NATURAL RESOURCES CONSERVATION SERVICE
WEST VIRGINIA DESIGN NOTE

RIPRAP-LINED OUTLET PROTECTION

INTRODUCTION

Outlet protection as presented here is a level apron of sufficient length and flare such that the expanding flow from a pipe or culvert loses sufficient velocity and energy and will not erode downstream of the discharge pipe. The design curves shown in Figures[A] 1a and 1b are for circular conduits flowing full. The curves provide the recommended apron dimension and median riprap diameter, D_{50}. Figure 1a presents curves for minimum tailwater condition and Figure 1b presents curves for maximum tailwater condition. This design procedure is applicable to all pipe, culverts, and storm sewer outlets greater than or equal to 4 inches in diameter and less than or equal to 42 inches in diameter and to detention structure pipe outlets less than or equal to 24 inches in diameter.

This design note is not intended for use with: 1) detention structures having outlet pipes greater than 24 inches in diameter or 2) general outlet pipes or culverts greater than 48 inches in diameter. Design Note 6 - Riprap Lined Plunge Pool for Cantilever Outlet, Technical Release (TR) 54 - Structural Design of SAF Stilling Basins, National Engineering Handbook Section 14 - Chute Spillways or TR 50 - Design of Rectangular Structural Channels may be used to design energy-dissipating outlet structures for these situations as appropriate.

DESIGN PROCEDURE STEPS

Document the pipe diameter (inches) and discharge (cfs) of the pipe when in full flow condition.

1. Based on the tailwater depth immediately below the pipe outlet classify the tailwater condition as either
    a. Minimum Tailwater Condition (Figure 1a) where the tailwater depth is less than half the diameter of the pipe at the discharge point.
    b. Maximum Tailwater Condition (Figure 1b) where the tailwater depth is equal or greater than half the diameter of the pipe at the discharge point.
2. Select Figure 1a or Figure 1b for the appropriate tailwater condition. Determine the
    a. Median Riprap Diameter, D_{50} (Ft)
        i. Go to the selected figure and select the full pipe discharge (cfs) on the x-axis, extend a vertical line to the pipe diameter in the lower set of curves. Then read horizontally to the y-axis on the right and determine the Median Riprap Diameter, D_{50}.
    b. Minimum Apron Length, La (Ft)
        i. Extend the vertical line (discussed in 2ai) to the pipe diameter in the upper set of curves in the figure until it intersects the pipe diameter. Then read horizontally to the y-axis on the left and determine the Minimum Apron Length, La.

Note: [A] The figures provided are generated from equations found in the U.S. Army Corps of Engineers *Erosion and Riprap Requirements at Culvert and Storm-Drain Outlets*, Bohan, J. P. Research Report H-70-2, 1970.

3. Calculate the Apron Width, W (Ft)
    a. Calculate the apron width by adding three times the pipe diameter (Do) to the apron length, La. W = (3 x Do(ft)) + La(ft) when minimum tailwater conditions prevail and the outlet is
        i. discharging into a flat channel or area or
        ii. discharging into a defined channel wider than the apron width (W).
    b. Calculate the apron width by adding three times the pipe diameter (Do) to 0.4 times the apron length, La. W = (3 x Do(ft)) + (La(ft) x 0.4) when maximum tailwater conditions are met and the pipe outlet is discharging into an area wider than the apron width.
    c. If the above conditions cannot be met and the outlet discharges into a channel narrower than the required apron width, then at a minimum, continuously line the channel one foot (1.0') above the design flow elevation or to the top of bank, whichever is less, and downstream to length of 1.2 x (La).

BOTTOM GRADE

The apron shall be constructed with no slope along its entire length (0.0% grade). The invert elevation of the downstream end of the apron shall be equal to the elevation of the invert of the receiving channel or flat area. There shall be no overfall at the end of the apron.

ALIGNMENT

The apron shall be straight and symmetrical for its entire length. The centerline of the discharging pipe shall be coincident with the centerline of the apron.

RIPRAP SIZE

The median D_{50} size of the riprap shall be taken from Figure 1 for the appropriate tailwater condition. The riprap shall be reasonably well graded between the limits of 3 inches and 1.5 times D_{50}.

EXAMPLE:

A hooded 2.0' diameter circular pipe flowing full is discharging into a channel with the following characteristics. Pipe flow Q=50.6 cfs; Inlet Invert Elev. = 96.0; Outlet Invert Elev. = 88.0, Tailwater = 89.2, channel bottom width 30'.

Maximum Tailwater Condition (Tw>=0.5 Dia.)

From Figure 1b- Median Riprap Diameter, D_{50} = 0.8 ft. (well-graded between limits of 3-29 inches)
Minimum Apron Length = 52.5 ', Minimum Apron Width = 3 x 2' + 0.4 * 52.5' = 27'

Figure 1a: Minimum Tailwater Condition

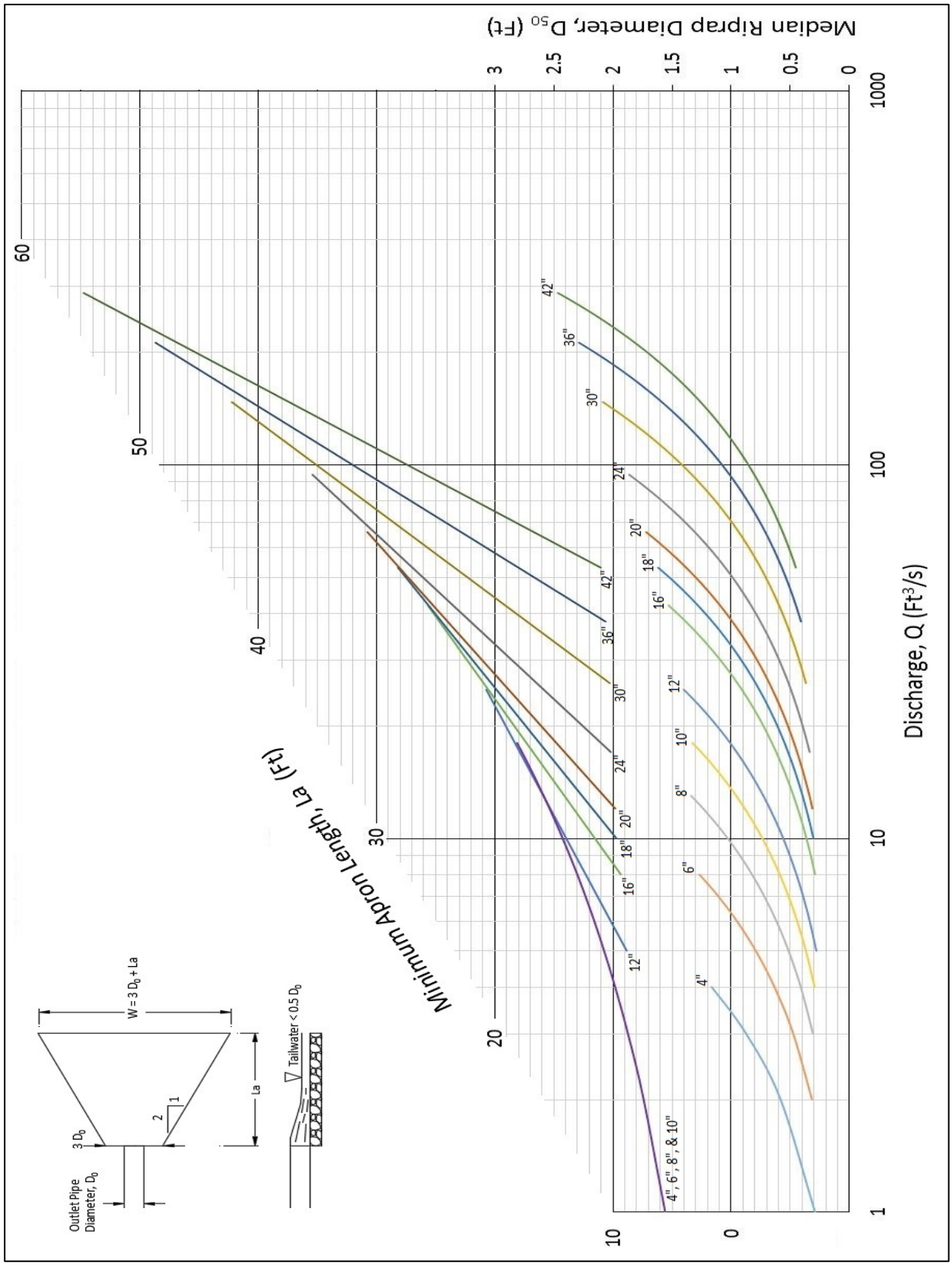

Figure 1b: Maximum Tailwater Condition