APRONS AND SCOUR PROTECTION

[Plastic Culvert Overview Flowchart](#) [Structural Defects Flowchart (Plastic)](#)
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1. SUMMARY

Scouring of culvert outlets is a common problem that can lead to damage to the culvert structure and neighboring land. Scour is possible at both culvert inlet and outlet.

Mendoza et al. (1983) found that the maximum depth, width, length, and volume of scour can be correlated to the discharge intensity but also observed that the maximum scour dimensions are approximately equal for both headwall and no-headwall conditions. Abida and Townsend (1991) investigated the local scouring phenomenon in sand that occurs downstream of box culverts. The principal factors governing this form of local scouring were found to be the discharge rate, the culvert width, the tailwater depth, the downstream channel width, and the bed-material properties. Liriano et al. (2002) measured the turbulent flow structure within scour holes downstream of pipe culvert outlets at different stages of development. Initial scour hole development was found to be a result of high velocities exceeding the critical velocity for sediment transport whilst further development results in a reduction in the magnitude of the near-bed velocities and an asymptotic increase in scour depth associated with the turbulent structure of the flow. Towards the downstream end of the scour holes, the jet comes into contact with the bed and flow structures similar to those observed downstream of backward facing steps are noted. FHWA’s HEC 14 (Thompson and Kilgore, 2006) presented a method for predicting local scour at the outlet of culverts based on discharge, culvert shape, soil type, duration of flow, culvert slope, culvert height above the bed, and tailwater depth. The equations were derived from tests conducted by the Corps of Engineers (Bohan, 1970) and Colorado State University.

FHWA’s HEC 23 (Lagasse et al., 1997) provided guidelines for the selection and design of appropriate scour countermeasures to mitigate potential damage to bridges and other highway components at stream crossings.

Gannett (2008) outlined the following culvert scour countermeasures:
- Inlet and outlet cutoff walls
- Stone fill apron at outlet
- Headwalls/wingwalls to protect embankment
- Downstream check dam where stream degradation exists
- Pre-formed scour hole for energy dissipation and fish habitat

NYSDOT (2005) Highway Design Manual (HDM) recommends culvert cut-off wall for all reinforced concrete box culverts with invert slab to prevent undermining as follows:
- Minimum width 450 mm (18 in.),
- Extend 1.2 m (47 in.) below invert, or to sound rock if shallower,
- Wall at both inlet and outlet end,
- An additional cut-off wall should be specified at the end of the apron when concrete apron is specified (however, if the apron is continuous with the barrel, the cut-off wall is only required at the end of the apron); and
- Wingwall footings should be set at or below bottom of cut-off wall.

Stone or concrete aprons can be used for scour protection of culverts. NYSDOT (2005) also recommends placing stone apron at the outlet and at the inlet of all culverts as follows:
- Minimum length of the stone apron 7.5 m (24 ft).

- The stone apron should cover the full width of the streambed, and in addition, stone filling should be placed on the side slopes to a minimum elevation of 300 mm (1 ft) above Design High Water.
- A 1.5 m wide by 1.2 m deep (5 ft by 4 ft) key of stone filling should be placed in the streambed at the end of the apron away from the culvert.
- Stone filling should also be used to stabilize all disturbed slopes to a minimum elevation of 300 mm (1ft) above Design High Water.

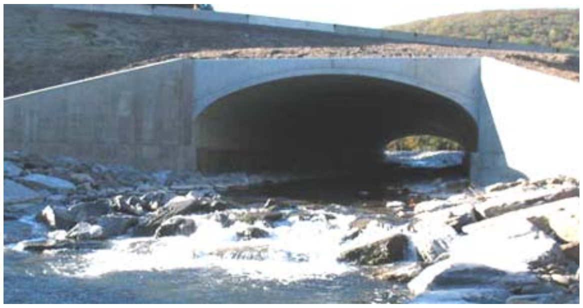

Figure 1. Culvert stone apron (Gannett , 2008)

Ballinger and Drake (1995) described several types of riprap (rock riprap, gravel riprap, wire-enclosed riprap), the procedures of installing them in Appendix B-13, and the procedure for the repair and replacement of culvert concrete or masonry aprons in Appendix B-14.

2. REFERENCES

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