FPInnovations prepared this guide to provide forest and resource workers with information on maintaining and monitoring streambed simulation in closed-bottom structures for fish streams. This pamphlet is the fourth in a series; other important considerations presented in this series and which are key to the successful implementation of a streambed simulation culvert include planning and design, culvert installation, and streambed material/construction.

FPInnovations worked in close co-operation with British Columbia's Fish Passage Technical Working Group in the development of this guide.

## REFERENCES:


BC Ministry of Forests, Lands and Natural Resource Operations, BC Ministry of Environment, and Fisheries and Oceans Canada. (2012). *Fish-stream crossing guidebook* (rev. ed.). Victoria, BC: BC Ministry of Forests, Lands and Natural Resource Operations and Fisheries and Oceans Canada.


Cover photo: View of large-diameter culvert under significant fill

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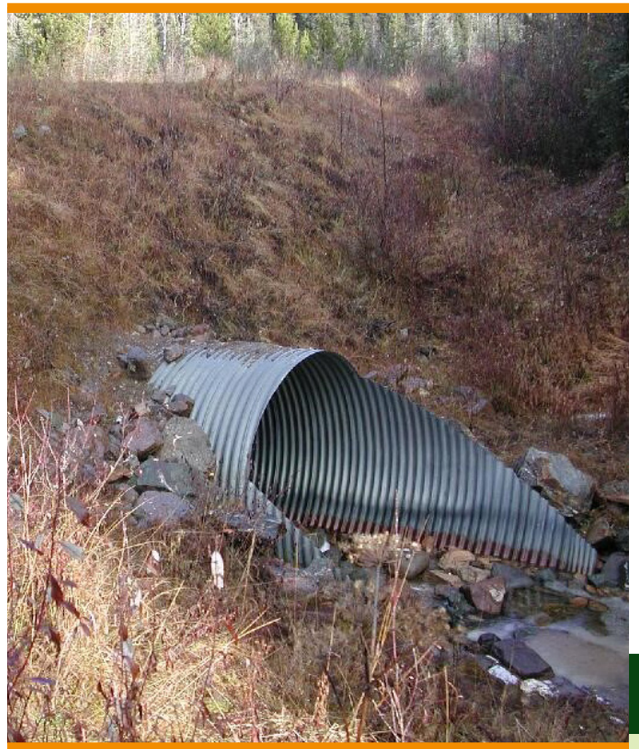

# Streambed Simulation: Monitoring and Maintaining a Fish-Friendly Culvert Crossing

A PRACTICAL GUIDE FOR FOREST AND RESOURCE WORKERS

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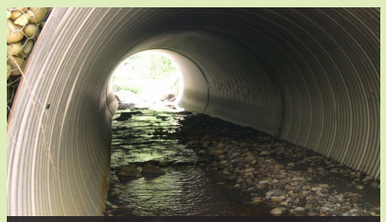
## MONITORING: FISH AND AQUATIC PASSAGE

Streambed simulation is a methodology that maintains the diversity and complexity of the stream through a road stream crossing. In order to accommodate the movement of fish and aquatic species, the hydraulics of the natural stream channel are simulated by maintaining natural channel width and stream gradients, and mimicking the natural streambed channel characteristics. The natural stream width will not be constricted if it is measured accurately and if the culvert is sized appropriately. The simulated streambed within new installations will adjust; monitoring of crossings will assist in identifying problems that may arise that may need to be addressed to maintain fish passage.

The streambed simulation design considers the swimming abilities of all life stages of fish. For the movement of benthic aquatic organisms, and those that tend to crawl, a continuous substrate covering the bottom of the culvert is important for their passage. Monitoring of crossings helps evaluate a structure's ability to provide for continued, unobstructed passage for fish and other aquatic organisms, and is a mechanism to support continuous improvement. Problems that have developed or could develop into barriers to fish passage need to be identified and mitigated.

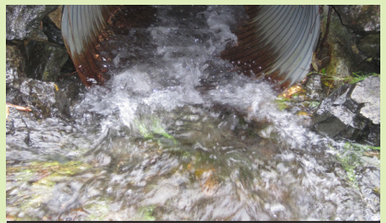
Barriers to fish passage can result from flows that are too fast or too shallow; flows that have gone subsurface, or have a freefall into, within, or outside of a culvert; loss or aggradation of streambed substrate which modify streamflow and streambed characteristics; and physical barriers such as debris jams.

## COMMON CONDITIONS THAT CREATE FISH MIGRATION BARRIERS:



Inadequate swimming depth within the culvert.

**Perched** and **undersized** culverts pose a barrier to fish and aquatic passage regardless of the height at which the bottom of the culvert is above the stream surface. Some perched culverts may be very slight and without a freefall of the water but with a shallow flow of water over aggregate.



Velocity and/or turbulence within the culvert.

## FISH PASSAGE ASSESSMENT

An observational coarse filter approach can be used to assess a structure's adequacy to provide fish and aquatic passage. A successful streambed simulation will have similar hydraulic conditions, and match natural stream reach characteristics including streambed width, continuous substrate, and gradient. A coarse filter approach will identify, for monitoring and maintenance purposes, obvious barriers such as outlet drops, increased stream velocity, lack of substrate, and lack of velocity shadows.

**The following conditions should be satisfied or else noted for correction:**

- The culvert contains substrate of a range and mixture of sizes similar to the natural streambed.
- The streambed substrate depth is continuous and sufficient throughout the entire length of the structure.
- The surface of the streambed substrate provides obstacles which create resting areas or velocity shadows during high flows.
- The inlet width of the streambed simulation structure is as wide as the natural stream width.
- The culvert is not perched and does not have an outlet drop.
- The gradient of the streambed simulation surface matches that of the natural stream long profile.

## SIMULATED STREAMBED ASSESSMENT

### WIDTH, GRADIENT, AND ELEVATION

Streambeds are mobile, dynamic fluvial systems. Streambed material naturally moves through culverts. The streambed will adjust, particularly during larger floods. For a simulated streambed system, the culvert and simulated streambed width, gradient, and elevation are designed to match that of the natural stream. Failure to match these characteristics will affect the streambed, stream flow, and natural hydraulic conditions within and local to the culvert and potentially become a barrier to fish passage. When the natural stream channel width divided by the culvert width is <1, there is no natural stream width constriction; >1 results in channel constriction and an increased velocity through the culvert. The gradient of the culvert is designed to match the slope of the natural stream; the use of an engineering level during installation is required for precision—even a difference of 1% can result in a barrier to fish passage.

Appropriate elevation of the culvert is also critical to its long-term performance. Aggradation and/or erosion of substrate within the culvert can indicate that the culvert is not matching the natural stream gradient and/or elevation. A culvert placed too high will result in erosion of the substrate and loss of channel width, whereas one placed too low will result in aggradation of material and loss of hydraulic capacity. Some aggradation and erosion should be anticipated, even in a well-designed and well-constructed installation; however, these should be minimal and have limited impact on hydraulic flows and fish passage.

### STREAMBED CONTINUITY

The surface of the simulated streambed should reflect that of the natural stream channel. The infill material within the culvert should contain a range and mixture of sizes similar to the natural streambed; a goal is to create roughness and some variation in flow to generate velocity shadows and lower-velocity "resting" sites to assist in fish passage. Infill material should be at a consistent depth through the culvert. The use of D90-sized substrate will help anchor material within the culvert. Areas within the culvert with higher or lower deposits of infill material, due to hydraulic pulsing and shifting, may restrict the use of the entire width of the simulated streambed resulting in concentrated flows through the culvert. During low flows, a low-flow channel should be present along the simulated streambed surface; subsurface stream flow through the culvert can be a barrier to fish passage.

Weirs that have been integrated into the design, to maintain the substrate and water depths in the culvert, need to be inspected and maintained. If the state of the streambed simulation is posing a barrier to fish passage, remediation measures should be taken to correct identified deficiencies.

Infill material that is not at a consistent depth or is absent through sections can pose a barrier to fish and aquatic passage.

Natural stream channel width should not be constricted within the culvert; this stream matched culvert width.

Natural stream channel width wider than the culvert will result in increased velocities through the structure. Culvert is slightly deformed.

## STRUCTURE INTEGRITY AND SITE ASSESSMENT

Structures must be periodically inspected for any deterioration or significant changes to the constructed as-built design that may affect the structural integrity or design service life. Abrasion and water chemistry can cause the protective coating on a culvert to abrade; pitting and bare metal are two indicators of this. Couplers used to join sections of culverts together should be fastened tightly to provide a secure, watertight connection. Water exiting the culvert at a coupler, or flowing along the outside of the culvert (piping), can promote erosion of the bedding and fill material, compromising the integrity of the structure.

Large debris near the inlet or within the culvert can negatively affect the hydraulic capacity of the structure and cause erosion of streambanks, end fills, or the streambed within the culvert, and should be removed. Culverts with severe deformation should be noted and discussed with a structural engineer and culvert supplier. Riprap to protect inlet and outlet slopes should be inspected for integrity and stability. Riprap should consist of angular, competent rock, which has been carefully placed and interlocked to cover the exposed soil at the inlet and outlet of the structure.

Erosion control measures will prevent sediment from entering the watercourse. Reclamation seed mixes, mulches, and erosion control fabrics can all be used to provide cover for the exposed soils; mulches and fabrics will provide immediate protection, whereas seed and vegetation will provide a longer-term control as they become rooted and established.

Altered culvert shape or deformation can influence the hydrology of the crossing and its structural integrity.

Embankment erosion at a culvert results in a high likelihood of sediment reaching the stream. Maintenance is required to prevent erosion at the site.

Shallow flows, subsurface flows, or the absence of a low-flow channel all pose a barrier and should be noted. Remediation for this condition can be a downstream weir to provide some backwater through the culvert.

Logs and debris that have migrated into the culvert can negatively affect the hydraulic capacity and should be noted and planned for removal.

Corrosion and abrasion of the culvert can lead to loss of service life and should be monitored for areas of complete loss of metal.