Field Note

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FPInnovations FERIC

Evaluation of an embedded culvert's performance[1]

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Introduction

The use of embedded culverts within British Columbia became a clearly defined option with the development of the Fish-stream Crossing Guidebook (2002),[2] where many aquatic habitat protection measures and installation techniques were presented as best management practices. Such measures include protection and reestablishment of riparian vegetation; minimal disturbance of streambanks; erosion control; and culvert infilling to establish a continuous connectivity of the stream channel and bedload, as well as to mimic the natural stream channel providing habitat and fish passage. Matching the installed culvert and simulated stream bed slope to that of the natural stable channel slope is best achieved by the use of typical survey techniques for vertical control. The procedures given in the Guidebook made it clear to the practitioner where and when a properly installed closed-bottom embedded culvert could be considered.

FPInnovations – Feric Division conducted case studies and site visits of closed-bottom embedded culvert installations starting in 2001. FPInnovations recently revisited sites in August 2008 to assess culvert performance; this Field Note summarizes observations for one site that was presented in Gillies (2003).[3] FPInnovations was not on site during the installation in 2001 but first visited the site in 2002. The design team for this site included engineers and fish habitat biologists for input, which resulted in habitat enhancement features being incorporated into the engineered design. This is the second of two Field Notes that retrospectively evaluate the performance of embedded culverts.

Observations

The natural stream had a shallow flow during the revisit. Infill material remained within the culvert; no areas were devoid of substrate. The wetted width of the stream inside the culvert varied from the entire width of the simulated streambed (263 cm) to less in areas. The minimum depth of flow through the culvert was 3 cm but some deeper pools had formed. Large woody debris and boulder-sized aggregate was placed within the culvert to help anchor the infill material, provide velocity shadows for fish passage, and promote the formation of steps and pools. Habitat features unique to the study site include a log placed partly inside the culvert at the outlet and a boulder placed near the inlet. A 5-cm-long fish was observed in a 17-cm-deep pool within the culvert, and cutthroat trout have been seen in this stream. Common features included sizing the culvert wider than the natural stream at embedment depth, minimal streambank disturbance through the right-of-way, and erosion and sediment control. Specifications for the structure and site are shown in Table 1.

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[1] FPInnovations acknowledges the funding contribution from Natural Resources Canada under the NRCan / FPInnovations – Feric Contribution Agreement.

[2] British Columbia Ministry of Forests (BCMOF). 2002. Forest practices code of British Columbia: Fish-stream crossing guidebook. Victoria, B.C. 68 pp.

[3] Gillies, C.T. 2003. Closed-bottom corrugated-steel embedded culverts in British Columbia: overview of twelve sites. FERIC (Forest Engineering Research Institute of Canada), Vancouver, B.C. Advantage Report 4(29). 31 pp.

Table 1. Report, culvert, and cost data for revisited site	
Culvert dimensions	3000 mm diameter round corrugated steel, 17 m long
Natural average stream width and gradient	170 cm / 4.9%
2002 gradient: culvert / simulated stream	3.5% / 2.4%
2008 gradient: culvert / simulated stream	n/a / 2.8%
2002 infill depth (at inlet / at outlet)	70 cm (23% of diameter) / 90 cm (30% of diameter)
2008 infill depth (at inlet / at outlet)	75 cm (25% of diameter) / 87 cm (29% of diameter)
Cost	Total installed $52 100 (2001)

The composition of the infill material remains similar to that of 2002; it is made up of gravel and cobble-sized material with boulders and woody debris spread throughout (Figures 1a and 1b). The 2002 measurements showed that both the simulated streambed and culvert were constructed at a flatter gradient than the natural stream. As well, infill material was delivered to a greater depth within the culvert at the outlet than the inlet, which resulted in the simulated stream gradient being less than the culvert's. The simulated stream has become slightly steeper (now 2.8%); infill material has moved from the outlet area and additional bedload material has deposited at the inlet area (Table 1). When a culvert is embedded and infilled to the level of the natural stream, it is expected that bedload will move through the culvert as it would the natural stream, including scour and deposition areas. The gradient differences measured between the natural stream, simulated stream, and culvert highlight the need for vertical control during construction.

Erosion control measures included the use of aggregate to armour the exposed soil along the slopes at the inlet and outlet of the culvert, the use of logging debris to provide cover, and seeding the exposed soils. All these combined with the undisturbed streambanks, remaining riparian vegetation, and downed woody debris will significantly reduce erosion and help prevent sediment from reaching the fish-bearing stream.

Critical habitat for fish includes deep pools, undercut banks, stable woody debris, and suitably sized spawning gravels. Many of these habitat features are mimicked within this culvert. In this case, pools formed within the culvert and woody debris was anchored amongst boulders. The choice of infill material can include suitably sized spawning gravels. The log placed within the culvert where the deep pool formed in some ways mimicked an undercut bank. Fish passage is also a critical design feature; the fish observed within the culvert was near the outlet. During the embedded culvert revisit, FPInnovations did not conduct a fish survey; instead, the fish were observed while conducting field measurements within the culvert.

Figures 1a (left) and 1b (right). Looking towards the outlet during 2002 (1a) and 2008 (1b).
Despite very heavy rain events since construction, the composition and flat nature of the simulated streambed has not changed significantly over six years; much of the woody debris and boulders are in similar positions.