BRITISH COLUMBIA | Ministry of Transportation and Infrastructure

Culverts and Fish Passage

The mandate of the Environmental Management Section is to ensure that the Ministry of Transportation and Infrastructure (MOTI) develops and maintains the Provincial transportation infrastructure in an environmentally responsible and effective manner.

This group develops and maintains environmental policies, standards, specifications, best practices, and provides technical expertise. The Section is responsible for providing advice regarding environmental assessments on highway projects, for improving overall environmental performance, and for delivering environmental enhancements with a direct benefit to transportation and infrastructure.

Information sheets are for use by ministry staff, contractors, and other stakeholders.

PART 1: OVERVIEW

One of the primary issues regarding fish and culverts is fish passage. Salmon and other aquatic species require access to freshwater habitat for rearing and spawning. The migrations of fish species (both upstream and downstream) can be restricted by many factors including culvert length and grade, impediments at inlet and outlets, water levels, turbulence, and water velocities. Culverts may reduce habitat connectivity by blocking fish access to important spawning and rearing areas such as the mainstem, tributaries, ponds, and wetlands.

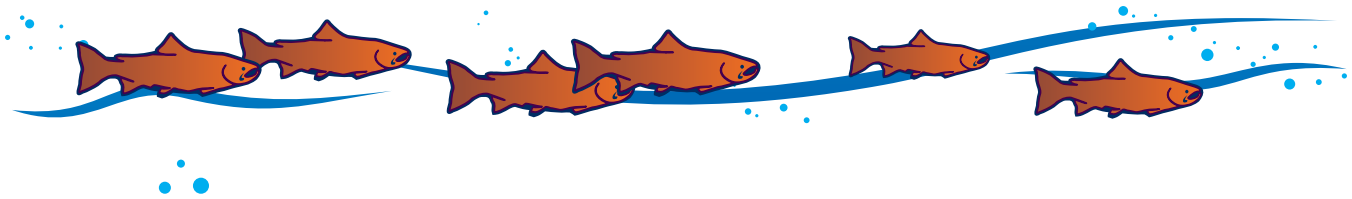
Maintaining connectivity between reaches for the fish species present in the stream is required under the Federal ***Fisheries Act*** and Provincial ***Water Act***. Culverts that are correctly designed, installed, and maintained enable fish passage for species and life stages using the watercourse. Proper culvert design and installation are not only important in terms of highway construction and maintenance activities, but are also necessary for the viability of fish and fish habitat.

1.1 Scheduling

Culvert installation and maintenance must occur in accordance with the appropriate timing windows for work in and around streams. For most regions in British Columbia, the fisheries window occurs during the summer months, but is dependent on the fish species and life stages present and prevailing environmental conditions. Generally, this period is when fish are least sensitive to instream disturbance and flows are low.

During the other three seasons, spawning and incubation occurs, with eggs, embryos, and fry potentially present in streambed gravels. Information on timing windows is available on the Fisheries and Oceans Canada (DFO) and Ministry of Forests, Lands and Natural Resource Operations (FLNR) websites or by contacting the local FLNR or DFO office.

Some emergencies may require works outside of windows to protect life and property. Contact the local environmental agencies before beginning debris removal or as soon as possible to inform them of the emergency situation, and the response taken.



When undertaking emergency work, take steps to minimize the impact to a watercourse by following best practices including use of erosion, sediment controls, and revegetation.

1.2 Culvert Designs

1.2.1 Stream Simulated Culverts

Stream simulation culvert design is desirable as it mimics a natural streambed by embedding the culvert and retaining substrates within a closed-bottomed pipe or bottomless arch culvert. Ideally, the culvert is at least as wide as the stream. The objective of stream simulated culverts is to provide similar fish passage to the adjacent stream. Substrates typically consist of a mix of granular materials that mimic the natural streambed.

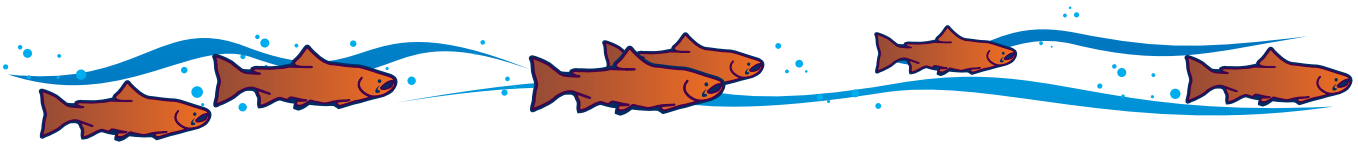
The placement of stream substrate can aid in the passage of adult and juvenile fish through culverts. This is often the preferred procedure because it creates hydraulic streambed conditions, with resting and holding areas and reduced velocities to enhance fish passage. On higher gradient streams there is more likelihood that the stream substrate placed in the culvert will be mobilized during higher runoff flows. To mitigate this and provide habitat complexity and roughness, larger rocks can be placed within the culvert to help anchor streambed materials.

1.2.3 Closed Bottomed Culverts

Corrugated closed bottom pipe-arch or box culverts can be a cost-effective option for smaller streams to provide an effective channel width with less embedment compared to round culverts. Closed bottomed culverts must be of an appropriate size, embedment, gradient and retain substrates to maintain fish passage.

1.2.4 Multiple Culvert Installations

Generally, a single culvert crossing is preferred over multiple culvert installations. However, in some cases such as lack of cover, may limit a single culvert. In multiple culvert installations, one pipe can be designed to pass higher flood flows and another installed as the primary fish passage structure. The pipe dedicated to fish passage should be installed lower than the flood culvert(s) to ensure low flows are not split, which might otherwise provide insufficient flows or depth for fish passage.



1.3 Culvert Retrofits

In some circumstances, a full replacement of a culvert may not be feasible to improve fish passage at a stream crossing. Modifications to existing culverts that have significant remaining life and works within the stream channel may be options to improve fish passage.

1.3.1 Tailwater Control

In most situations an outlet barrier can be corrected by installing one or more rock Newbury weirs downstream from the culvert. The purpose of these weirs is to raise the tailwater elevation and backflood the culvert outlet, which will in turn reduce current velocity at the culvert outlet and enhance fish access. Constructing an outlet pool and weir may be as simple as hand placing rocks or it may involve larger rip rap placement with heavy equipment. Tailwater control structures may achieve the following:

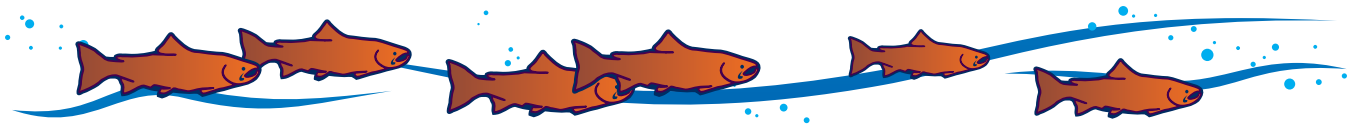
- Elimination of a culvert outlet drop.
- Providing a resting pool for migrating fish;
- Allowing for adequate water depths in the culvert though backwatering;
- Reducing the velocity at the culvert outlet;
- Reducing downstream erosion and headcutting; and
- Providing a transition zone between the culvert and the natural stream channel downstream.

1.3.2 Baffles

There may be situations where existing culverts are smaller or at a steeper gradient than the natural channel. Baffles are an option to reduce velocities to enable fish passage but must be assessed, designed and installed correctly. Baffles can be effective but they are recommended only after other structure options (i.e. box culvert, bottomless arch) have been investigated and eliminated.

The height and spacing of the baffles must provide fish resting areas during high flows and maintain adequate water depth during lower flow periods. Baffles must not reduce culvert capacity below hydraulic design standards, cause flooding or capture excessive debris.

Baffled culverts may increase maintenance requirements. Sizing and spacing between baffles will depend on roughness, culvert size, stream gradient and water velocity within the culvert. Baffles should be structurally sound to last the lifespan of the crossing structure. Concrete, metal, or similarly durable baffle materials are possible low maintenance options.



1.4 On-Site Considerations

1.4.1 Sediment Control During Construction

Water quality is to be maintained at all times during culvert installation and maintenance activities. The addition of sediments to a stream can have serious impacts on fish, fish habitat, and other aquatic resources. In order to minimize the release of sediment into streams, it is preferred to install culverts through effective site isolation. As site conditions allow, the work zone may be temporarily isolated by flow bypasses, fish salvages, and installation of fish exclusion barriers. There are numerous techniques that can be used to prevent silt-laden water at the work site from entering a stream such as silt fencing, filter cloths, pumping, and coffer dams. As the stream is re-connected through a newly installed culvert, flows should be monitored to ensure desirable water quality is maintained.

1.4.2 Site Clearing

During culvert installations, minimize the removal of streambank vegetation and disturbance to the natural banks.

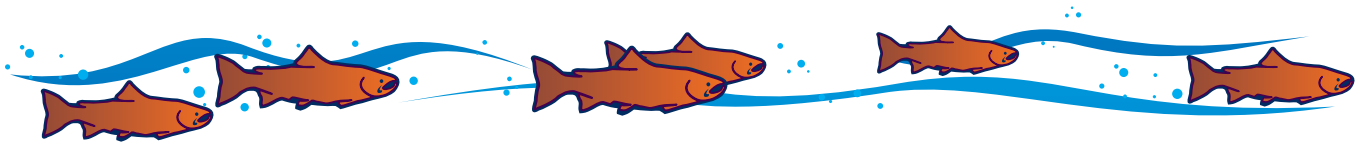
Undertake rehabilitation works along the banks, including headwall protection and revegetation to reduce future erosion and sedimentation. Where armouring is required, it should minimize displacement of natural habitat and be used to create fish habitat enhancements.

Do not allow erodible ditches to drain directly into the stream. Treatment may include:

- Diversion of ditchwater onto stable forested vegetation which can filter sediments before the water reaches the stream;
- Settling structures, e.g. ponds or constructed wetlands;
- Vegetated swales or ditches;
- Ditch blocks.

1.4.3 Post-Construction

Monitoring a culvert after it is installed is useful to ensure that design requirements are met, the culvert is functioning and stable for fish passage, and as guidance for future installations. Performance checks include assessment of streambed materials within the crossing, juvenile and adult fish passage, site stability, sufficient flows for fish passage during dry conditions, suitable velocities for passage during higher flow migration periods, and riparian restoration.



Replanting and restoration work should occur as soon as possible following disturbance to minimize the impact of erosion on the site and adjacent ecosystems. After work has been completed at the site, the following measures should be undertaken:

Restore disturbed areas in or adjacent to the stream and stabilize the work area, using reclamation seeding, native plantings, and bioengineering solutions such as wattle fences (retaining walls constructed of live willow cuttings);

Sites that use typical engineering methods for slope stabilization such as rip rap may still incorporate revegetation to improve the riparian features of the site;

Where vegetative cover has been removed or damaged, take appropriate measures to re-establish native vegetation. It may be necessary to ensure growth by initiating a replanting or watering program.

PART 2: EFFECTS OF CULVERTS ON FISH PASSAGE AND HABITAT

The cumulative effect of several obstacles within a culvert may cause a complete, temporal or partial barrier to fish passage. A complete barrier to fish passage prevents all life stages and all species from passing through the culvert. A temporal barrier prevents fish from moving through the culvert during certain flows. A partial barrier may prevent smaller or weaker fish from traversing the culvert. Fish passage objectives should be determined based on target fish species and life stages.

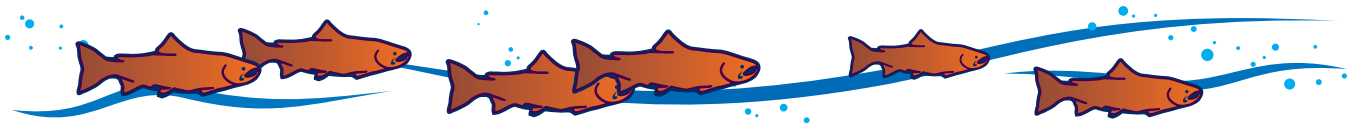
Common causes of fish passage barriers and damage to associated habitat within culvert reaches are as follows:

- High velocity within the culvert barrel;
- Excessive turbulence within the culvert;
- Impassable drop at the culvert outlet;
- Water depth within culvert is less than natural levels, or 0.2 metre at time of adult fish passage; and
- Debris and sediment accumulation.

2.1 High Velocity within the Culvert Barrel

2.1.1 Culvert Length and Grade

Within closed bottomed culverts water velocity usually increases with increasing culvert length and gradient. The higher the water velocity, the more difficult it is for fish to negotiate the culvert.



For stream simulated culverts, a grade of less than 3% is recommended. With slopes greater than 3%, the water may begin to wash out the substrate unless there are modifications to the culvert. Adding larger substrate material that can help to retain smaller sediment in steep grade or high flowing conditions will allow for a steeper slope.

When designing a culvert, site assessments should establish a reference reach, which would be used to determine the grade, dimensions, and streambed material. The reference would ideally be upstream and close to the project site. If fish are able to pass at the reference reach and the streambed material is stable, then fish will likely be able to traverse the culvert. A culvert that is much narrower than the natural stream width would result in an increase in the flow velocity at the inlet. As fish travel through culverts, especially long installations, it may cause the fish to approach exhaustion by the time it reaches the inlet.

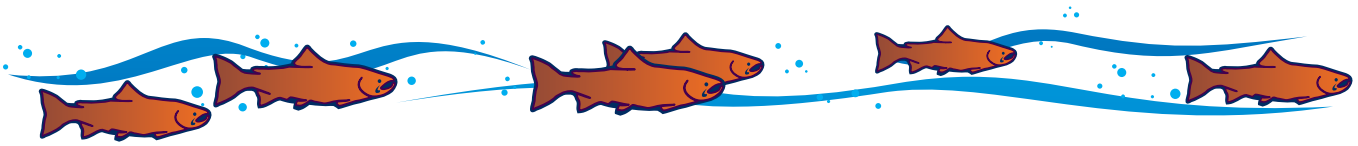
2.1.2 Culvert Alignment

The culvert alignment should follow the natural channel. This reduces disturbance to the natural stream. The alignment of the stream is straightened through a culvert installation, which may increase the gradient and water velocity. The increased water velocity can lead to negative effects such as loss of streamside vegetation, bank erosion, downcutting of the streambed, and loss of spawning gravels and other substrate alterations. To avoid increasing water velocity and erosion the following guidelines should be followed:

- Locate the culvert where the channel is relatively straight;
- Avoid skewing the entrance to the culvert;
- Align the culvert so that the culvert outflows are not directed into a streambank;
- If the road crossing is not perpendicular to the stream, skew the culvert.

2.2 Turbulence Within the Culvert

Roughness elements such as large boulders or baffles may be installed in a culvert to reduce water velocities, increase water depth, retain substrate, and provide resting areas for migrating fish. Roughness may reduce the velocities by creating turbulence which would allow certain species of fish passage through the culvert. Proper design of these elements is important, as too much roughness can also create a turbulence barrier for adult and/or juvenile fish. Baffles are only to be used where they will be stable, will not result in adverse impacts, and alternatives are not feasible.



2.3 Excess Drop at the Culvert Outlet

An increased stream velocity can cause erosion at the outlet pool. Ideal culvert design and installation for fish passage should result in no increase in flow velocities at the outlet.

A drop at the culvert outlet, referred to as a perched or hanging culvert may be barrier to fish passage. Perching occurs when culvert outlets are installed above streambeds or where culvert outlet water velocities erode the streambed. Perching can also occur at very low culvert gradients and at low water velocities, even if the culvert is installed at or below natural stream grade. Proper culvert installation goes a long way toward preventing this problem.

The following steps should be taken to prevent erosion at culvert outlet pools:

- The width of the outlet pool should approximate natural pool widths of the stream; and
- A downstream weir or riffle will be situated downstream of the outlet pool, especially in culverts with a slope higher than 3%.

2.4 Water Depth is Less Than Natural Levels or < 0.2 Metres at Time of Fish Passage

Depth within a culvert should be sufficient for fish to pass during lower flow and spawning migrations. An important design consideration in using stream simulated culverts is to ensure enough fines to fill the voids between the larger substrate material. This will reduce water infiltrating into the channel bed, and reduce sub-surface flow.

2.5 Debris and Sediment

Some culverts have a higher chance of collecting debris, or becoming an area for sediment deposition especially during higher water flows. The deposition of stream bed material, vegetation and large woody debris may result in the accumulation of debris at a culvert inlet or within a culvert pipe. This may impede fish passage, cause damage to habitat and create flooding concerns.

Debris and sediment accumulation may result from the following:

- Baffled culverts;
- Culverts being installed at a flatter gradient than the natural stream bed;
- Culverts improperly aligned to the natural channel;
- Undersized culverts that causes a backwater condition which promote deposition at the inlet; and
- Improperly located trash racks.

Remove only the debris that is necessary to re-establish flows and to ensure integrity of the culvert and roadway. Any remaining debris may provide habitat ranging from refuge to insect production.

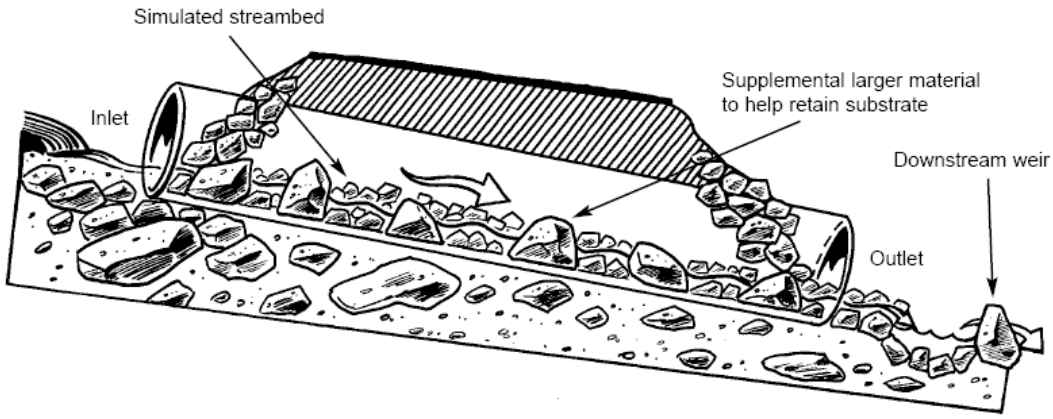


Figure 1: Stream simulated culvert proper installation: culvert is at the same gradient as the natural stream channel, and there is an outlet pool two channel widths in length with some armouring if necessary when the stream is susceptible to erosion or scour. (From Fish-stream Crossing Guidebook)

For additional information, please visit the BC Interagency Fish Passage Technical Working Group website at: http://www.for.gov.bc.ca/hfp/fish/FishPassage.html.

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