Flushing should only be used when the water can be discharged to a sediment trap or basin.

Repair any broken pavement immediately.

Inspect and clean sediment traps immediately following each rainfall.

Dispose of sediment in a suitable area in such a manner that it will not erode.

Remove stabilized construction entrances as soon as they are no longer needed to provide access to the site. Bring the disturbed area to grade, and stabilize it using appropriate permanent stabilization methods.

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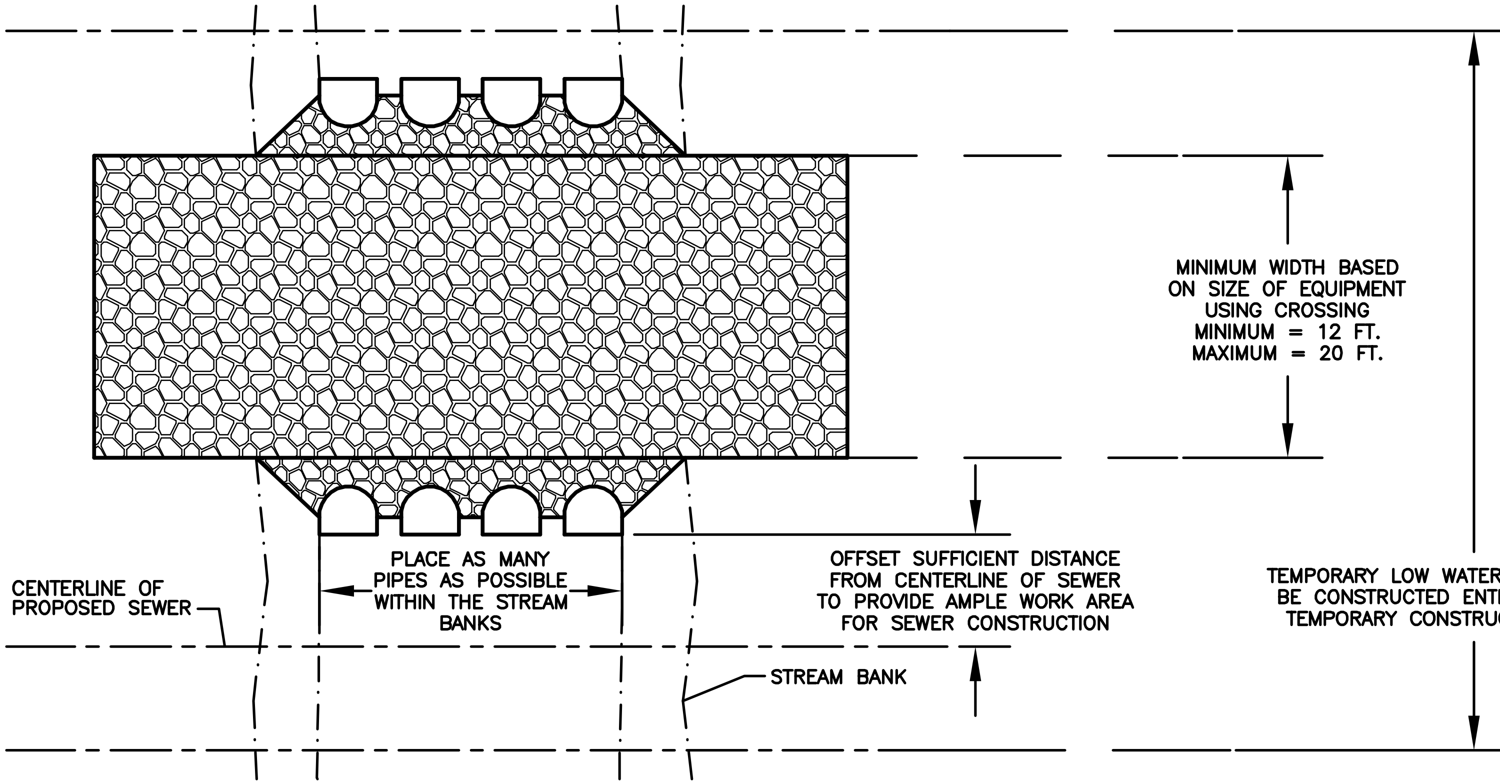
STABILIZED CONTRUCTION ENTRANCE

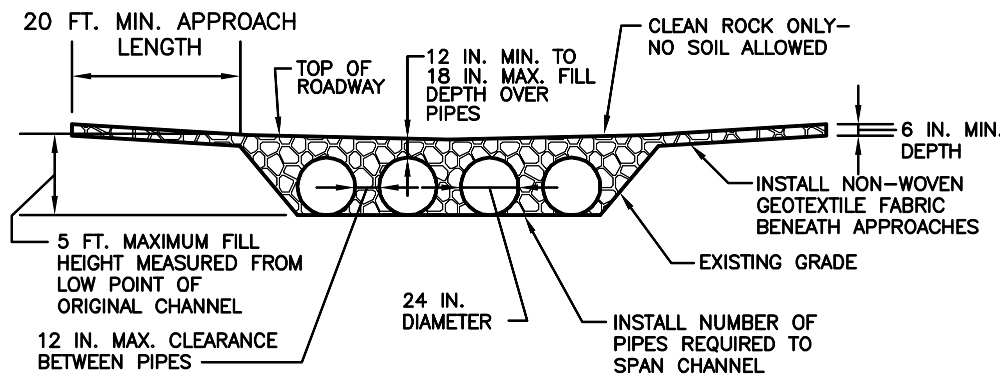
STANDARD DRAWING NO. ER–01–03 Page 3 of 3

APPROVED BY: DIRECTOR OF ENGINEERING

DATE 4/30/2012



PLAN VIEW



ELEVATION

NOTES:

1. INITIATE PUMP–AROUND DIVERSION PRIOR TO ANY EXCAVATION IN A STREAM.
2. DO NOT EXCAVATE STREAMS WITH ROCK BOTTOMS IN ORDER TO PLACE ALL PIPES AT THE SAME LEVEL AS THE LOW POINT OF THE STREAM. PLACE AS MANY PIPES AS PRACTICAL WITHIN THE LOW AREA OF THE STREAM.

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CONSTRUCTION ROAD STABILIZATION
TEMPORARY LOW WATER CROSSING

STANDARD DRAWING NO. ER–02–03 Page 1 of 3

APPROVED BY: Steve W Emly — DIRECTOR OF ENGINEERING — 4/30/2012 DATE

TEMPORARY STREAM LOW WATER CROSSING

Prior to constructing a temporary stream crossing, the owner/ person financially responsible for the project must submit an Application for Permit to Construct Across or Along a Stream to the Kentucky Division of Water (KDOW). Temporary stream crossings require a Section 404 Permit from the Corps of Engineers. If the crossing creates more than 200 linear feet of fill or more than 1/3 acre of fill, a 401 permit may be necessary.

Installation:

Crossings shall be installed prior to any other activities within the stream.

Pump—around diversions shall be installed and maintained prior to any excavation and during the installation of the crossing.

Crossings shall be placed in temporary construction easements only.

The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15 degrees from a line drawn perpendicular to the centerline of the stream at the intended crossing location. However every effort shall be taken to install the crossing perpendicular to the stream. All fill materials associated with the roadway approach shall be limited to a maximum height of two feet above the existing flood plain elevation.

Streambank clearing shall be kept to a minimum. Do not excavate rock bottom streambeds to install the crossing. Place geotextile fabric directly on streambed prior to placing pipes and stone. Lay the culvert pipes on the streambed "as is" when applicable. Place as many pipes as possible within the low area of the stream.

The maximum number of pipes possible should be placed within the stream banks with a maximum spacing of 12—inches between pipes. The pipe culvert shall be 24—inches.

The length of the culvert shall be adequate to extend the full width of the crossing, including side slopes.

Coarse aggregate with KTC No. 3 stone or greater will be used to form the crossing. The depth of stone cover over the culvert shall be equal to ½ the diameter of the culvert or 12—inches, whichever is greater but no greater than 18—inches.

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TEMPORARY STREAM
LOW WATER CROSSING

STANDARD DRAWING NO. ER—02—03 Page 2 of 3

APPROVED BY: DIRECTOR OF ENGINEERING 4/30/2012 DATE

TEMPORARY STREAM LOW WATER CROSSING

Installation:

All fill materials associated with the roadway approach shall be limited to a maximum height of 2–feet above the existing flood plain elevation.

The approaches to the structure shall consist of clean stone or concrete fill only with a minimum thickness of 6–inches. The minimum approach length shall be 20–feet and the width shall be equal to the width of the structure.

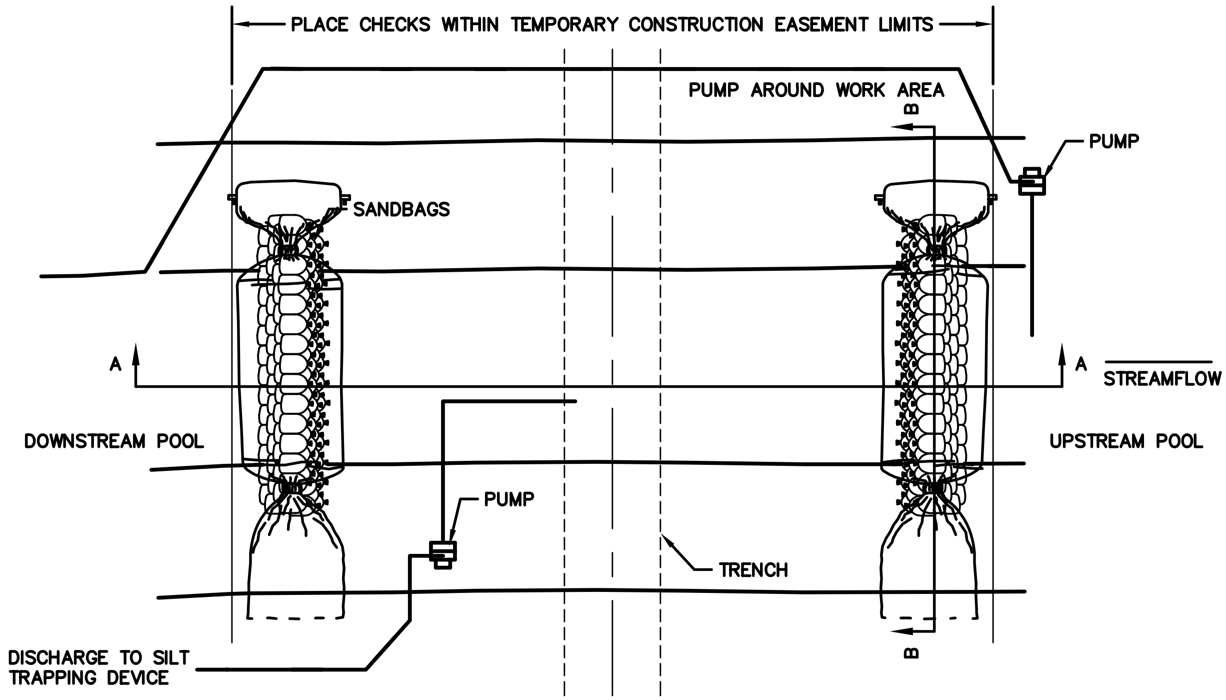
Inspection and Maintenance:

Inspect crossings every seven (7) calendar days and within 24–hours after each rainfall event that produces ½–inches or more of precipitation. Check the structure integrity and for excessive sediment deposition and replace fill stone as needed.

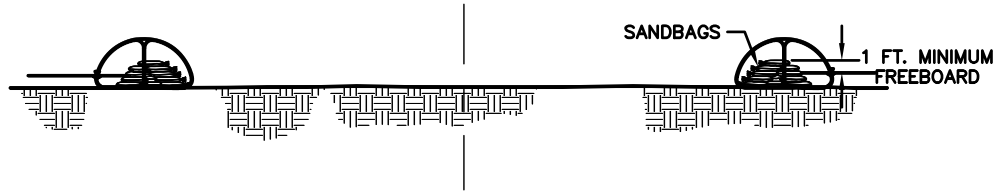
Clean mud and/or sediment from the roadway and do not allow it to enter the stream.

The structure shall be removed when it is no longer required to provide access to the construction area. During removal, leave stone and geotextile fabric for approaches in place. Place fill over the approaches as part of the stream bank restoration operation.

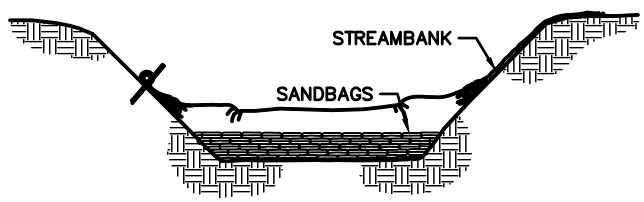
A temporary culvert crossing should be in place no longer than 24 months.



PLAN



SECTION A–A



SECTION B–B

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PUMP – AROUND FLOW DIVERSION

STANDARD DRAWING NO. ED–01–01 Page 1 of 2

APPROVED BY: DIRECTOR OF ENGINEERING 9/30/2009 DATE

STREAM CROSSINGS USING WATER-INFLATABLE CHECK DAMS (WATER STRUCTURES)

1. WATER-INFLATABLE CHECK DAMS SHALL BE WATER STRUCTURES AS MANUFACTURED/DISTRIBUTED BY SUNSHINE SUPPLIES, INC., BIRMINGHAM, ALABAMA OR ITS EQUIVALENT. THE CHECK DAMS CONSIST OF TWO INNER TUBES CONSTRUCTED USING 15 MIL REINFORCED VINYL THAT ARE SURROUNDED WITH A MASTER TUBE CONSTRUCTED FROM WOVEN GEOTEXTILE FABRIC. THE WATER STRUCTURES USED IN THIS APPLICATION SHALL BE THE OPEN ENDED SYSTEM, HAVE AN INFLATED HEIGHT OF 3 FT. AND MEET THE FOLLOWING SPECIFICATIONS:

MASTER TUBE:	WOVEN GEOTEXTILE
INNER TUBES:	POLYETHYLENE
APPROX. INFLATED HEIGHT:	3 FT.
FILL CAPACITY:	135 GAL/FT.
APPROX. WIDTH:	6.5 FT.
END TREATMENT:	OPEN ENDED
MINIMUM FREEBOARD OR STRUCTURE HEAD:	1.0 FT.

2. CHECK DAMS SHALL BE INSTALLED ACROSS THE STREAM BOTH UPSTREAM AND DOWNSTREAM OF THE SEWER ALIGNMENT WITHIN THE TEMPORARY CONSTRUCTION EASEMENT AS SHOWN ON THE PLAN GIVEN IN THE STREAM CROSSING DETAIL ON THIS SHEET PRIOR TO ANY EXCAVATION ACROSS THE STREAM.

3. REMOVE ANY DEBRIS SUCH AS WIRE, GLASS, BRANCHES, STONES, ETC. THAT COULD PUNCTURE A WATER STRUCTURE FROM THE AREA IN WHICH WATER STRUCTURES ARE TO BE INSTALLED PRIOR TO INSTALLATION OF THE STRUCTURES.

4. CHECK DAMS SHALL BE INSTALLED ONLY DURING LOW FLOW CONDITIONS WHEN THE REQUIRED MINIMUM FREEBOARD CAN BE MAINTAINED.

5. CLOSE THE INFLATED ENDS OF THE STRUCTURE USING EMBOSSED POLYETHYLENE BINDING STRAPS. SECURE THE EXCESS WATER STRUCTURE LEFT ON THE ROLL TO THE STREAMBANK USING WOODEN STAKES. (DO NOTPUNCTURE THE WATER STRUCTURE.) PLACE SAND BAGS ON THE INLET END OF THE WATER STRUCTURES TO HOLD THEM IN PLACE ON TOP OF THE BANK.

6. FOLLOW THE MANUFACTURER'S INSTALLATION PROCEDURES, APPLICABLE OSHA SAFETY REGULATIONS AND THE MANUFACTURER'S SAFETY PRECAUTIONS. FOLLOW THE MANUFACTURER'S MAINTENANCE PROCEDURES.

7. PUMP STREAMFLOW AROUND THE CONSTRUCTION AREA AS DEPICTED IN THE PLAN SHOWN IN THE STREAM CROSSING DETAIL ON THIS SHEET. PUMPING MUST MAINTAIN A MINIMUM OF 1 FT. FREEBOARD (OR STRUCTURE HEAD) ON THE STRUCTURES. PROTECT AREAS AT THE PUMP DISCHARGE FROM SCOUR BY THE DISCHARGE.

8. PUMP WATER FROM THE WORK AREA BETWEEN THE STRUCTURES TO THE SILT TRENCH. ALSO USE THIS PUMP TO PUMP DOWN WATER IN THE TRENCH DURING EXCAVATION AND SEWER CONSTRUCTION OPERATIONS. WATER PUMPED FROM THE TRENCH MUST ALSO BE DISCHARGED INTO THE SILT TRENCH.

9. PROCEED WITH CONSTRUCTION OF SEWER LINE ACROSS THE STREAM.

10. WHEN SEWER LINE CONSTRUCTION ACROSS THE STREAM IS COMPLETE, STABILIZE THE DISTURBED STREAMBANK FROM THE TOE OF THE SLOPE TO A LEVEL NO LESS THAN 2 FT ABOVE THE WATER LEVEL IN THE STREAM.

11. PUMP WATER FROM THE STREAM TO THE AREA BETWEEN THE CHECK DAMS TO EQUALIZE WATER LEVELS ON THE SIDES OF THE STRUCTURES BEFORE THEIR REMOVAL.

12. CONSTRUCTION OPERATIONS SHALL BE SCHEDULED SUCH THAT STREAM CROSSINGS ARE COMPLETED WITHIN ONE WORKDAY. IF THE CROSSING IS NOT COMPLETED IN ONE WORK DAY, PUMPING OPERATIONS MUST BE MAINTAINED AROUND THE CLOCK WHILE THE CHECK DAMS ARE IN PLACE. A WORK FORCE SHALL REMAIN ON SITE THAT IS SUFFICIENT TO MAINTAIN PUMPING OPERATIONS AND ALERT THE ENGINEER IF PROBLEMS ARISE.

13. REMOVE BINDING STRAPS BEFOR REMOVING WATER STRUCTURES FROM THE STREAM.

14. FOLLOW THE MANUFACTURER'S PROCEDURES FOR REMOVAL OF THE WATER STRUCTURES FOR REUSE. FLATTEN AND STRAIGHTEN THE MASTER TUBE AND INNER TUBE BEFORE REWRAPPING THE STRUCTURES. USE AN AIR BLOWER TO FACILITATE THE STRAIGHTENING OF TUBES THAT HAVE BEEN KINKED OR TWISTED.

BINDING STRAP SPECIFICATIONS

BINDING STRAP AND BUCKLES SHALL MEET THE FOLLOWING SPECIICATIONS:

MATERIAL:	EMBOSSED POLYETHYLENE
BURST STRENGTH:	800 LB.
WIDTH:	XX
THICKNESS:	XX
<u>BUCKLE</u>	
TYPE:	WIRE
BUCKLE EFFICIENCY:	50%

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PUMP – AROUND FLOW DIVERSION

STANDARD DRAWING NO. ED-01-01 Page 2 of 2

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9/30/2009
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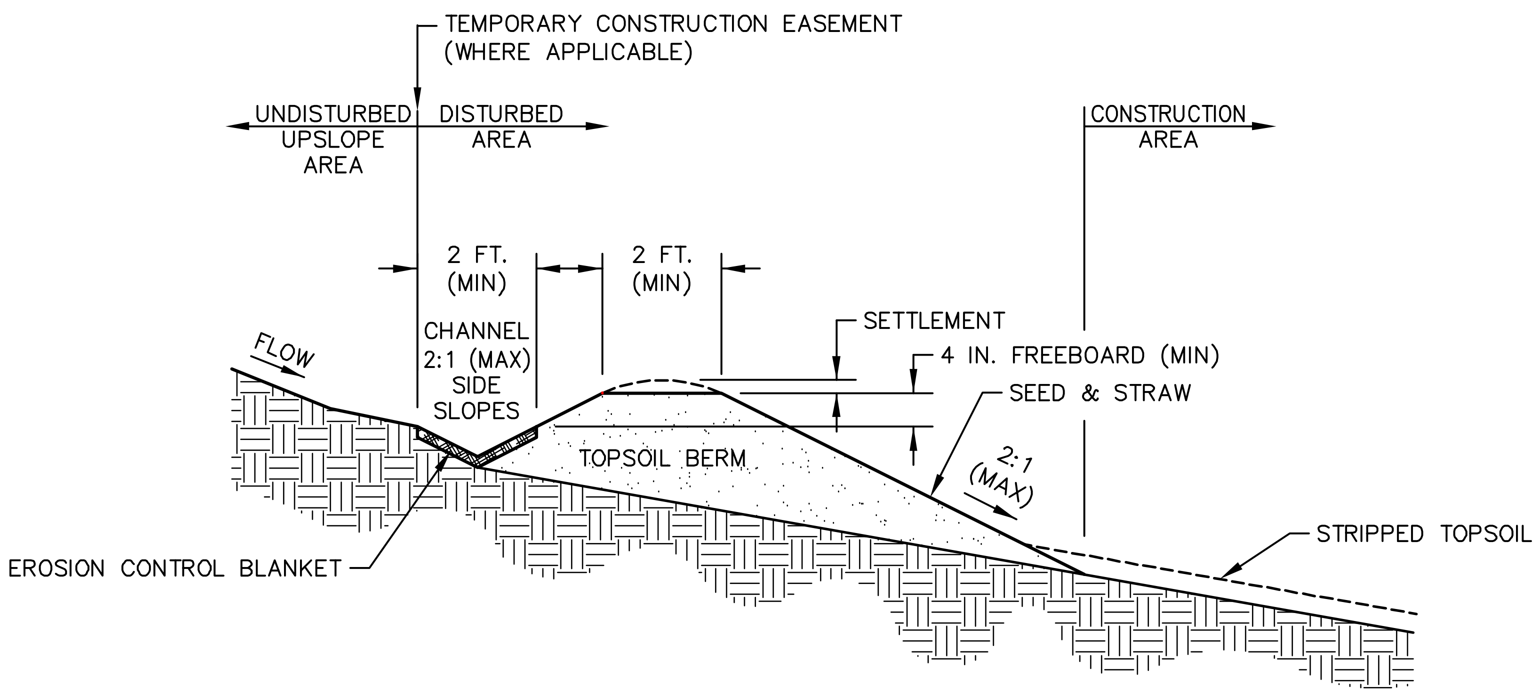

TYPICAL SECTION (N.T.S.)

NOTE:

1. This typical section is used to divert upslope runoff from flowing across construction areas.
2. The channel shown may not be required if the upslope runoff is minimal. In such case, the topsoil berm will serve as temporary topsoil storage until final grading/restoration operations.

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TEMPORARY DIVERSION CHANNEL & TOPSOIL BERM

STANDARD DRAWING NO. ED-02-02 Page 1 of 2

APPROVED BY: [signature] DIRECTOR OF ENGINEERING

6/17/2013 DATE

TEMPORARY DIVERSION CHANNEL & TOPSOIL BERM

1. The contractor shall install a temporary diversion channel and topsoil berm along the upslope side of the disturbed area or temporary construction easement.

2. The berm shall be constructed of stripped topsoil not mixed with other materials.

3. The purpose of the temporary diversion channel and topsoil berm is to direct clear water runoff from the undisturbed upslope area to a location where it can be collected and piped across the width of construction in a controlled manner that does not interfere with construction and minimizes the potential for addition of sediment to the clear water within the limits of the temporary construction easement prior to its release.

4. The contractor shall:

   4.1. Provide a topsoil berm of sufficient height to prevent overland or shallow concentrated runoff into the construction area by directing the upslope flow to a collection point into a 12–inch (minimum) diameter pipe (capable of withstanding construction traffic) laid through the construction area for the clear water flow to pass through it rather than across the construction area. The pipes that carry upslope clear water runoff through the construction area shall be located at all existing, defined, channels and at intermediate intervals, as needed.

   4.2. At the discharge point, provide for positive drainage away from the construction area.

   4.3. Maintain all diversion measures until such time as construction areas have been stabilized sufficiently to receive pre–construction runoff.

   4.4. Remove the temporary diversion channel and topsoil berm prior to final project close–out.

5. For bidding purposes the cost to install, maintain, and remove the temporary diversion channel and topsoil berm, and related control features, shall be incidental to the sewer line installation cost and shall not be priced as a separate item (unless erosion control features are specifically included as a bid item).

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TEMPORARY DIVERSION CHANNEL & TOPSOIL BERM

STANDARD DRAWING NO. ED–02–02 Page 2 of 2

APPROVED BY: Steve W Emly — DIRECTOR OF ENGINEERING   6/17/2013 — DATE

APPENDIX F

MSD DESIGN MANUAL CHAPTER 4 EXHIBITS

MSD

Louisville and Jefferson County
Metropolitan Sewer District
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EXHIBIT 4-1 PAGE 1
STANDARD LAYERS

EFFECTIVE DATE: JUNE 30, 2009

NAME	DESCRIPTION	COLOR	LINETYPE	LINETYPE EXAMPLES
BM	BENCH MARK	50	CONTINUOUS	
BORDER-0	BASE SHEET LAYER	12	CONTINUOUS	
BORDER-1	BASE SHEET LAYER	20	CONTINUOUS	
BORDER-2	BASE SHEET LAYER	40	CONTINUOUS	
BORDER-3	BASE SHEET LAYER	50	CONTINUOUS	
BORDER-4	BASE SHEET LAYER	150	CONTINUOUS	
BORDER-ROLL	BASE SHEET LAYER	2	CONTINUOUS	
DRNA	DRAINAGE AREA	230	HIDDEN	
E-ASPH	EXISTING ASPHALT	12	HIDDEN	
E-BASE	EXISTING BASELINE	130	CONTINUOUS	
E-BLDG	EXISTING BUILDING	32	CONTINUOUS	
E-CONC	EXISTING CONCRETE	12	HIDDEN	
E-CONT-MJR	EXISTING MAJOR CONTOUR	22	HIDDEN2	
E-CONT-MNR	EXISTING MINOR CONTOUR	12	HIDDEN2	
E-CONT-TXT	EXISTING CONTOUR TEXT (L80)	12	CONTINUOUS	
E-CRST	EXISTING CRUSHED STONE	172	HIDDEN4	
E-DTCH-E	EXISTING EARTH DITCH	102	FLOW LINES	
E-DTCH-P	EXISTING PAVED DITCH	102	DASHED2	
E-ESMNT	EXISTING EASEMENTS	102	PERM ESMT	
E-FENC	EXISTING FENCES	12	FENCE	X X
E-FLTS	EXISTING FAULTS	7	CONTINUOUS	
E-GRND	EXISTING GROUND (TOP OF BANK)	22	EXIST SHOULDER	
E-PL	EXISTING PROPERTY LINES	162	CONTINUOUS	
E-PL-CH	EXISTING PROPERTY LINE CHORD	162	HIDDEN2	
E-ROAD	EXISTING EDGE OF ROAD, PAVEMENT	162	EXIST EDGE PVMT	
E-RR	EXISTING RAILROADS	32	CONTINUOUS	
E-RW	EXISTING RIGHT OF WAY	115	RIGHT OF WAY	
E-SANI *	EXISTING SANITARY SEWERS	102	HIDDEN 2	
E-SPOT	EXISTING SPOT ELEVATION (L80)	195	CONTINUOUS	
E-STRM *	EXISTING STORM SEWERS	102	EXIST PIPE OR STRUCT	
E-STRP	EXISTING PAVEMENT STRIPING	16	CONTINUOUS	
E-TOPO	EXISTING TOPOGRAPHY	12	CONTINUOUS	
E-U-CBTV	EXISTING OVERHEAD CABLE TELEVISION	12	OHC	OHC
E-U-CBTV2	EXISTING UNDERGROUND CABLE TELEVISION	12	CABLETV	CTV
E-U-ELEC	EXISTING OVERHEAD ELECTRIC	22	OHE	OHE
E-U-ELEC2	EXISTING UNDERGROUND ELECTRIC	12	ELEC	UGE
E-U-GAS *	EXISTING GAS	92	GAS	G G
E-U-TELE	EXISTING OVERHEAD TELEPHONE	92	OHT	OHT
E-U-TELE2	EXISTING UNDERGROUND TELEPHONE	92	TELE	UGT
E-U-WATR *	EXISTING WATER	172	WATER	W W
E-VEG	EXISTING VEGETATION, TREES, SHRUBS	12	CONTINUOUS	
FILE-INFO	FILE INFORMATION	7	CONTINUOUS	
GL	GRID LINE	252	CONTINUOUS	
GT	GRID TEXT (L120)	7	CONTINUOUS	
HT	HATCH	92	CONTINUOUS	
P-ASPH	PROPOSED ASPHALT	215	CONTINUOUS	
P-ASPH-HT	PROPOSED ASPHALT HATCH PATTERN	182	CONTINUOUS	
P-BASE	PROPOSED BASELINE	230	CONTINUOUS	
P-BLDG	PROPOSED BUILDING	230	CONTINUOUS	
P-CONC	PROPOSED CONCRETE	214	CONTINUOUS	
P-CONC-HT	PROPOSED CONCRETE HATCH PATTERN	188	CONTINUOUS	

* SEE EXHIBIT 4-2 FOR ADDITIONAL EXPLANATION.

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EXHIBIT 4-1 PAGE 2

STANDARD LAYERS

EFFECTIVE DATE: JUNE 30, 2009

NAME	DESCRIPTION	COLOR	LINETYPE	LINETYPE EXAMPLES
P-CONT-MJR	PROPOSED MAJOR CONTOUR	210	CONTINUOUS	
P-CONT-MNR	PROPOSED MINOR CONTOUR	200	CONTINUOUS	
P-CONT-TXT	PROPOSED CONTOUR TEXT (L100)	210	CONTINUOUS	
P-CRST	PROPOSED CRUSHED STONE	213	CONTINUOUS	
P-CURB	PROPOSED CONCRETE CURB	40	CONTINUOUS	
P-DSTB	PROPOSED DISTURB LIMITS	89	DOT2	
P-DTCH-E	PROPOSED EARTH DITCH	210	FLOW LINES	• • • • • • • • • • • • • •
P-DTCH-P	PROPOSED PAVED DITCH	210	CONTINUOUS	· ——— · · · ———
P-EPSC	PROPOSED SILT CONTROL DEVICES	50	CONTINOUS	
P-FENC	PROPOSED FENCE	210	FENCE	—x———x———x—
P-FLOW	PROPOSED DRAINAGE DIRECTIONAL FLOW ARROW	20	CONTINUOUS	
P-GRND	PROPOSED GROUND	210	CONTINUOUS	
P-PERM	PROPOSED PERMANENT EASEMENTS	210	PERM ESMT	——— ——— ——— —
P-PL	PROPOSED PROPERTY LINE	245	CONTINOUS	
P-ROAD	PROPOSED EDGE OF ROAD, PAVEMENT	240	CONTINUOUS	
P-RW	PROPOSED RIGHT OF WAY	233	RIGHT OF WAY	——— — — ———
P-SANI *	PROPOSED SANITARY SEWERS	210	CONTINUOUS	————————
P-SF	PROPOSED SILT FENCE \ TREE PROTECTION FENCE	50	SF	——— SF ———
P-SPOT	PROPOSED SPOT ELEVATION (L80 w/o obliquing)	40	CONTINUOUS	
P-STRM *	PROPOSED STORM SEWERS	211	CONTINUOUS	
P-STRP	PROPOSED PAVEMENT STRIPING	52	CONTINUOUS	
P-TEMP	PROPOSED TEMPORARY EASEMENT	190	TEMP ESMT	——— — — ———
P-U-CBTV	PROPOSED OVERHEAD CABLE TELEVISION	200	PROP OHC	——— OHC ———
P-U-CBTV2	PROPOSED UNDERGROUND CABLE TELEVISION	200	PROP UGC	——— UGC ———
P-U-ELEC	PROPOSED OVERHEAD ELECTRIC	201	PROP OHE	——— OHE ———
P-U-ELEC2	PROPOSED UNDERGROUND ELECTRIC	201	PROP UGE	——— UGE ———
P-U-GAS *	PROPOSED GAS	205	GAS	——— G ———
P-U-TELE	PROPOSED OVERHEAD TELEPHONE	203	PROP OHT	——— OHT ———
P-U-TELE2	PROPOSED UNDERGROUND TELEPHONE	203	PROP UGT	——— UGT ———
P-U-WATR *	PROPOSED WATER	200	WATER	——— W ———
P-VEG	PROPOSED VEGETATION, TREES, SHRUBS, ETC.	205	CONTINUOUS	
PAPER	PAPER	7	CONTINUOUS	
PNTS	POINTS MADE FROM LDD / CIVIL 3D	7	CONTINUOUS	
PRELIM	PRELIMINARY	7	CONTINUOUS	
SL	STATION LABELS (L140)	7	CONTINUOUS	
SNDG	ROCK SOUNDINGS	55	CONTINUOUS	
TX0	TEXT L60	12	CONTINUOUS	
TX1	TEXT L80	20	CONTINUOUS	
TX2	TEXT L100	40	CONTINUOUS	
TX3	TEXT L120	50	CONTINUOUS	
TX4	TEXT L140	70	CONTINUOUS	
TX5	TEXT L175 AND ABOVE	80	CONTINUOUS	
XREF	EXTERNAL REFERENCE	7	CONTINUOUS	

* SEE EXHIBIT 4-2 FOR ADDITIONAL EXPLANATION.

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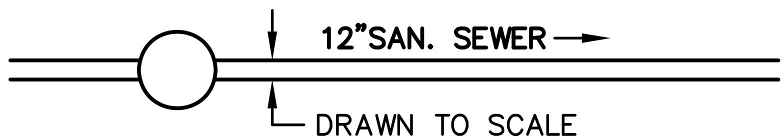
EXHIBIT 4-2
STANDARD LINETYPE EXHIBITS AND MISCELLANEOUS FEATURES

EFFECTIVE DATE: JUNE 30, 2009

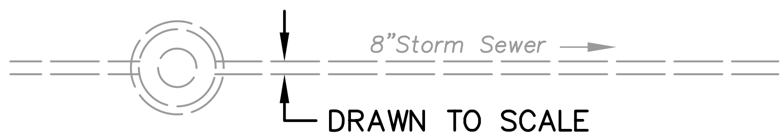
LINETYPES

EXISTING SANITARY SEWER

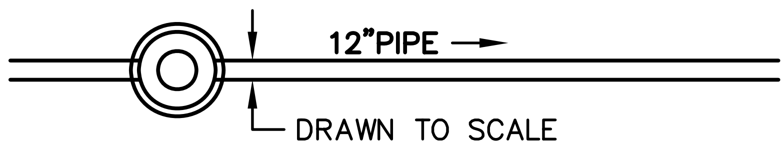
PROPOSED SANITARY SEWER



EXISTING STORM SEWER



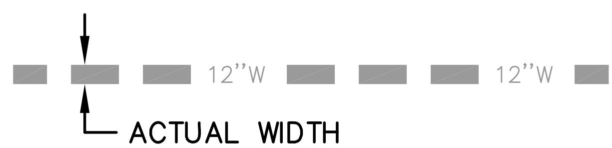
PROPOSED STORM SEWER



APPLIES TO GAS AND WATER

EXISTING UTILITY UP TO 10"

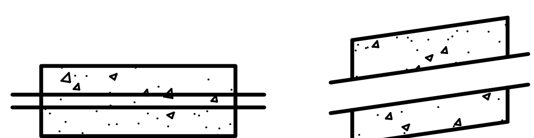
EXISTING UTILITY 12"AND LARGER SHOWN WITH ACTUAL WIDTH ASSIGNED TO LINE,



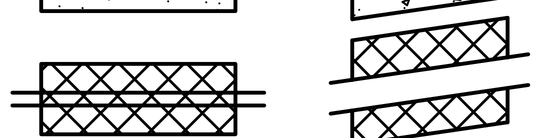
MISCELLANEOUS FEATURES

PLAN PROFILE

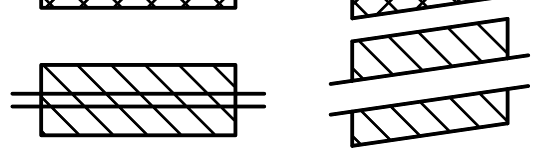
CONCRETE ENCASEMENT



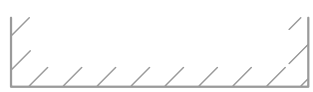
TUNNELING OR PIPE JACKING



BORE & JACK OR DIRECTIONAL DRILLING



EXISTING BUILDINGS IN PLAN
(FIELD LOCATED)



EX BUILDINGS IN PROFILE LEFT AND RIGHT OF BASELINE

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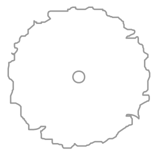
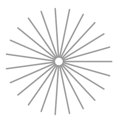
STANDARD SYMBOLS

EFFECTIVE DATE: JUNE 30, 2009

SYMBOLS	DESCRIPTION	FILE NAME (.dwg)
	*Existing Tree (with size, type & drip line diameter)** * When locating tree sizes for plan views, measure diameter of trunk at breast height (in inches) and measure actual diameter of Drip line to the nearest foot.	MSDATREE.dwg
	*Existing Pine or Spruce W/Size*	MSDPINE.dwg
	*Existing Bush W/Size*	MSDSHRUB.dwg
Wooded Area	*Edge of Woods*	
	Existing Traffic Sign	MSDSIGN.dwg
○MB	*Existing Mailbox*	MSDMB.dwg
□PB	*Existing Paperbox*	MSDPB.dwg
	Contract Bench Mark	MSDBM.dwg
	Existing Guy Anchor	MSDANCHOR.dwg
	Existing Power Pole	MSDPP.dwg
	Existing Pole W/Light	MSDLS.dwg
	Existing Light Post	MSDLTSTD.dwg
□ EPED	*Existing Electrical Pedestal*	MSDELECPED.dwg
(E)	*Existing Electrical Manhole*	MSDEMH.dwg
(T)	*Existing Telecommunications Manhole*	MSDTMH.dwg
□ TPed	*Existing Telecommunications Pedestal*	MSDTPED.dwg
○ CATV–PED	*Existing Cable T.V. Pedestal*	MSDCPED.dwg
● 437.2±	*Overhead Power Lines (Profile)*	
○GM	*Existing Gas Meter*	MSDGM.dwg
○GV	*Existing Gas Valve*	MSDGV.dwg
○GLM	*Existing Gas Line Marker*	MSDGLM.dwg
	Existing Fire Hydrant	MSDFH.dwg
○WM	*Existing Water Meter*	MSDWM.dwg
○WV	*Existing Water Valve*	MSDWV.dwg
(W)	*Existing Water Manhole*	MSDWMH.dwg
○ WLM	*Existing Water Line Marker*	MSDWML.dwg

SYMBOLS	DESCRIPTION	FILE NAME (.dwg)
CO	*Existing Sewer Clean-out*	MSDCO.dwg
S	*Existing Sanitary Manhole*	MSDSMH.dwg
M.H.	*Existing Storm Manhole*	MSDSTMH.dwg
	Existing Catch Basin (Single)	MSDCB.dwg
	Existing Catch Basin (Double)	MSDCBD.dwg
	Existing Catch Basin (Round)	MSDCBR.dwg
Steel	*Bridge (type of bridge shall be noted)*	MSDBRDG.dwg
R.P.	*Railway Pole*	MSDRP.dwg
	Railroad Rails (Profile)	MSDRR.dwg
P.L. (PIPE)	*Existing Property Line Pipe (TYPE)*	MSDPLP.dwg
⊠	*Right Of Way Marker*	MSDRWM.dwg
3	*Parcel Number*	MSCPN.dwg
C-3	*Consent and Release Parcel Number*	MSDCRN.dwg
S	*Sounding Location (Plan)*	MSDSND.dwg
	Sounding To Rock or Refusal (Profile)	MSDSNDRK.dwg
	Sounding No Rock (Profile)	MSDSNDNRK.dwg
B-0	*Boring Location And Number. Geotechnical borings were drilled utilizing a truck-mounted drill rig. Borings were taken to a depth of one foot below flow line or until refusal.*	
	PROPOSED EMBANKMENT OR EXCAVATION SLOPE	
	PROPOSED STORM MANHOLE	MSDPSTMH.dwg
	PROPOSED DOUBLE CURB INLET	MSDPDCI.dwg
	PROPOSED CATCH BASIN DOUBLE	MSDPCBD.dwg
	PROPOSED SANITARY MANHOLE	MSDPSMH.dwg

SYMBOLS	DESCRIPTION
	*Denotes 4" property service connection to be constructed to property or easement line as directed.*
	*Denotes 4" Y or T branch with stopper. Property service connection is not to be constructed.*
	*Denotes 4" property service connection to be constructed from stack at sewer to property or easement line as directed. (See note below)*
	*Denotes 4" Y or T branch with stopper to be constructed from stack at sewer. Property service connection is not to be constructed. (See note below)*
	*Denotes a 4" property service connection (PSC) to be constructed. The PSC is <u>not</u> available for connection until the capacity charge, applicable at the time, is paid.*

Note: ***The following must be added to the general*** **notes:**

All stacks must conform to the requirements of section 8.14 of the MSD Design Manual.

4" connections are for single family only all others are 6".

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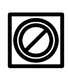
STANDARD SYMBOLS

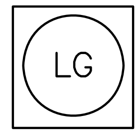
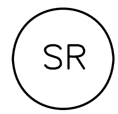
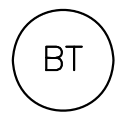
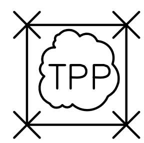
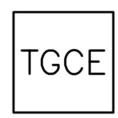
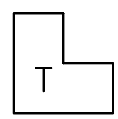
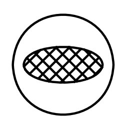
EFFECTIVE DATE: JUNE 30, 2009

SYMBOLS	DESCRIPTION
	*Denotes 6" property service connection to be constructed to property or easement line as directed.*
	*Denotes 6" Y or T branch with stopper. Property service connection is not to be constructed.*
	*Denotes 6" siamese property service connection to be constructed to property or easement line as directed.*
	*Denotes 6" property service connection to be constructed from stack at sewer to property or easement line as directed. (See note below)*
	*Denotes 6" Y or T branch with stopper to be constructed from stack at sewer. Property service connection is not to be constructed. (See note below)*
	*Denotes a 6" property service connection (PSC) to be constructed. The PSC is not available for connection until the capacity charge, applicable at the time, is paid.*

Note: ***The following must be added to the general notes:***

All stacks must conform to the requirements of section 8.14 of the MSD Design Manual.

MAPPING SYMBOLS AND NOMENCLATURE FOR EROSION AND SEDIMENT CONTROL PLANS FOR LAND DISTURBING ACTIVITIES

DESCRIPTION	SYMBOL
SITE PREPARATION:	
LAND GRADING:	
SURFACE ROUGHENING:	
BULLDOZER TRACKED:	
TREE PRESERVATION AND PROTECTION:	
TEMPORARY GRAVEL CONSTRUCTION ENTRANCE/EXIT:	
BENCH TERRACING:	
TOPSOILLING:	

MAPPING SYMBOLS AND NOMENCLATURE FOR EROSION AND SEDIMENT CONTROL PLANS FOR LAND DISTURBING ACTIVITIES (CONT.)

DESCRIPTION	SYMBOL
SURFACE STABILILIZATION:	
TEMPORARY SEEDING:	TS
PERMANENT SEEDING:	PS
SODDING:	SO
MULCHING:	M
DUST CONTROL:	DC
EROSION CONTROL BLANKET:	ECB
TURF REINFORCEMENT MAT:	TRM

MAPPING SYMBOLS AND NOMENCLATURE FOR EROSION AND SEDIMENT CONTROL PLANS FOR LAND DISTURBING ACTIVITIES (CONT.)

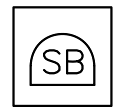
DESCRIPTION	SYMBOL
OUTLET PROTECTION:	
OUTLET STABILIZATION STRUCTURE:	OS
INLET PROTECTION:	IP
GRAVEL AND WIRE MESH INLET SEDIMENT FILTER:	GWI
FILTER FABRIC DROP INLET PROTECTION (TEMPORARY):	FDI
BLOCK AND GRAVEL INLET PROTECTION (TEMPORARY):	BGDI
STONE BAG INLET PROTECTION:	SIP
SEDIMENT TRAPS AND BARRIERS:	
TEMPORARY SEDIMENT TRAP:	TS

MAPPING SYMBOLS AND NOMENCLATURE FOR EROSION AND SEDIMENT CONTROL PLANS FOR LAND DISTURBING ACTIVITIES (CONT.)

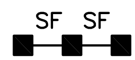
DESCRIPTION — SYMBOL

SEDIMENT TRAPS AND BARRIERS (CONT):

SEDIMENT BASIN:

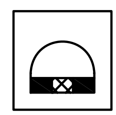


SILT FENCE (SEDIMENT FENCE):

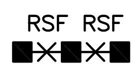


DITCH CHECK:

TEMPORARY SEDIMENT BASIN:

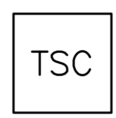


REINFORCED SILT FENCE:

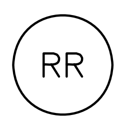


STREAM PROTECTION:

TEMPORARY STREAM CROSSING:



RIPRAP:



VEGETATED FILTER STRIPS:

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MAPPING SYMBOLS AND NOMENCLATURE FOR EROSION AND SEDIMENT CONTROL PLANS FOR LAND DISTURBING ACTIVITIES (CONT.)

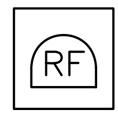
DESCRIPTION	SYMBOL
RUNOFF CONTROL MEASURES:	
PERMANENT CLEAN WATER:	→ PCW →
TEMPORARY CLEAN WATER:	→ TCW →
TEMPORARY SEDIMENT LADEN:	→ TSL →
ROCKFILL:	
RUNOFF CONVEYANCE MEASURES:	RCM ➡ RCM ➡ RCM ➡
GRASS-LINED CHANNELS:	GC ➡ GC ➡ GC ➡
SOD LINED CHANNELS:	SC ➡ SC ➡ SC ➡
RIPRAP-LINED CHANNELS:	RRC ➡ RRC ➡ RRC ➡
TURF REINFORCED CHANNELS:	TRC ➡ TRC ➡ TRC ➡
PAVED CHANNELS:	PC ➡ PC ➡ PC ➡
TEMPORARY SLOPE DRAINS:	TSD ➡ TSD ➡ TSD ➡
PIPE SLOPE DRAINS:	PSD ➡ PSD ➡ PSD ➡
RUNOFF CONVEYANCE MEASURES (CONT):	
STONE BAG CHECK DAM:	SBCD ▶ SBCD ▶ SBCD
OTHER RELATED PRACTICES:	
SUBSURFACE DRAIN:	⊏⊐ SSD ⊏⊐ SSD ⊏⊐
CONSTRUCTION DEWATERING:	

EXHIBIT 4-4
PEN SIZE ASSIGNMENTS

EFFECTIVE DATE: JUNE 30, 2009

STANDARD ASSIGNMENTS

PEN SIZE	*COLOR*	*COLOR RANGE 1*	*COLOR RANGE 2*	*COLOR RANGE 3*	*COLOR RANGE 4*
0.18mm	1, 9, 250	10-19	90-99	170-179	
0.25mm	2, 251	20-29	100-109	180-189	
0.30mm	3, 252	30-39	110-119	190-199	
0.35mm	4, 253	40-49	120-129	200-209	160-169
0.50mm	5, 254	50-59	130-139	210-219	
0.60mm	6, 255	60-69	140-149	220-229	
0.70mm	7	70-79	150-159	230-239	
0.90mm	8	80-89		240-249	

SHADING

All pens in the following ranges ending with the number 2 except "2" will plot shaded as follow

COLOR			**PLOTS**		
12-172			40% of black		
182			6% of black		
192-242			40% of black		
188			2% of black		
16			30% of black		

Appendix G

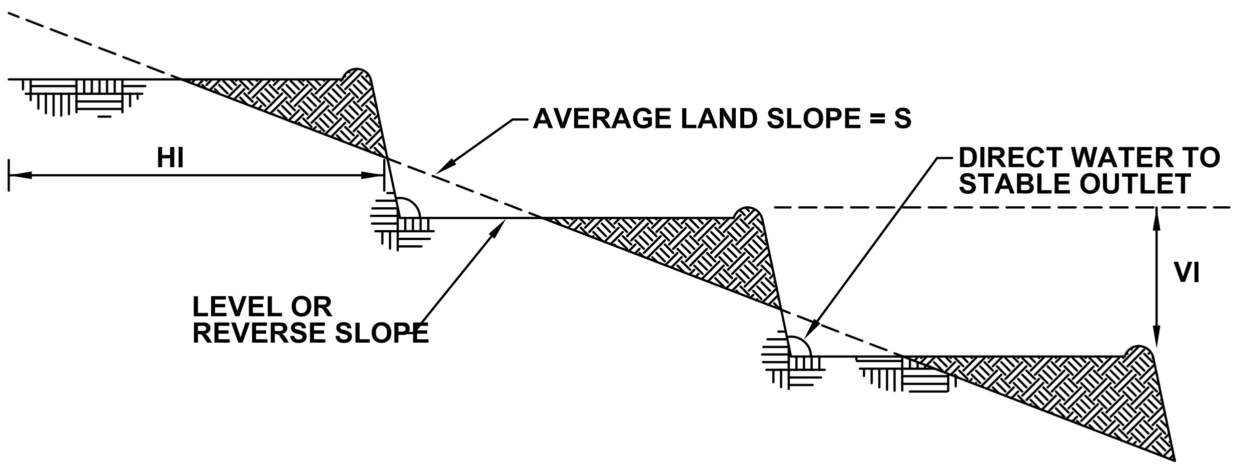
MSD Design Manual Chapter 12 Exhibits

Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913

502-587-0603 – WWW.MSDLOUKY.ORG

EXHIBIT 12-1
BENCH TERRACES
FOR URBAN AREAS

EFFECTIVE DATE: JUNE 30, 2009



EQUATION FOR HORIZONTAL AND VERTICAL INTERVALS

$$HI = VI \times \frac{100}{S}$$

$$VI = aS + b$$

WHERE a = 0.5 FOR LOUISVILLE
b = 1 FOR ERODIBLE CONDITION
2 FOR RESISTANT SOILS WITH GOOD COVER.

S = AVERAGE LAND SLOPE IN PERCENT
HI = HORIZONTAL INTERVAL BETWEEN TERRACES
VI = VERTICAL INTERVAL BETWEEN TERRACES

BENCH TERRACES

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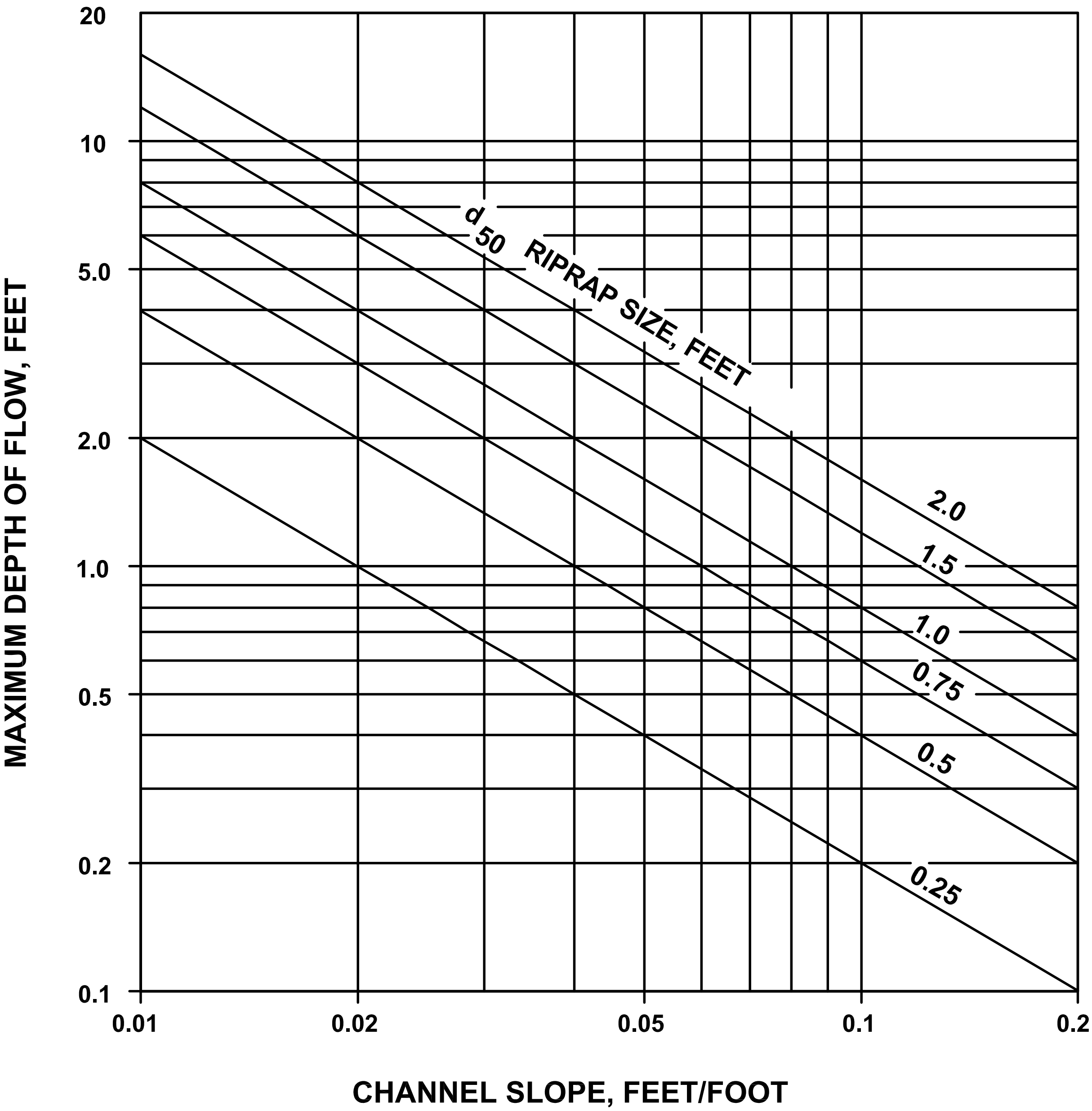
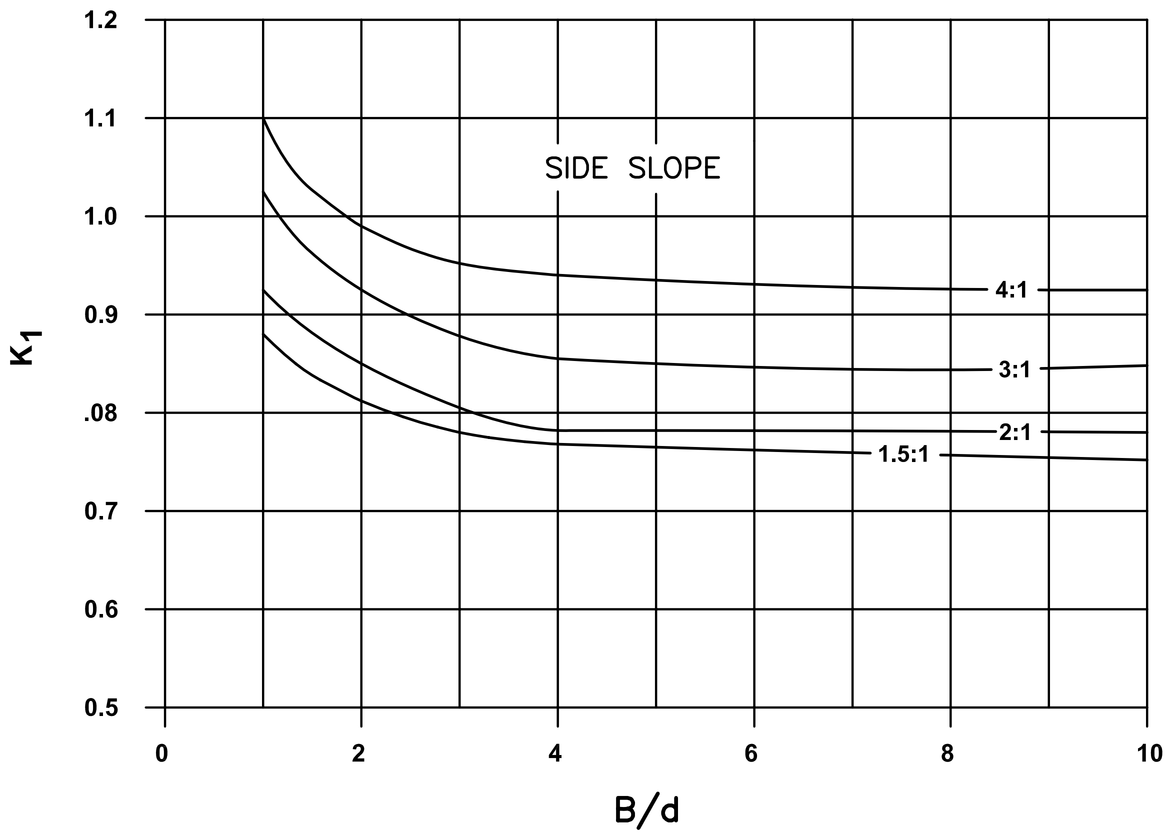
EXHIBIT 12-2
MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

EFFECTIVE DATE: JUNE 30, 2009



MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS



DISTRIBUTION OF BOUNDARY SHEAR AROUND WETTED PERIMETER OF TRAPAZOIDAL CHANNEL

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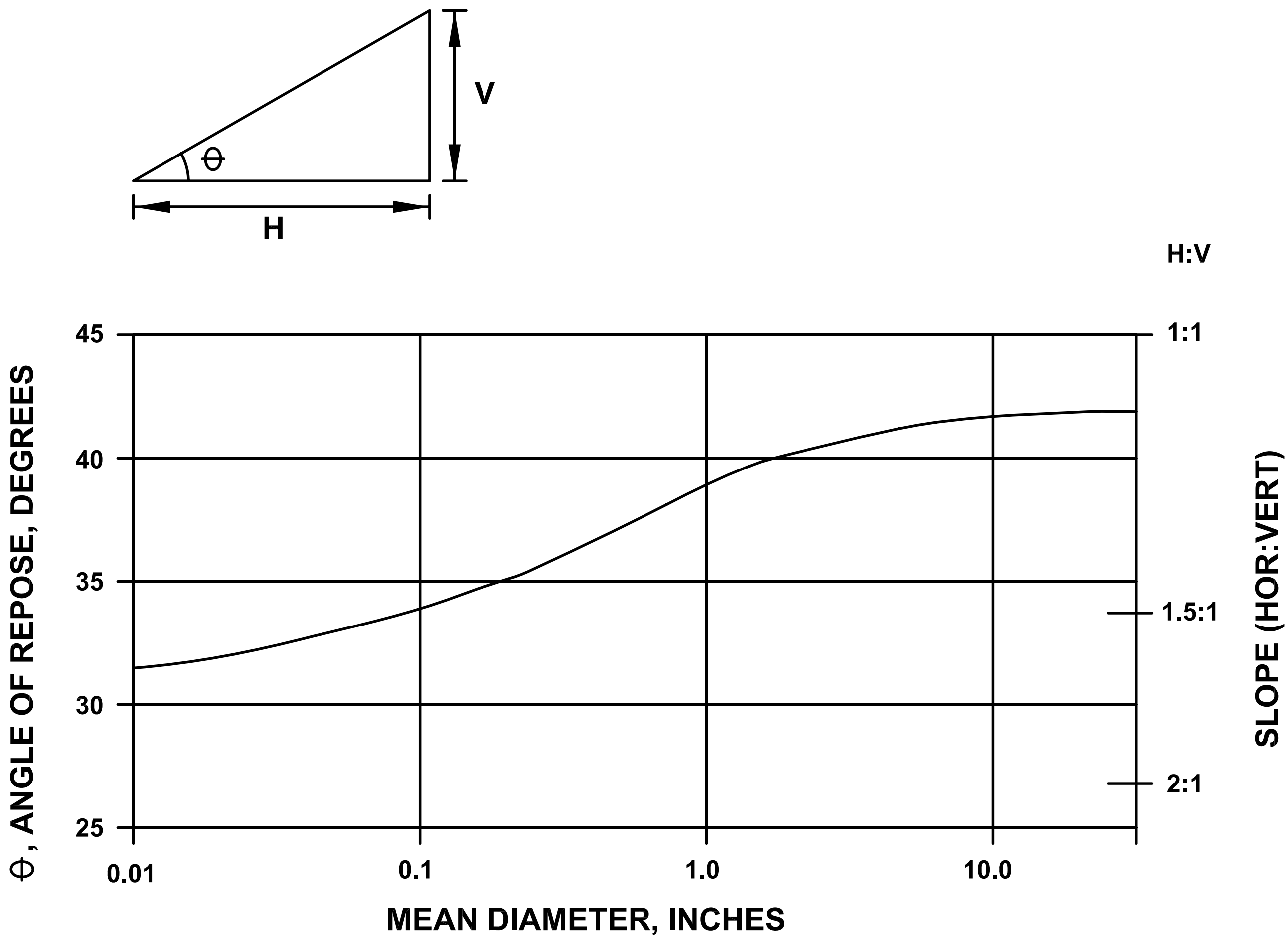
EXHIBIT 12-4
ANGLE OF REPOSE FOR RIPRAP STONES

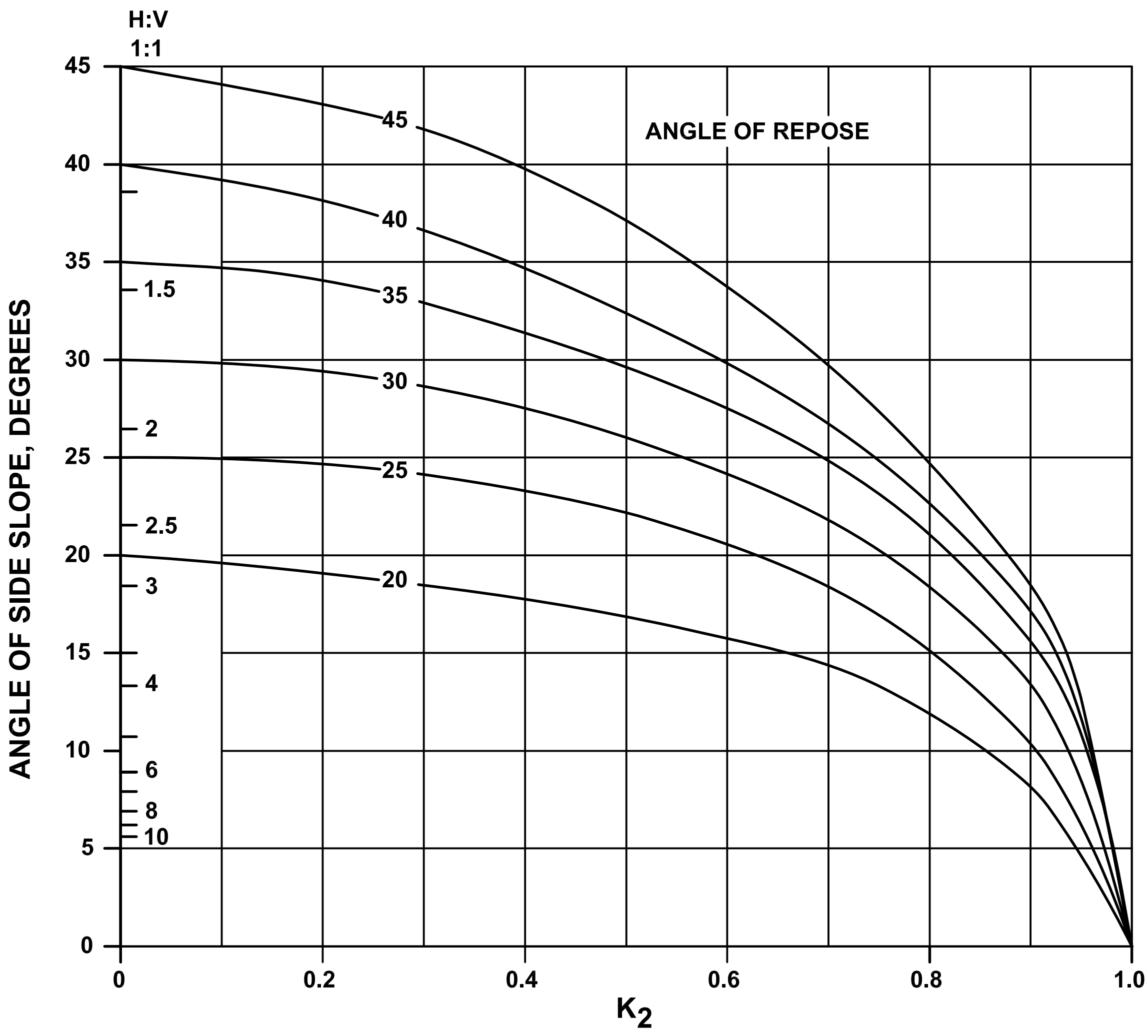
EFFECTIVE DATE: JUNE 30, 2009



ANGLE OF REPOSE FOR RIPRAP STONES

EXHIBIT 12-5
RATIO OF CRITICAL SHEAR STRESS ON SIDES TO CRITICAL SHEAR STRESS ON BOTTOM

EFFECTIVE DATE: JUNE 30, 2009



RATIO OF CRITICAL SHEAR ON SIDES TO CRITICAL SHEAR ON BOTTOM

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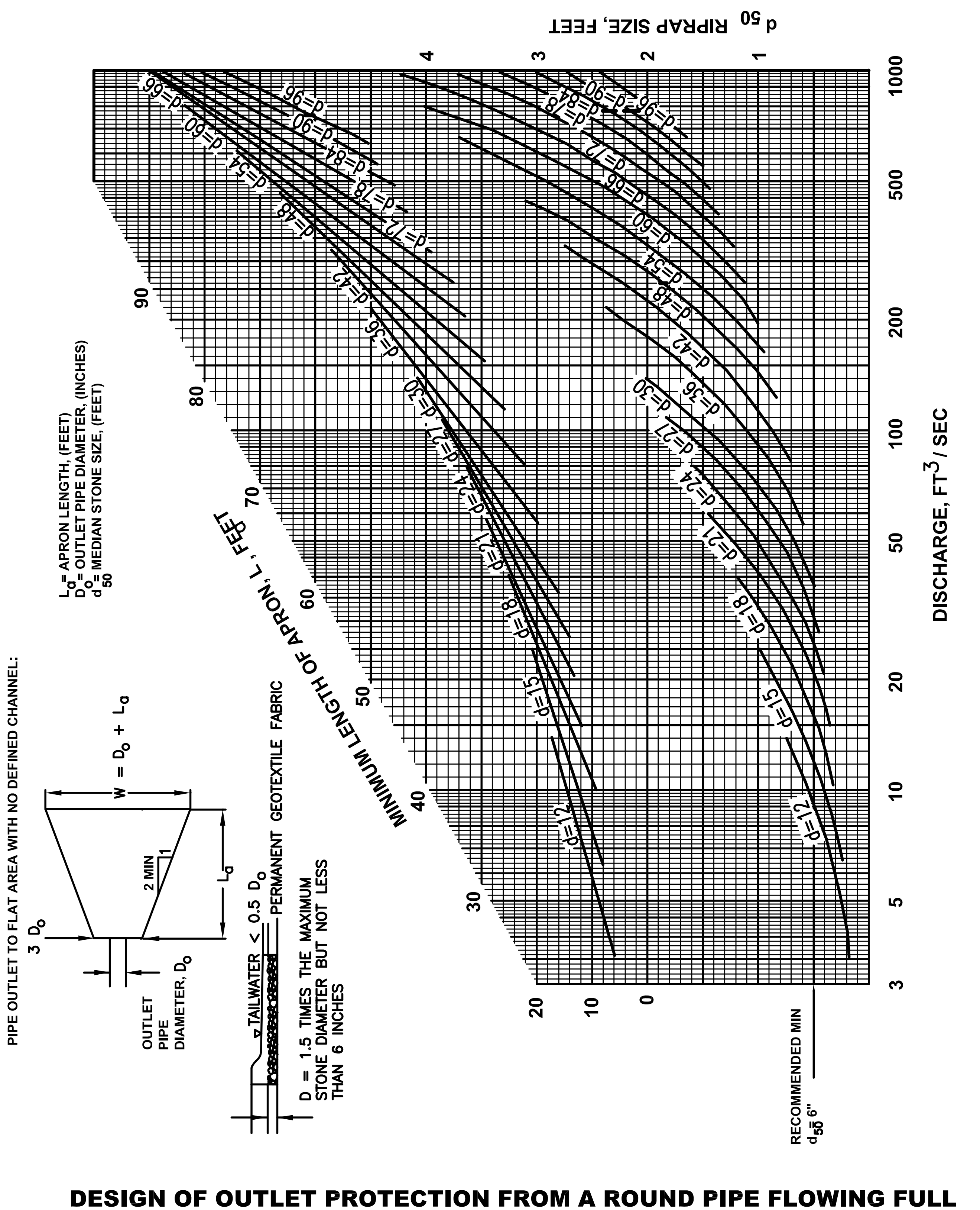
EXHIBIT 12-6
MINIMUM TAIL WATER CONDITION

EFFECTIVE DATE: JUNE 30, 2009



DESIGN OF OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL MINIMUM TAILWATER CONDITION (T < 0.5 DIAMETER)

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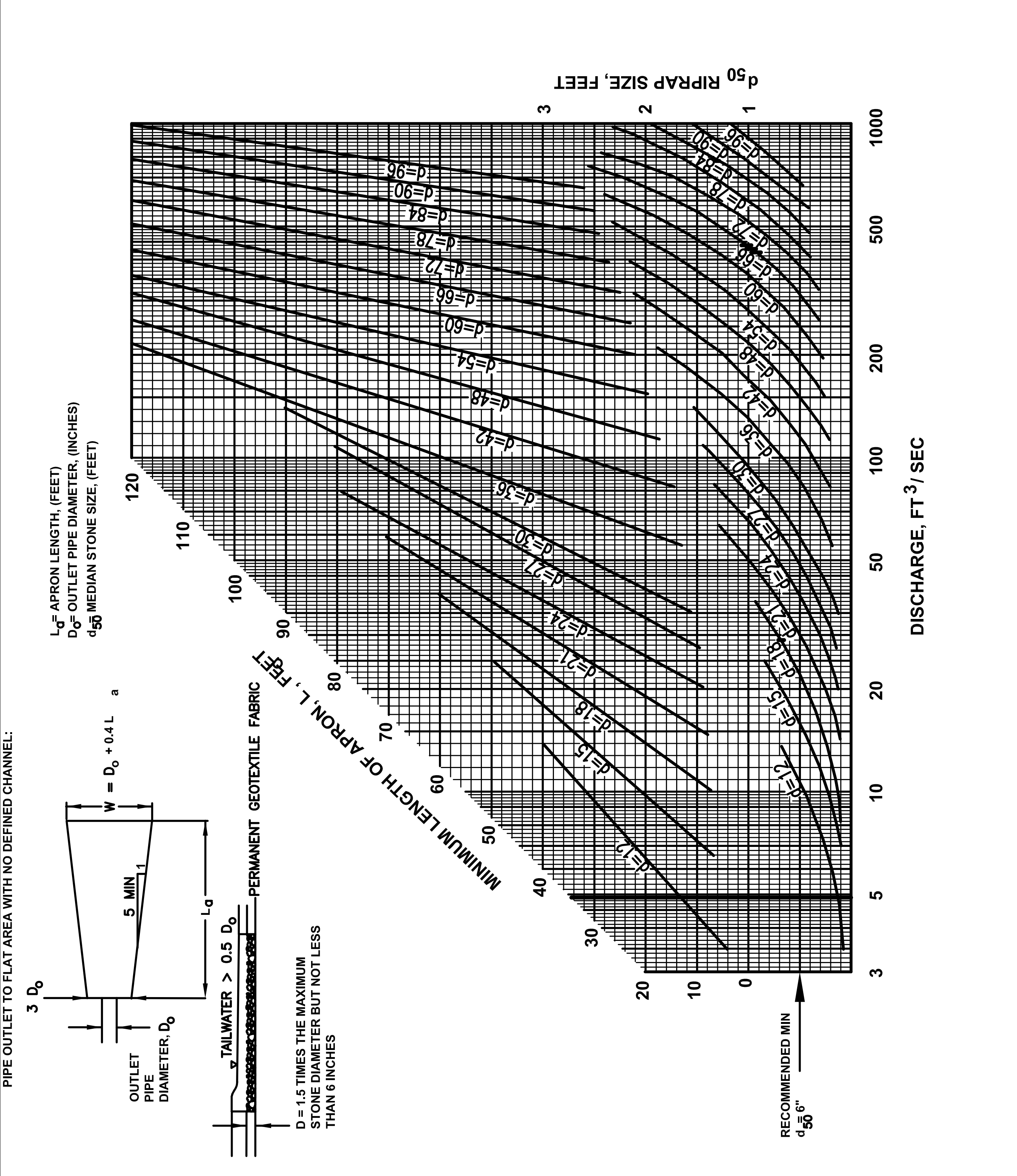
EXHIBIT 12-7
MAXIMUM TAILWATER CONDITION

EFFECTIVE DATE: JUNE 30, 2009



DESIGN OF OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL
MAXIMUM TAILWATER CONDITION (T_w < 0.5 DIAMETER)

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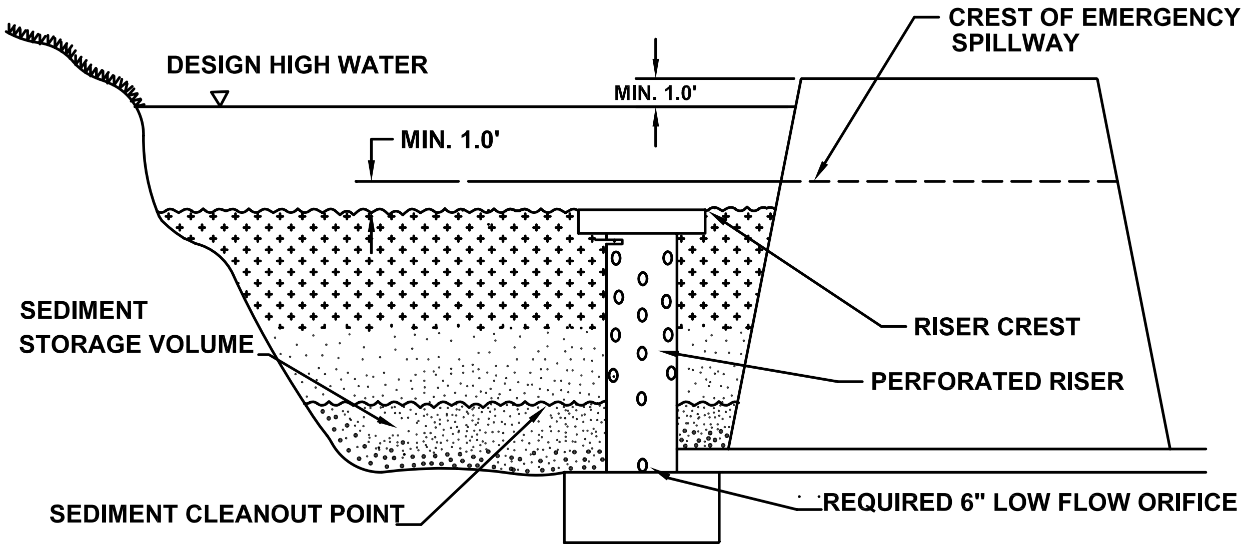
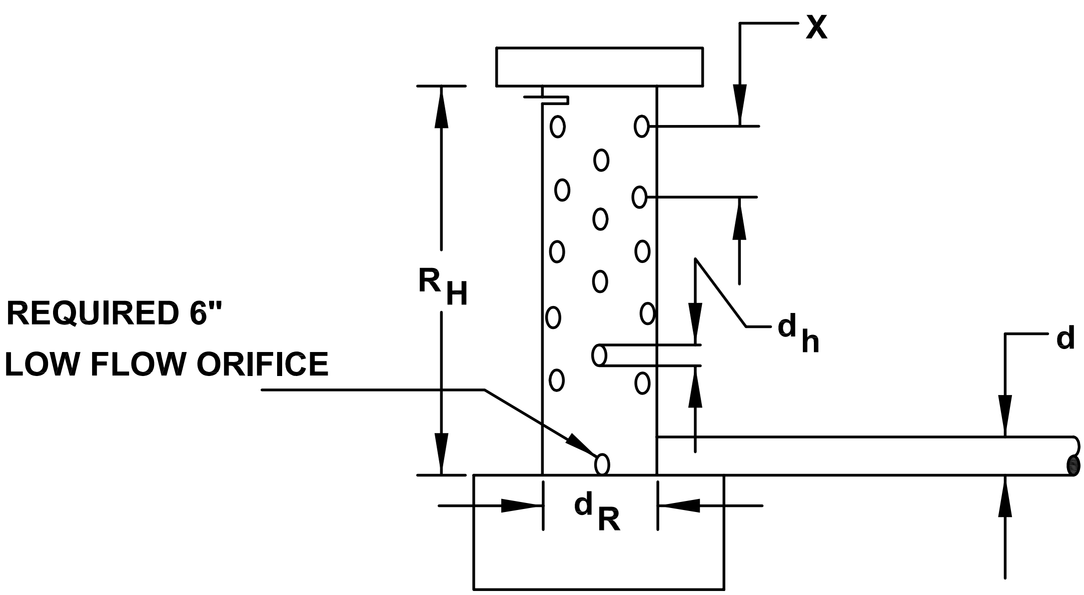
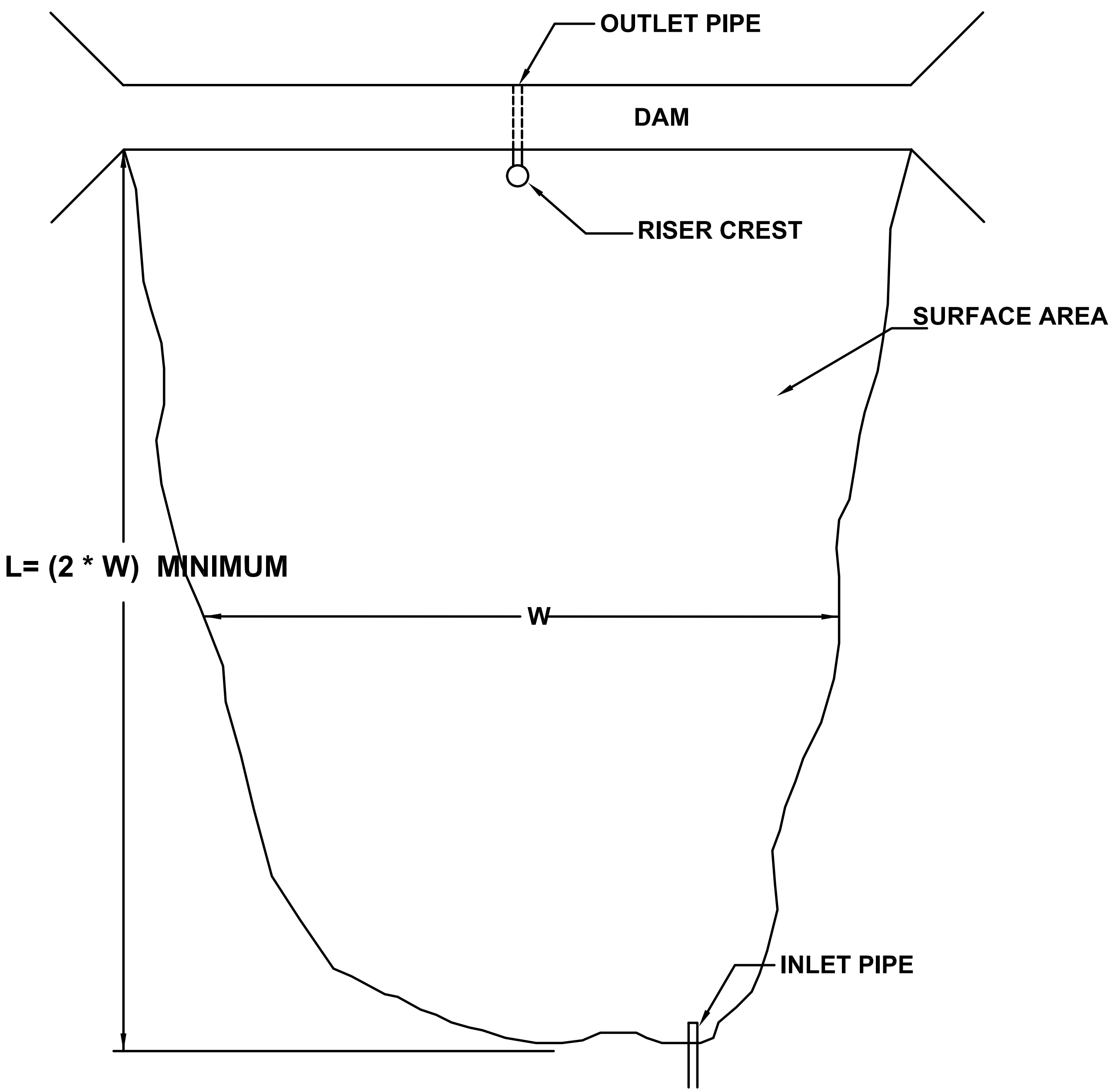


DESIGN ELEVATIONS WITH REQUIRED EMERGENCY SPILLWAY



RISER PIPE DETAIL


OUTLET PIPE
DAM
RISER CREST
SURFACE AREA
L= (2 * W) MINIMUM
W
INLET PIPE

PLAN VIEW

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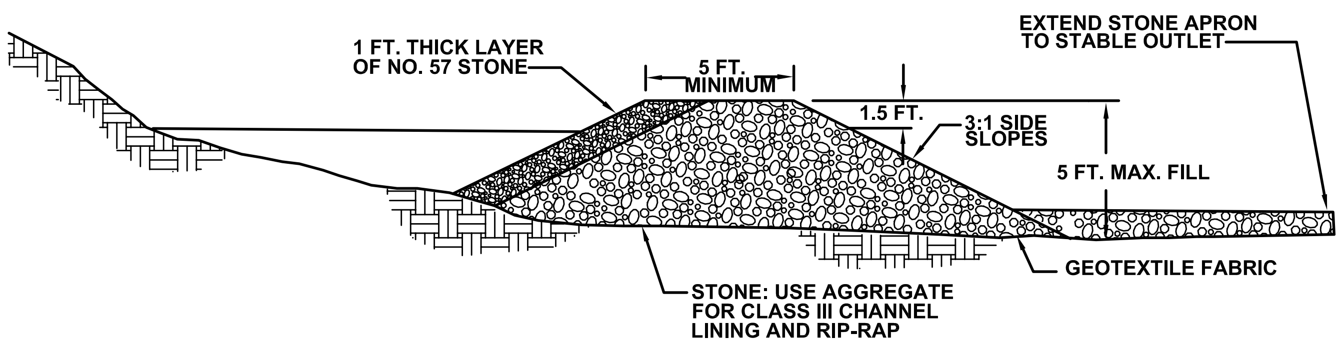
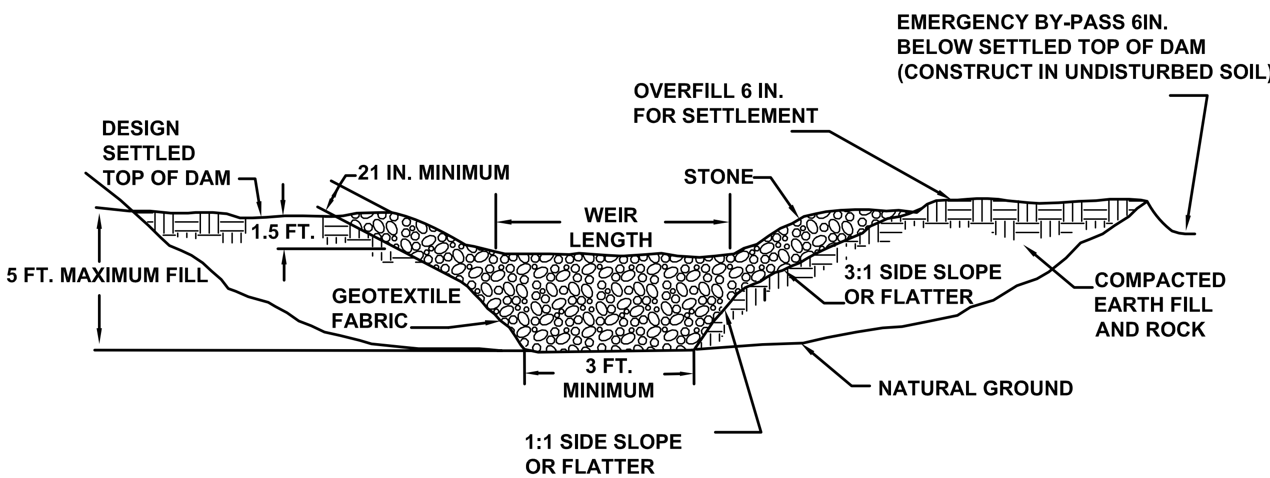
EXHIBIT 12-9A PAGE 1
TEMPORARY SEDIMENT TRAP
FOR URBAN AREAS

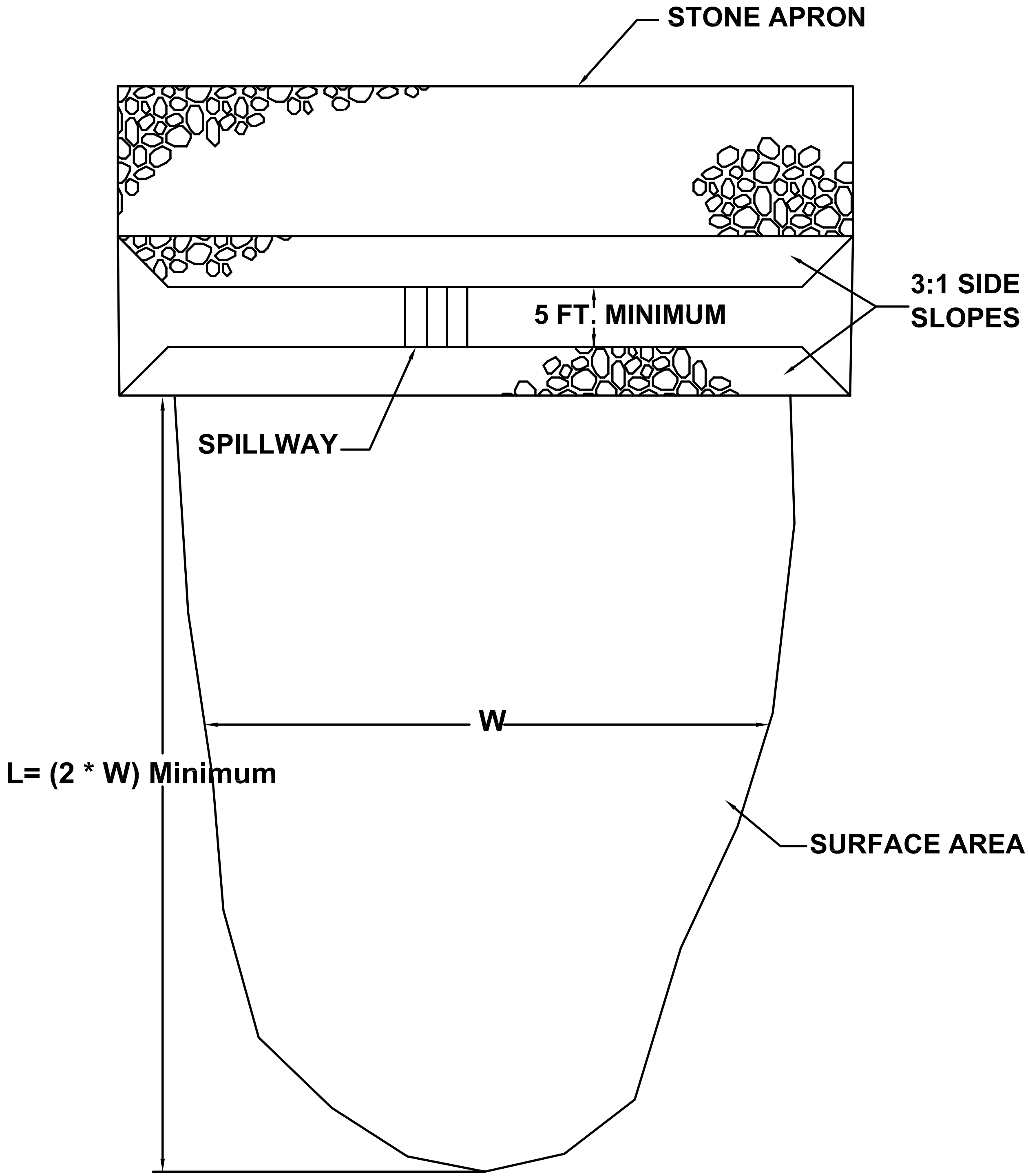
EFFECTIVE DATE: JUNE 30, 2009



STONE SECTION



EMBANKMENT AND SPILLWAY ELEVATION


STONE APRON
3:1 SIDE SLOPES
5 FT. MINIMUM
SPILLWAY
W
L= (2 * W) Minimum
SURFACE AREA

PLAN VIEW

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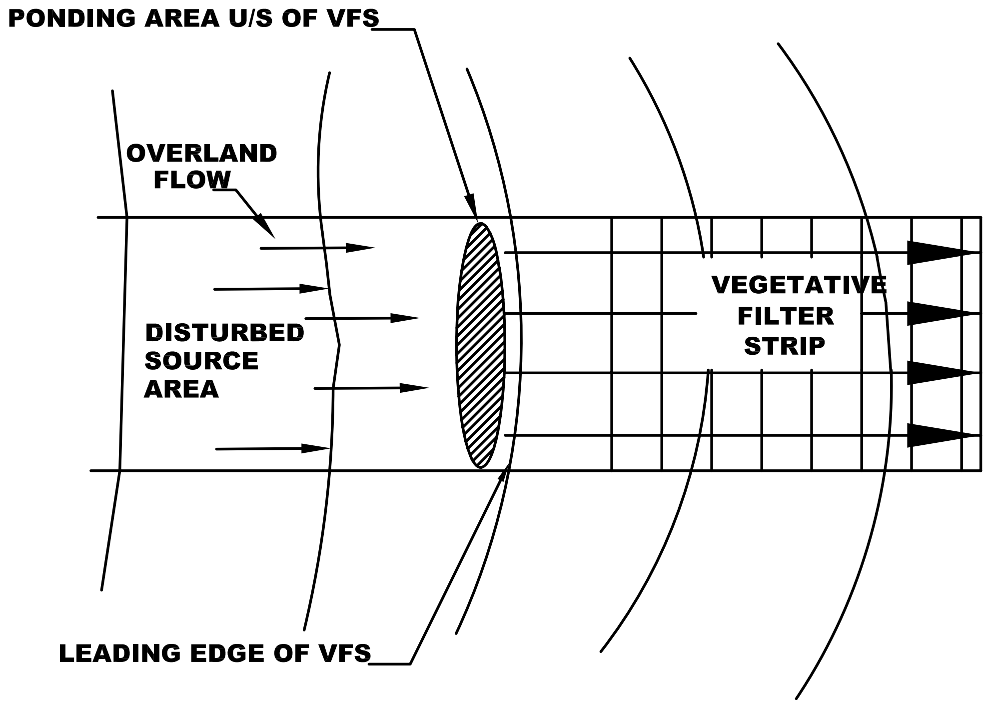
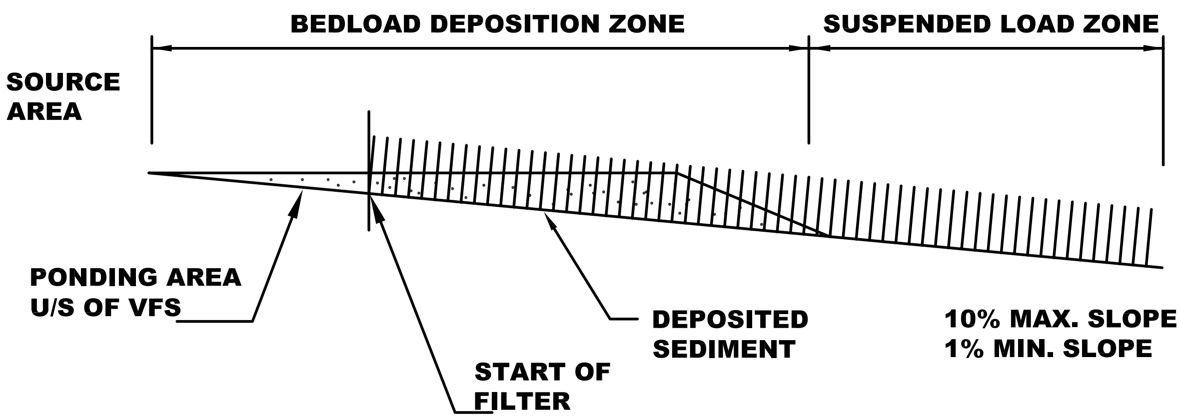
EXHIBIT 12-10
VEGETATED FILTER STRIPS

EFFECTIVE DATE: JUNE 30, 2009



PLAN VIEW



PROFILE VIEW

SCHEMATIC OF A TYPICAL VEGETATIVE FILTER STRIP

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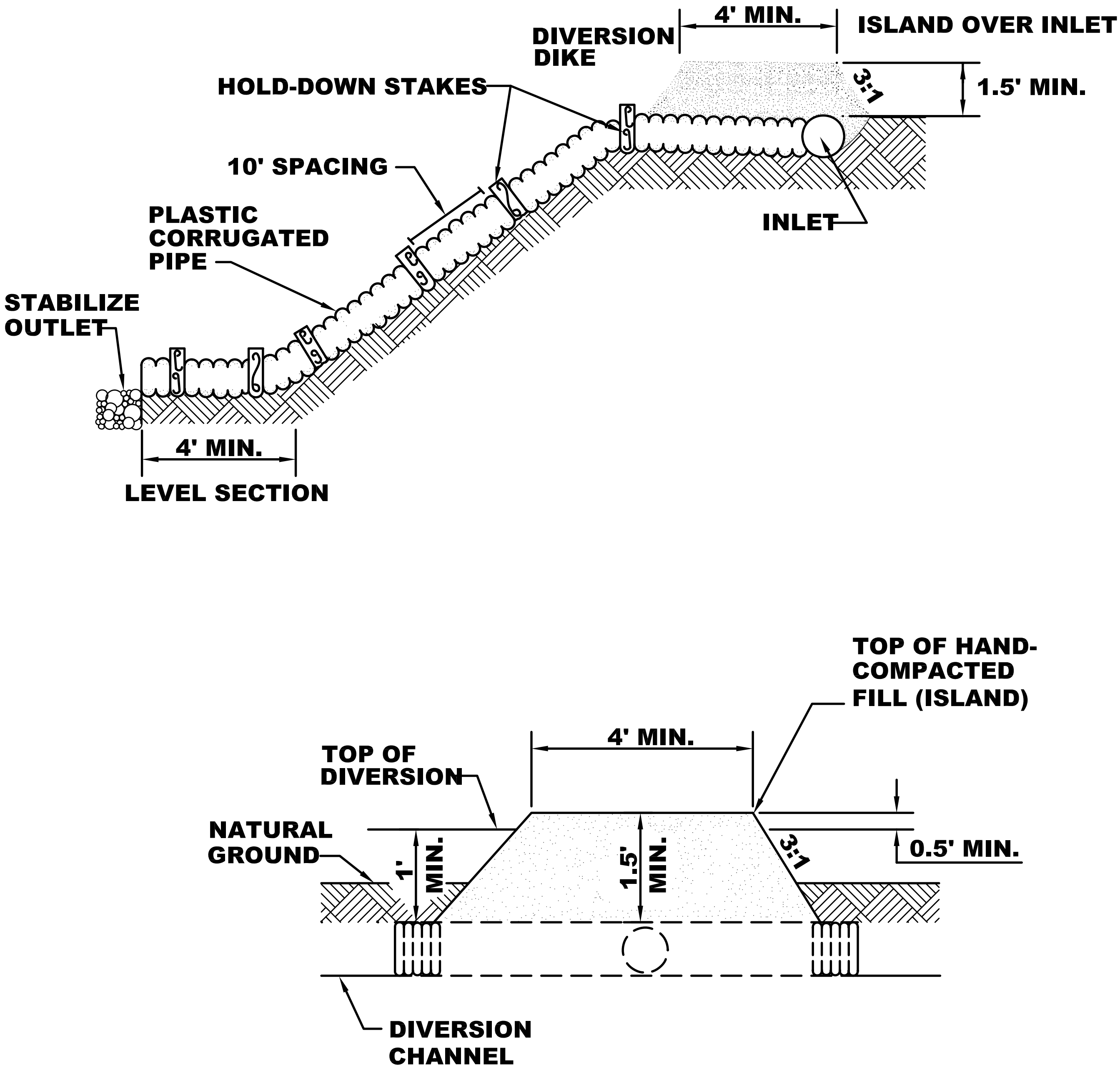
EXHIBIT 12-11
PIPE SLOPE DRAIN

EFFECTIVE DATE: JUNE 30, 2009



TYPICAL PIPE SLOPE DRAIN LAYOUT

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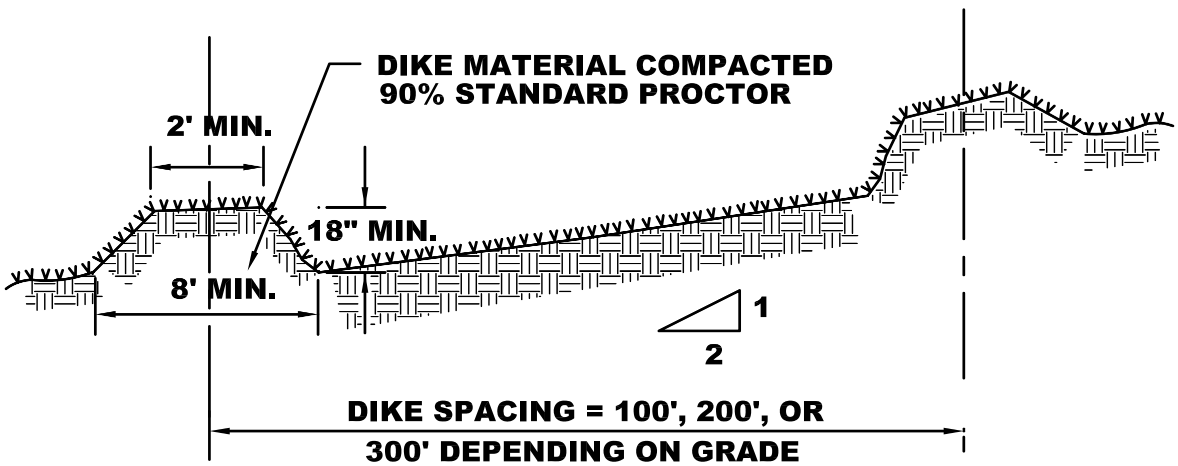
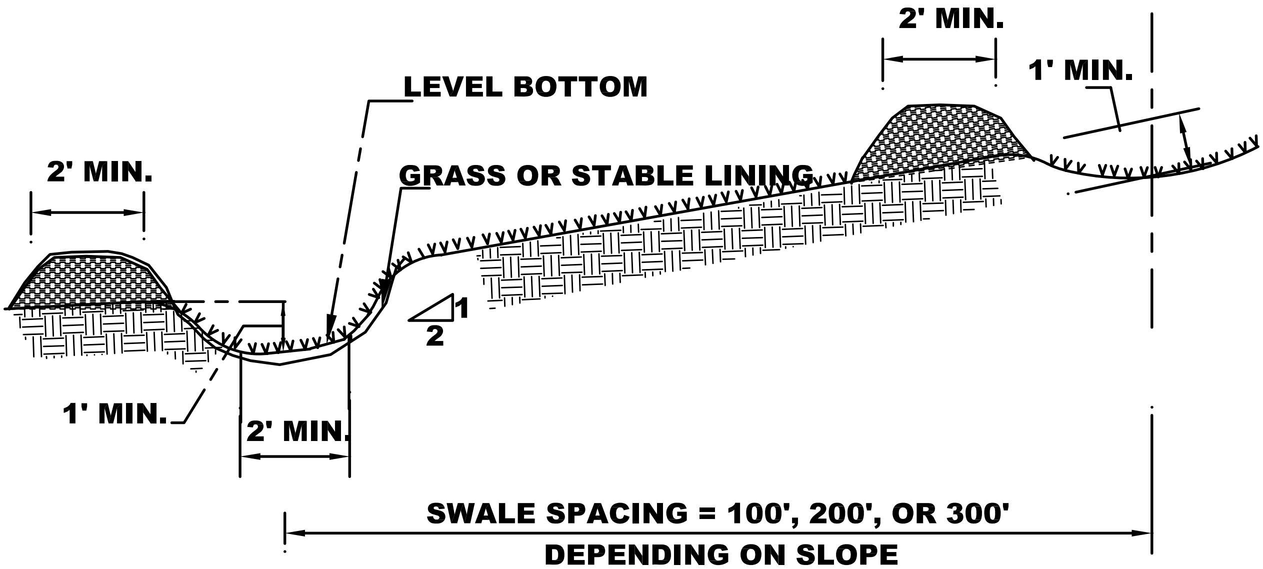
EXHIBIT 12-12
DIKES AND SWALES

EFFECTIVE DATE: JUNE 30, 2009



DIKE



SWALE

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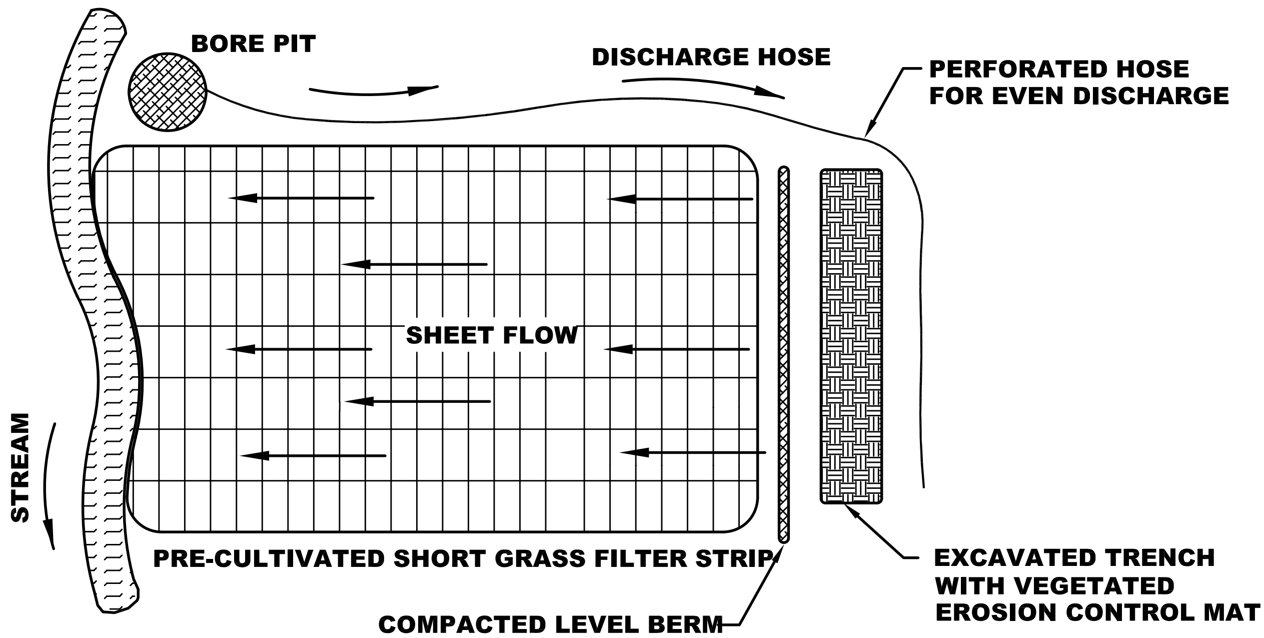
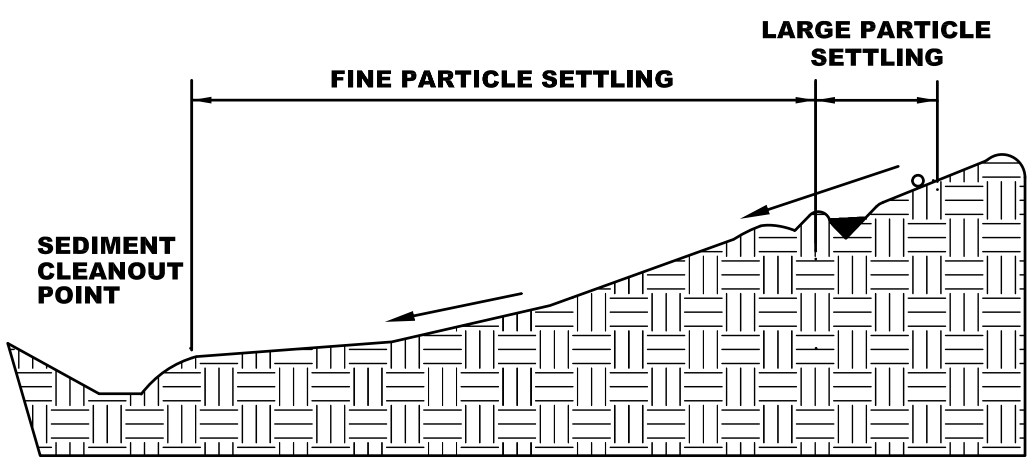
EXHIBIT 12-13
DEWATERING OPERATIONS FOR PUMPING TO A VEGETATED BUFFER ZONE

EFFECTIVE DATE: JUNE 30, 2009



PLAN VIEW



PROFILE VIEW

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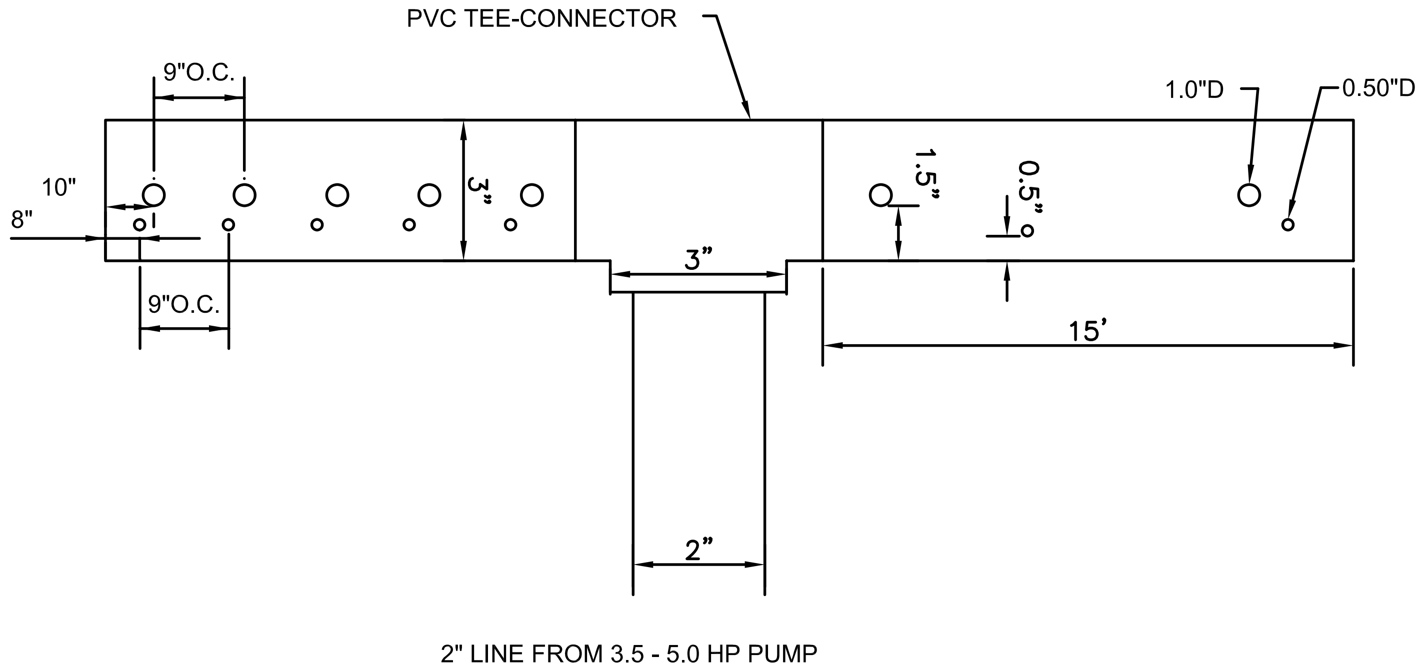
EXHIBIT 12-14
DETAIL FOR DEWATERING OUTLET STRUCTURE

EFFECTIVE DATE: JUNE 30, 2009

- TWO 15-FT. SECTIONS OF 3-INCH DIAMETER SCHEDULE 40 PVC PIPE ATTACHED TO 3" PVC TEE SECTION. EACH OPEN PIPE END SHALL BE CAPPED.
- EACH 15-FT. SECTION HAS 20, 0.50-INCH DIAMETER HOLES LOCATED 0.5 INCHES FROM THE BOTTOM OF THE PIPE LINEARLY SPACED 9 INCHES ON CENTER, WITH THE FIRST HOLE STARTING 8 INCHES FROM THE EXTREME END OF THE PIPE.
- EACH 15-FT. SECTION HAS 18, 1.00-INCH DIAMETER HOLES LOCATED 1.5 INCHES FROM THE BOTTOM OF THE PIPE LINEARLY SPACED 9 INCHES ON CENTER, WITH THE FIRST HOLE STARTING 10 INCHES FROM THE EXTREME END OF THE PIPE.



DEWATERING OUTLET STRUCTURE TO VEGETATED BUFFER ZONE