Feature

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Cottonwood Culverts Post-Flood Assessment August 1999

Michael Parker

In the fall of 1998, West Fraser Mills - Quesnel undertook Forest Renewal BC funded Watershed Restoration Program activities in the Cottonwood River drainage, Quesnel Forest District, Cariboo Region of British Columbia. Part of these activities was to restore fish passage at four culvert road crossings on the 1300 Road. Scour of the stream bed below all four of these sites had left the outlet with drops between 25 and 60 centimeters (Figures 1 and 2). The four separate systems all had a bankfull width of approximately 3 meters. Rainbow trout were the primary target species of these works, although bull trout have been found in the watershed at other locations. Although the outlet drops alone were not definitive barriers to fish passage, in combination with culvert water velocities, lack of

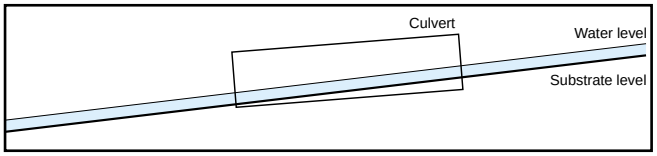

Figure 1. Initial placement - culvert near stream gradient, substrate throughout.

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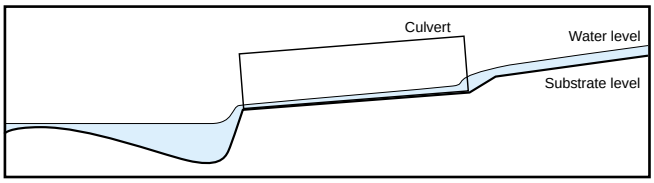

Figure 2. Placement after x years - outlet scour has led to a drop into a plunge pool, substrate no longer holds in culvert so velocity increases, substrate back-cuts to culvert entrance or beyond.

substrate within a culvert, and lack of an outlet plunge pool, passage was at best limited to adult fish.

Two different techniques were implemented to improve fish passage at the four sites. At three sites, a riffle weir was constructed a few meters downstream of the culvert outlet. The crest of the weir was constructed at an elevation that caused water to backflood to slightly above the bottom lip of the culvert outlet (Figure 3). These structures provided a pool between the culvert outlet and the crest of the riffle. One such structure required two weirs in order to achieve the necessary elevation gain to backflood the culvert. Weir design and substrate sizing was conducted according to need (Technical Circular 9).

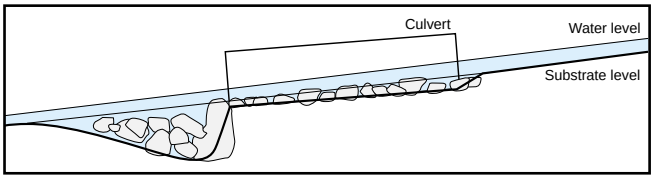

Figure 3. A backflood weir built at the tail of the plunge pool eliminates the drop, but creates a steep slope riffle.

The second technique, employed at one site, was to construct a riffle from the outlet of the culvert to the stream bed at a moderate gradient over approximately 7 meters (Figure 4). This did not provide any pool habitat at the outlet, but did ensure water flowed along a stream substrate from above the culvert, through the culvert, and down the constructed riffle, all at very moderate gradients.

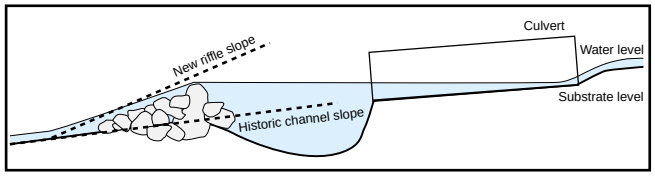

Figure 4. Restored outlet. Assume culvert size is adequate, a large key stone at outlet extends to height of historic bed to hold material in culvert, and reestablish outlet riffle. Assorted angular rock is used to build riffle and line culvert. Small gravels used to fill interstitial spaces. Reduces water velocity and eliminates outlet drop to improve fish passage. Note: evaluate if loss of pool habitat significant to the system.

Seven months after construction, elevations of the four riffle/weir structures were measured. It was considered that this would provide good baseline data, as the structures had time to settle after installation, but had not gone through a high flow event. For the three structures that had backflood weirs installed, the residual pool depths at the culvert outlets were measured at between 0.5 m and 1.13 m. There was no pool associated with the fourth site, but the riffle crest and end elevations were measured to determine if the riffle would shift over time.

During the spring of 1999, the Cottonwood River area received an estimated 2-year return flood. As waters receded a second set of elevation data was collected to determine how much shift had occurred in the four riffle/weir structures. Evaluation of the elevation data shows that the greatest post-flood change was the reduction in residual depth of the three primary pools created by the weirs backflooding the culverts. On average, the pools filled in with fine bedload, reducing residual depths by between 60-89% of the pre-flood measure. In one case, this meant that more than 95 cm in depth was lost. In all cases, the bedload was of fines to gravel size, and cobble-to-boulder material remained in place. The bedload movement of these small materials was not evident in the pre-work assessment of the sites. The other change, one appears related to the fines movement, is that two of the weir crests actually were slightly higher than the original installation. The smaller material filled in the tail of the outlet pool, effectively filling the interstitial spaces at the weir crest and causing the crest to be slightly higher than the original construction. Significant changes were observed on the face of these riffle weir structures, as flood waters had created step pool morphology on the face of the riffles. However, this change was anticipated; it is what allows for effective fish passage up the riffle face at lower flows. During August 1999, sampling rainbow trout were found in every constructed riffle, pool, and culvert. Seventeen fish between 68-141 mm were sampled during 892 seconds of electrofishing.

Expectations:
Over the long term, the extended riffle structure from the lip of the culvert will be more durable and more likely to maintain an elevation close to design specifications than the other three backflood weir riffles.

The backflood pools below the three culverts with downstream weir riffles will not be further infilled. It is expected that a point of stability has been reached and that spring freshet will help maintain the minimal pools that now exist.

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Figure 5. Rock riffle from culvert outlet that formerly had a 0.54 m drop.

Over the long term, the weir riffle structures may be less stable and the relative elevations will drop slightly. However, the large angular material prescribed and used in construction is expected to keep the structures functional.

Bed material in the weir riffle structures will, at least partially, wash out of the inside of the culverts at the downstream ends, while the one riffle structure will maintain all substrate within the culvert due to key riffle boulders at the outlet holding material in place.

Recommendations:
Based on observations of this limited test site, we recommend installing a riffle from the lip of a culvert, instead of a backflood weir, whenever feasible. This may not be possible in some situations where culvert capacity is inadequate or the outlet pool is considered an essential habitat feature to be maintained. The benefits of this type of application is that construction is closer to the road surface, so bed material in the culvert is more stable, and riffle slope is less than a downstream weir. It is anticipated that the long-term stability of this technique is better than a downstream weir. The work at the four sites described included hauling 192 cubic yards of angular rock some 50 km, and yet the cost per site was just over $2,300; thus, it is an economical alternative to culvert replacement, if the existing structure is in good condition and is adequately sized.

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Technical Tip

Watersheds BC: Strategic Information About BC's Watersheds

Malcolm Gray

Introduction
Geographic Data BC's objective for the Watersheds BC project is to provide decision-makers with comprehensive and easy-to-use information about the land and water resources of British Columbia. These summaries of province-wide GIS databases, containing many measurements that pertain to the cumulative effects of forest practices, are available in highly accessible formats.

We produce two standard products: *Environmental Statistics*, a database that contains 435 relevant statistics for each of the 18,481 watersheds identified in the BC Ministry of Fisheries' Watershed Atlas; and *Map Folios*, a composite map derived from those input maps most important to the summarization process.

These products can be updated readily when new data become available, as the process for creating them is highly streamlined. The products are also compatible with such office software as Word, Excel, Access, and by map viewing packages including Arc/View.

Product Description
The *Watersheds BC - Environmental Statistics* provides extensive summary information on many relevant land and resource indicators. This information is summarized in a number of categories for each of the province's