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

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 courtesy of FPInnovations.
View of streambed simulation.

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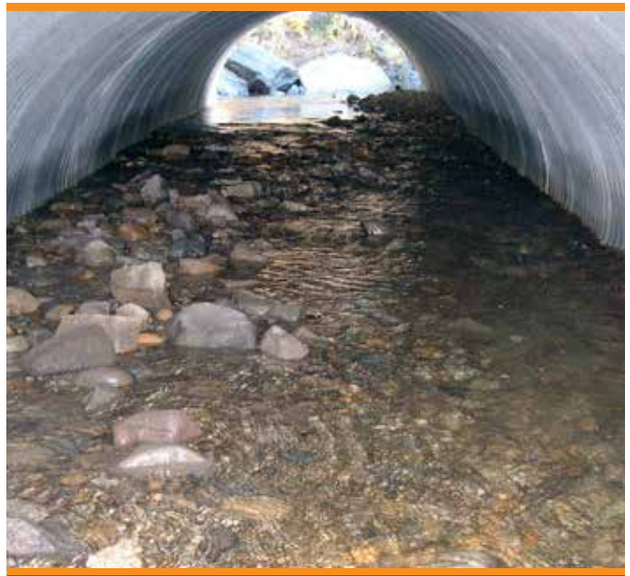

Streambed Simulation: Streambed Construction, Infill Methods, and Rewatering for Closed-Bottom Stream Crossings

A PRACTICAL GUIDE FOR FOREST AND RESOURCE WORKERS

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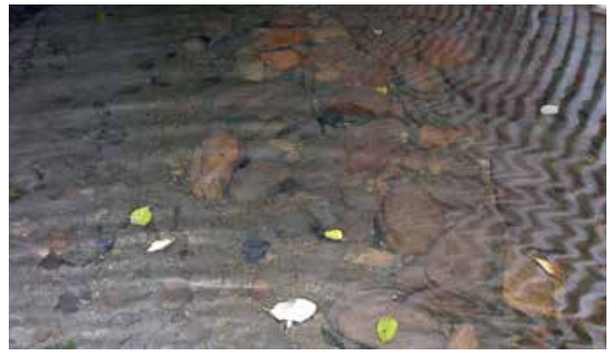
INITIAL PLANNING AND METHODOLOGY

- All streambed simulation construction projects must have an engineered general arrangement design prepared. The party responsible for assuring that the crossing is installed according to the design must be intimately familiar with the design and, if needed, obtain clarity from the designer. The construction notes shall be followed for the installation and construction of the simulated streambed, including composition of infill material, use of large boulders (D90 sized material), and material gradation.
- The overall methodology, as well as the material and equipment requirements, should be planned ahead of time to bring efficiencies to the project and to minimize both the time required for installation and any disturbance to the site. Safety should be discussed and planned for each phase of the operation.
- The goal for the composition of the simulated streambed is to emulate the characteristics of the natural stream channel. It may be possible to reuse on-site material; otherwise, imported material will need to be stockpiled for use. Constructed stream surface composition will reflect that of the natural stream so as to provide similar aquatic habitat features, stream depth, roughness, and overall navigation for fish and aquatic organisms.
- The substrate materials will be supplemented with additional larger material (D90 in size) to help anchor the substrate within the culvert. This larger material should be placed at various heights within the delivered substrate, including along the surface. Inserting organics such as branches, logs, and stumps within the culvert barrel or near the entrance or outlet of the culvert is not recommended.



The final streambed composition will reflect that of the natural stream.

Large boulders help anchor the imported material within the culvert and help prevent it from being easily eroded. This D90-sized material should be placed at various depths within the delivered material as well as along the surface. The surface material will help prevent material from eroding as well as provide velocity shadows for fish passage during high flows.

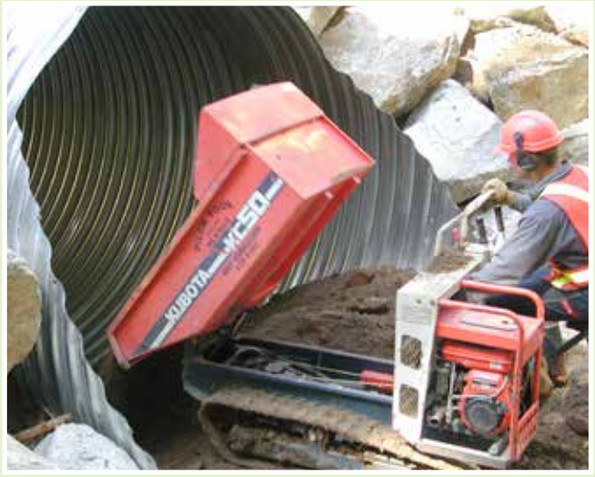
INFILL METHODS

Filling a closed-bottom structure to the target infill depth can be accomplished by manual methods (e.g., wheelbarrows) or by the use of machinery. Manual methods can be labour intensive and time consuming but may be necessary for smaller-diameter culverts where the use of machinery is not feasible. Machines that can be used to deliver infill material include powered wheelbarrows, front-end skid-steer loaders, and conveyor systems. When using a combustible engine, care must be taken to address air quality within confined spaces.

Target levels for infill heights can be marked along the inside barrel of the culvert. A measuring rod/stick can also be prepared to gauge the target infill depth by measuring from the top of the inside of the culvert downwards to the delivered substrate.

A powered self-dumping wheelbarrow is commonly used for infilling a culvert. With any delivery equipment, adequate space is required to be able to deliver and manipulate the imported material. Wheelbarrows require adequate clearance to dump without contacting the culvert, as well as to safely maneuver.

A conveyor system provides a means for infill material to be delivered into the culvert.



Manual infill methods include buckets and wheelbarrows. Careful attention needs to be given to the staging area to address safety near the edge of the culvert.

The size of the culvert will have an influence on feasible infill methods. There needs to be enough room to work and maneuver both within the culvert and at the staging area.

STREAMBED AND CHANNEL EMULATION

Crossing structures are expected to provide unrestricted fish passage. Streambed simulation provides continuity through crossing structures, allowing all aquatic species present to move freely through them to access habitat. The streambed simulation approach consists of designing a structure with a streambed that has characteristics that are as similar as possible to those of a natural channel in terms of channel dimensions, slope, and streambed structures. A key objective of streambed simulation design is to create a channel that mimics a natural channel so that fish and other aquatic organisms will navigate through the structure in a similar manner as if the crossing did not exist. Considering that features within a stream simulation are manmade, some nuances need to be addressed to help mimic nature. These include employing methods to retain the infill material in the culvert barrel, keeping the material evenly distributed, sealing the surface to help negate subsurface flows through interstitial voids, and promoting low-flow channels. Streambeds are fluvial systems. The embedded culvert systems are intended to provide sufficient room for the stream to adjust itself over time.

Due to the nature of delivering substrate material within a culvert, there will be numerous interstitial voids within it which may result in subsurface flow once the streamflow is introduced into and through the culvert. The goal is to have the stream flow along the surface of the simulated streambed. One method to help fine material migrate into and fill the voids, as well as seal the simulated streams' surface, is to use pumped water to saturate the surface and infill material. Where the delivered material contains a sand component, this finer material will be suspended and settle into the voids. Sand can also be applied to the surface before using the pumped water. Upon completion of the streambed simluation construction, water should be on the streambed surface and provide for fish passage.

Infill material can be pulsed through or within the culvert during high flow events. Having the proper matrix of material sizes to mimic the natural stream substrate helps to keep this material in place and prevent the culvert bottom from being exposed.

Shallow laminar flows may pose a migration challenge for adult fish, while juvenile migration may be unhindered. Such laminar flows will likely incise over time to create a deeper low-flow channel.

Over time, natural migration and infilling can result in the deposition of fine material and the establishment of a low-flow channel.

The natural establishment of a non-peak flow channel may occur next to the culvert wall. To promote more area of the channel to be exposed to a natural substrate (i.e., away from the culvert wall), triangular gyrons constructed of aggregate have been used to force the low-flow channel to meander through the culvert.