

Module 7: Outlet Protection Problems

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Learning Objectives

At the end of this module, you will be able to:

- Determine proper dimensions for outlet protection.
- Comprehend common calculations associated with outlet protection design.

Outlet Protection Problems

Use the Virginia Stormwater Management Handbook (VSWHB), Chapter 7.4, C-ECM-15.

Round final answers to one decimal place, when practical.

1. Given a discharge of 13 cubic feet per second (cfs) from a 15-inch pipe into water depth less than half the pipe diameter, what is the apron length, L_a (feet); median stone size of riprap, d_{50} ; upstream apron width, W_u (feet); and downstream apron width, W_d (feet), required for outlet protection?

Step 1: Determine the tailwater condition given the information provided above.

Step 2: Determine which figure (C-ECM-15-3 or C-ECM-15-4) to use in the VSWHB given the tailwater condition.

Step 3: Select the discharge given on the bottom horizontal axis.

$$Q = \text{_____ cfs}$$

Step 4: Read up to the bottom half of the chart to the given pipe diameter.

$$d = \text{_____ inches}$$

Step 5: Read over to the right for the median size riprap stone.

$$d_{50} = \text{_____ feet}$$

Step 6: From discharge ($Q = 13$ cfs), read up to top half of chart to pipe diameter.

$$d = \text{_____ inches}$$

Step 7: Read to the left for the minimum apron length.

$$L_a = \text{_____ feet}$$

Step 8: Calculate upstream apron width.

$$\text{Upstream Apron Width } (W_u, \text{ in feet}) = 3 \times \text{Pipe Diameter } (D_o, \text{ in feet})$$

$$\text{_____ feet} = 3 \times \text{_____ feet}$$

Step 9: Calculate downstream apron width.

$$\begin{aligned} &\text{Downstream Apron Width } (W_d, \text{ in feet}) \\ &= \text{Pipe Diameter } (D_0, \text{ in feet}) + \text{Apron Length } (L_a, \text{ in feet}) \\ &\quad \text{_____ feet} = \text{_____ feet} + \text{_____ feet} \end{aligned}$$

2. Given an 18-inch pipe that discharges 20 cubic feet per second (cfs) into water depth greater than half the pipe diameter (Maximum Tailwater Condition), what is the apron length, L_a (feet); median stone size, d_{50} ; upstream apron width, W_u (feet); and downstream apron width, W_d (feet), required for outlet protection?

Step 1: Determine which figure (C-ECM-15-3 or C-ECM-15-4) to use in the VSWHB given the tailwater condition. On the bottom horizontal axis, select the given discharge.

$$Q = \text{_____ cfs}$$

Step 2: Read up to bottom half of the chart to the given pipe diameter.

$$d = \text{_____ inches}$$

Step 3: Read over to the right for the median size riprap stone.

$$d_{50} = \text{_____ feet}$$

Step 4: From discharge ($Q = 20$ cfs), read up to the top half of the chart to the pipe diameter.

$$d = \text{_____ inches}$$

Step 5: Read to the left for the minimum apron length.

$$L_a = \text{_____ feet}$$

Step 6: Calculate upstream apron width.

$$\begin{aligned} &\text{Upstream Apron Width } (W_u, \text{ in feet}) = 3 \times \text{Pipe Diameter } (D_0, \text{ in feet}) \\ &\quad \text{_____ feet} = 3 \times \text{_____ feet} \end{aligned}$$

Step 7: Calculate downstream apron width.

$$\begin{aligned} &\text{Downstream Apron Width } (W_d, \text{ in feet}) \\ &= \text{Pipe Diameter } (D_0, \text{ in feet}) + 0.4 \times \text{Apron Length } (L_a, \text{ in feet}) \\ &\quad \text{_____ feet} = \text{_____ feet} + (0.4 \times \text{_____ feet}) \end{aligned}$$