DEBRIS CONTROL STRUCTURES

Concrete Culvert Overview Flowchart
Structural Defects Flowchart (Concrete)
Bedding Deficiencies Flowchart (Concrete)
Hydraulic Capacity Flowchart (Concrete)

1. SUMMARY

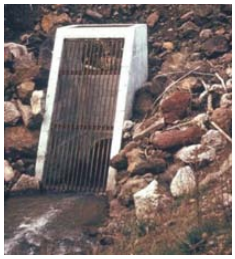
FHWA's HEC 9 (Bradley et al., 2005) described problems associated with debris accumulation at culverts, provided guidelines how to analyze and model debris impacts on structures, and presented general criteria how to select and design available debris countermeasures. The accumulation of debris at inlets of highway culverts may result in erosion at culvert entrances, overtopping and failure of roadway embankments and damage to adjacent properties, increased local scour at piers and/or abutments, and the formation of pressure flow scour. Various types of structural measures are shown in Table 1 and in Figure 1. A debris-control countermeasures matrix provides guidance in the selection of countermeasures suitable for various types of the debris (see Table 2).

Table 1: Structural debris control measures for culverts (after Bradley et al., 2005)

Measure	Description
Debris deflectors	Structures placed at the culvert inlet to deflect the major portion of the debris away from the culvert entrance. They are normally "V"-shaped (a).
Debris racks	Structures placed across the stream channel to collect the debris before it reaches the culvert entrance. Usually vertical and at right angles to the stream flow, but they may be skewed with the flow or inclined with the vertical (b).
Debris risers	Closed-type structure placed directly over the culvert inlet to cause deposition of flowing debris and fine detritus before it reaches the culvert inlet. Risers are usually built of metal pipe
Debris cribs	Open crib-type structures placed vertically over the culvert inlet in log-cabin fashion to prevent inflow of coarse bed load and light floating debris
Debris fins	Walls built in the stream channel upstream of the culvert. Their purpose is to align the debris with the culvert so that the debris would pass through the culvert without accumulating at the inlet (c).
Debris dams and basins	Structures placed across well-defined channels to form basins which impede the stream flow and provide storage space for deposits of detritus and floating debris (d).
Combination devices	Combination of two or more of the preceding debris-control structures at one site to handle more than one type of debris and to provide additional insurance against the culvert inlet from becoming clogged.

Non-structural debris control measures include emergency maintenance (removing debris from the culvert entrance and/or an existing debris-control structure) and annual maintenance (removing debris from within the culvert, at the culvert entrance, and/or immediately upstream of the culvert, or repairing any existing structural debris control measures).

(a) Steel rail and cable debris deflector.



(b) Debris rack

(c) Concrete debris fin

(d) Debris dam of precast concrete sections

Figure 1. Examples of structural debris countermeasures (after Bradley et al., 2005)

Table 2: Culvert debris-control countermeasures matrix (after Bradley et al., 2005)

Counter-measures	Debris Classification							Maintenance	Aesthetics	Environ. Impact	Installation Experience by State	Design Guideline
	Floating Debris			Flowing Debris	Bed Material							
	S	M	L		F	C	B					
Structural countermeasures												
Deflectors		x	x				x	H	A	L	CA	6.2.1
Racks	x	x						H	A	L	CT, CA	6.2.2
Risers				x	x	x		L	A	L	CA	6.2.3
Cribs	x					x		M	A	L	CA	6.2.4
Fin			x					M	A	L	SD, TN, CA	6.2.5
Dams, Basins				x	x	x		H	A	H	Widely Used	6.2.6
Non-structural countermeasures												
Emergency and annual maintenance		x	x	x				H	U	M	Widely Used	-
Debris management plan		x	x	x				H	D	L		6.4
	S=small M=medium L=large			F= fine detritus C= coarse detritus B= boulders				H=high M=moderate L=low	A=acceptable D=desirable U=undesirable	H=high M=moderate L=low		Section in FHWA's HEC 9

Ballinger and Drake (1995) provided guidelines for debris removal in Appendix B-1, and for sediment removal in Appendix B-2. High pressure water hose and vacuum systems offer a cost-effective, efficient way to flush sediment from culverts. Vacuum cleaning (Figure 2) is a cost effective method of removing dirt, grit, and other debris from culverts, and can be used for removal of practically any type of material (earth, water, sludge, spills, debris, etc.).

Figure 2. Culvert vacuum cleaning (downloaded from www.badgerinc.com/services/debris_rem.html) on June 17, 2010

Self-cleaning culvert design is a new approach in addressing the debris accumulation problem where the formation of sediment deposits is prevented using the hydraulic power of the stream. Muste et al. (2009) developed and tested a self-cleaning design method for a 3-box culvert configuration. Further research is focused on developing self-cleaning designs for 2-box culverts, conducting laboratory performance tests for culverts retrofitted with upstream and downstream cleaning fillets, assessing of the performance of

self-cleaning culverts for overtopping design criteria, and estimating the effect of culvert modifications on the head losses through culverts.

2. REFERENCES

Ballinger, C.A., and P.G. Drake, 1995. *Culvert Repair Practices Manual*, Vol. 1 & Vol. 2 (Appendices), FHWA-RD-95-089, May 1995, US Department of Transportation, Federal Highway Administration (FHWA), McLean, VA, 330p & 321p

Bradley, J.B., D.L. Richards and C.D. Bahner, 2005. *Debris Control Structures Evaluation and Countermeasures*, HEC No.9, Third Edition, FHWA-IF-04-016, Sep 2005, 179p

Muste, M., R. Ettema, H-C. Ho and S. Miyawaki, 2009. *Development of Self-Cleaning Box Culvert Designs*, IIHR Report No. 475, Iowa Institute of Hydraulic Research, The University of Iowa, Iowa City, June 2009, 111p.

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