British Columbia Ministry of Transportation and Highways

Environmental Management Section Fact Sheet

The Environmental Management Section, Engineering Branch *coordinates the needs and concerns of environmental agencies with those of the Ministry of Transportation and Highways, while pursuing and initiating progressive environmental programs and strategies. These fact sheets are for use by Highways Regional personnel, maintenance contractors and the general public.*

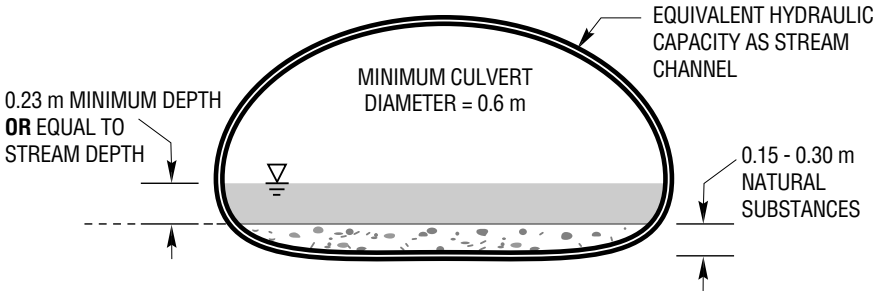
CULVERTS AND FISH PASSAGE

Overview

Be sure to minimize the impact on fish and fish habitat when installing culverts. Proper culvert design and installation are not only important in terms of highway construction and maintenance activities, but they are also necessary for the viability of fish and fish habitat.

One of the primary issues regarding fish and culverts is fish passage. The migrations of fish species (both upstream and downstream) can be restricted by many factors including culvert length and grade, inlet and outlet pools, water levels and water velocities. Improper culverts can block fish access to important rearing areas such as small creeks, channels, ditches, and wetlands. However, culverts that are correctly designed and installed do not hinder fish passage.

Figure 1
Culvert Cross Section



Culvert Length and Grade

Culvert length and grade are closely related potential inhibitors of fish passage. Water velocity tends to increase with increasing culvert length and grade. The higher the water velocity, the more difficult it is for fish to negotiate the culvert. It is imperative that culverts are properly designed and that the following guidelines are not exceeded:

Grade:

- 0.5 % for a culvert greater than 24 metres in length, unless baffles are included.
- 1.0 % for a culvert less than 24 metres in length, unless baffles are included.
- 5.0 % at any time, even with the addition of baffles.

Length:

- Culverts that are under 24 metres long can have water velocities up to 1.2 m/sec.
- Culverts that are over 24 metres long can have water velocities of up to 0.9 m/sec.

Also, it is important that water depths within culverts are at natural levels, or at least 0.23 meters, at times of adult passage.

Culvert Alignment

Align culverts with the existing stream channel to minimize changes in flow direction. This will reduce the need to armor stream banks and instream structures. Straightening a stream meander by installing a culvert forces water to fall the same height but over a shorter distance, thereby increasing water velocities. The resulting scour causes negative effects such as loss of streamside vegetation, downcutting of the streambed, and loss of spawning gravels.

To avoid these problems the following guidelines should be followed.

- Locate the culvert where the channel is relatively straight.
- 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.
- Try to avoid the use of aprons at the inlet and outlet. Concrete aprons have low roughness coefficients, promote shallow flow depths, and are often installed at steeper gradients than the culvert; therefore, their use is not recommended.

Inlet and Outlet Control

Inlet Control

Even a culvert installed in accordance with culvert length and grade guidelines can interfere with fish passage, often due to insufficient consideration given to a culvert's inlet and outlet pools.

A culvert that is capable of carrying more flow than its inlet accepts, creates supercritical flow immediately downstream from the inlet. This flow remains supercritical throughout the culvert unless a hydraulic jump forms at some point in the culvert. However, the hydraulic jump may itself be a blockage to upstream fish movement. Therefore, it is imperative that culverts are installed so that there are no increases in flow velocities at their inlets. In most cases the best method for ensuring culverts satisfy the above guidelines for length and grade is to maintain the natural stream width and grade. Where this is not possible, special engineering structures must be designed.

Inlet drops may result from the following:

- deposition of stream bed material in the inlet pool;
- culverts being laid at a flatter angle than the natural stream bed;
- undersized culvert pipes that causes a backwater condition promote deposition; and,
- deposition of rip rap material from adjacent roadway embankments.

Once again, maintaining stream width and grade are the best method for avoiding problems such as inlet drops.

Outlet Control

Culvert design and installation resulting in no increase in flow velocities at the outlet are the best possible scenario for fish passage. For this reason every effort must be made to ensure that culvert installation activities do not alter stream width or capacity.

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

- the width of the outlet pool should approximate the natural width of the stream;
- the length of the outlet pool should be at least two times the width; and,
- the bottom of the outlet pool should be at least 0.61 metres below the invert elevation at the culvert outlet.

Armoring material for these outfall basins should be rip rap large enough to prevent streambed scour.

Figure 2
Proper Installation

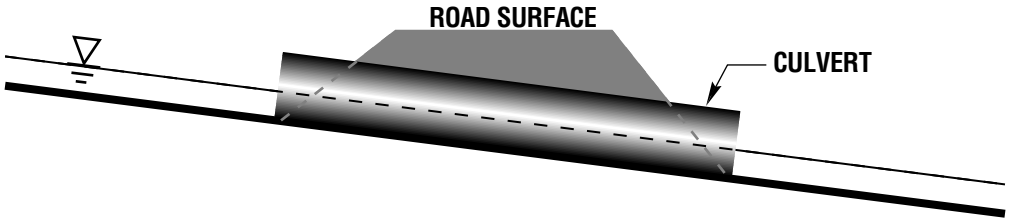
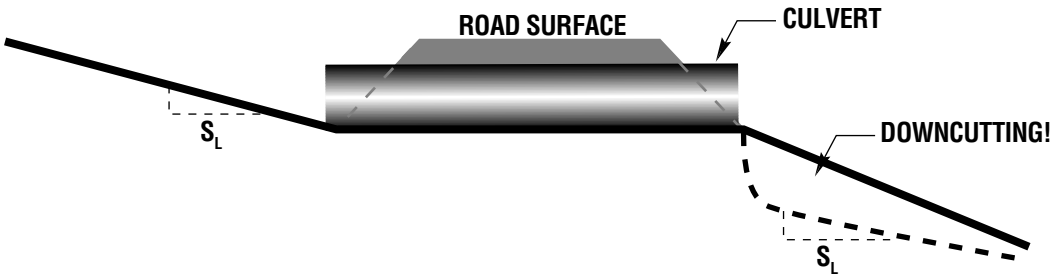


Figure 3
Improper Installation



Outlet pools should also incorporate a method of tailwater control. There should not be a sudden drop in the water surface greater than 0.31 metres at any point within the culvert influence. Unfortunately, sudden drops in the water surface often occur at culvert outlets. This situation, referred to as perching, is an outfall barrier to fish passage. Proper culvert installation goes a long way toward preventing this problem. Perching occurs when culvert outlets are above streambeds or where water velocities through culverts are high enough to wash out the streambed under them. 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.

In most situations an outfall barrier can be corrected by installing one or more low-head dams downstream from the culvert outfall. The purpose of these dams is to raise the tailwater elevation and flood the culvert outlet, which will in turn reduce current velocity at the culvert outlet and enhance fish access. Constructing an outlet pool may be as simple as hand placing rocks or installing logs with low flow notches. However, these structures must not prevent free fish passage. Low head dams should not result in a drop greater than 0.31 meter unless they have a weir to allow for fish passage. Tailwater control structures result in the following benefits:

- provide a resting pool for migrating fish;
- allow for adequate water depths in the culvert though their backwater effect;
- reduce the velocity at the culvert outlet; and,
- provide a transition zone between the culvert and the natural stream channel downstream.

The outlet control device should ensure that stream depths at the culvert outlet are greater than 0.23 metres. It is important that water depths within culverts are at natural levels, or greater than 0.23 metres, at times of adult fish passage.

Baffles

Due to engineering considerations there may be situations where the above criteria cannot be met. Fortunately, there are methods of flow control that allow for fish passage in most of these situations.

Baffles may be installed in a culvert to reduce water velocities and provide resting areas for migrating fish. Baffles can be effective but they are recommended only after other structure options (i.e., box culvert, bottomless arch) have been investigated and eliminated. Baffled culverts have high maintenance requirements, especially in high-energy stream systems, where large bed-load movements tend to fill the spaces between baffles rendering them ineffective.

Installation of baffles in a previously installed culvert may sometimes be required. If so, these baffles must provide fish resting areas during high flows and maintain adequate water depth during low flows. Baffle installation must not reduce culvert capacity to below design standards.

Baffles should be greater than 0.60 metres wide and between 0.13 to 0.16 metres high. They can be made from wood, metal, or concrete. Concrete is the preferred option by the Ministry due to its low maintenance advantage.

Multiple culvert installations may be warranted in some situations. In multiple culvert installations, one pipe can be designed to pass high flows and another designed to allow for fish passage. The pipe dedicated to fish passage should be installed at least 0.31 metres lower than the other culvert(s) to ensure fish passage at various stream levels.

Juvenile and Resident Fish

Culvert design and installation often focuses primarily on migrating adult salmon. However, it is also important that the effects of these installations on juvenile fishes and resident fish species – such as the trout and char – are considered prior to culvert placement.

Before a culvert is installed, the physical requirements and abilities of non-adult fish must be considered. Juvenile fish are very susceptible to instream obstructions, particularly sockeye salmon that often migrate upstream to their rearing habitat in lakes. Also, the physical abilities of trout and char to negotiate instream obstructions and high water velocities are generally less than those of salmon.

The placement of stream substrate within a culvert can aid in the passage of juvenile fish through culverts. This is often the preferred procedure because it mimics natural streambed conditions, thus providing resting areas for fish. Use this technique only on low gradient streams, otherwise it is likely that the stream substrate placed in the culvert will be carried away with the spring freshet. The integrity of such additions should be monitored on a regular basis and after high flow events.

Scheduling

Culvert installation and maintenance must occur in accordance with the appropriate timing windows for work in and around streams. For most regions in B.C., depending on the fish species present, the fisheries window occurs during the summer months. Generally, this is when fish are least sensitive to instream disturbance. During the other three seasons, spawning activity occurs, eggs and fry are present in channel gravels. If you are unsure of the appropriate timing windows for the area where you will be working, then contact your local Ministry of Environment, Lands and Parks Office. In the case of emergency maintenance requirements involving work in or around a stream, proceed as necessary to protect life and property. However, be sure to contact the local environmental agencies as soon as possible to inform them of the emergency situation, and the response taken.

Site Clearing

During culvert installations keep the removal of streambank vegetation and disturbance to the natural banks and bed of the stream to a minimum. Hand clearing of bank slopes minimizes erosion and siltation.

After work has been completed at the site, the following measures should be undertaken.

- Return all disturbed areas in or adjacent to the stream to their original configuration and stabilize the work area.
- 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 program.

Undertake rehabilitation works within the stream channel before the stream is diverted through the completed culvert installation. Where armoring of the stream channel is required, it should minimize displacement of natural habitat, except where armoring is part of fisheries enhancement work.

Control of Sediment

It is imperative during culvert installation and maintenance activities that water quality is maintained at all times.

The addition of sediments to a stream can have serious impacts on fish and fish habitat. Sediment can have the following negative consequences.

- Siltation can clog or abrade a fish's gills causing suffocation or infection.
- Sediment can smother and displace invertebrate organisms (i.e., mayflies, caddisflies, etc.) that serve as an important food source for fish.
- Sediment can settle on spawning beds, thus smothering eggs or newly hatched fish (alevins), and sealing gravels to a point where they can not be used by spawning fish.

In order to minimize the release of sediment into streams, it is best to install culverts in the dry. As site conditions allow, either divert the stream or isolate construction from the stream's main stem. 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 clothes and sand bags. Before water is allowed to flow through a newly placed culvert the site should be stable and free of excess sediments.

Debris Control

Many streams, especially during high water conditions, can carry large organic debris, rocks, and other material that result in an accumulation of debris at a culvert inlet or within a culvert pipe.

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

Culvert cleaning should occur within the Timing Windows for Working around Water and Fish, as determined by the Ministry of Environment, Lands and Parks/Department of Fisheries and Oceans, except, of course, in emergency situations.

Source Material

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Department of Fisheries and Oceans, Ministry of Environment, Lands and Parks and Ministry of Municipal Affairs. *Stream Stewardship: a Guide For Planners and Developers (Part of the Stewardship Series).* Department of Fisheries and Oceans, Ministry of Environment, Lands and Parks and Ministry of Municipal Affairs. ISBN 0-7726-2237-X

BRITISH COLUMBIA

Ministry of Transportation and Highways

These fact sheets provide a quick overview of environmental issues concerning the Ministry of Transportation and Highways.
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