DESIGN OF RIPRAP OUTLET PROTECTION

User Input Data
Calculated Value
Reference Data

Designed By:	JFO	**Date:**	8/1/2024
Checked By:	RBS	**Date:**	8/1/2024
Company:			
Project Name:	Franco C&M		
Project No.:			

Site Location (City/Town)	Zebulon
Culvert Id.	Site Outfall
Total Drainage Area (acres)	0.3

Step 1. Determine the tailwater depth from channel characteristics below the pipe outlet for the design capacity of the pipe. If the tailwater depth is less than half the outlet pipe diameter, it is classified minimum tailwater condition. If it is greater than half the pipe diameter, it is classified maximum condition. Pipes that outlet onto wide flat areas with no defined channel are assumed to have a minimum tailwater condition unless reliable flood stage elevations show otherwise.

Outlet pipe diameter, D_o (in.)	18
Tailwater depth (in.)	12
Minimum/Maximum tailwater?	Max TW (Fig. 8.06b)
Discharge (cfs)	2
Velocity (ft./s)	4

Step 2. Based on the tailwater conditions determined in step 1, enter Figure 8.06a or Figure 8.06b, and determine d_{50} riprap size and minimum apron length (L_a). The d_{50} size is the median stone size in a well-graded riprap apron.

Step 3. Determine apron width at the pipe outlet, the apron shape, and the apron width at the outlet end from the same figure used in Step 2.

	Minimum TW	**Maximum TW**
	Figure 8.06a	Figure 8.06b
Riprap d_{50}, (ft.)		0.75
Minimum apron length, L_a (ft.)		8
Apron width at pipe outlet (ft.)	4.5	4.5
Apron shape		Rectangle
Apron width at outlet end (ft.)	1.5	4.7

Step 4. Determine the maximum stone diameter:

$$d_{max} = 1.5 \times d_{50}$$

	Minimum TW	**Maximum TW**
Max Stone Diameter, dmax (ft.)	0	1.125

Step 5. Determine the apron thickness:

$$\text{Apron thickness} = 1.5 \times d_{max}$$

	Minimum TW	**Maximum TW**
Apron Thickness(ft.)	0	1.6875

Step 6. Fit the riprap apron to the site by making it level for the minimum length, L_a, from Figure 8.06a or Figure 8.06b. Extend the apron farther downstream and along channel banks until stability is assured. Keep the apron as straight as possible and align it with the flow of the receiving stream. Make any necessary alignment bends near the pipe outlet so that the entrance into the receiving stream is straight.

Some locations may require lining of the entire channel cross section to assure stability.

It may be necessary to increase the size of riprap where protection of the channel side slopes is necessary (*Appendix 8.05*). Where overfalls exist at pipe outlets or flows are excessive, a plunge pool should be considered, see page 8.06.8.

DESIGN OF RIPRAP OUTLET PROTECTION

User Input Data
Calculated Value
Reference Data

Designed By:	JFO	**Date:**	8/1/2024
Checked By:	RBS	**Date:**	8/1/2024
Company:			
Project Name:	Franco C&M		
Project No.:			

Site Location (City/Town)	Zebulon
Culvert Id.	Driveway Pipe
Total Drainage Area (acres)	

Step 1. Determine the tailwater depth from channel characteristics below the pipe outlet for the design capacity of the pipe. If the tailwater depth is less than half the outlet pipe diameter, it is classified minimum tailwater condition. If it is greater than half the pipe diameter, it is classified maximum condition. Pipes that outlet onto wide flat areas with no defined channel are assumed to have a minimum tailwater condition unless reliable flood stage elevations show otherwise.

Outlet pipe diameter, D_o (in.)	24
Tailwater depth (in.)	12
Minimum/Maximum tailwater?	Max TW (Fig. 8.06b)
Discharge (cfs)	21
Velocity (ft./s)	4

Step 2. Based on the tailwater conditions determined in step 1, enter Figure 8.06a or Figure 8.06b, and determine d_{50} riprap size and minimum apron length (L_a). The d_{50} size is the median stone size in a well-graded riprap apron.

Step 3. Determine apron width at the pipe outlet, the apron shape, and the apron width at the outlet end from the same figure used in Step 2.

	Minimum TW	Maximum TW
	Figure 8.06a	Figure 8.06b
Riprap d_{50}, (ft.)		0.75
Minimum apron length, L_a (ft.)		10
Apron width at pipe outlet (ft.)	6	6
Apron shape		Rectangle
Apron width at outlet end (ft.)	2	6

Step 4. Determine the maximum stone diameter:

$$d_{max} = 1.5 \times d_{50}$$

	Minimum TW	Maximum TW
Max Stone Diameter, dmax (ft.)	0	1.125

Step 5. Determine the apron thickness:

$$\text{Apron thickness} = 1.5 \times d_{max}$$

	Minimum TW	Maximum TW
Apron Thickness(ft.)	0	1.6875

Step 6. Fit the riprap apron to the site by making it level for the minimum length, L_a, from Figure 8.06a or Figure 8.06b. Extend the apron farther downstream and along channel banks until stability is assured. Keep the apron as straight as possible and align it with the flow of the receiving stream. Make any necessary alignment bends near the pipe outlet so that the entrance into the receiving stream is straight.

Some locations may require lining of the entire channel cross section to assure stability.

It may be necessary to increase the size of riprap where protection of the channel side slopes is necessary (*Appendix 8.05*). Where overfalls exist at pipe outlets or flows are excessive, a plunge pool should be considered, see page 8.06.8.