Summary of Fish Passage Methodology for Alberta Transportation Culverts

The following information can be applied to analyze fish passage in Alberta Transportation culverts. Section 1 covers typical applications while Section 2 covers more difficult sites.

1 FISH PASSAGE EVALUATION IN CULVERTS

Use the following steps to evaluate fish passage in the proposed structure.

1. Perform initial culvert sizing based on the design discharge. Information on culvert design is located in the Department's documents:
    - Design Guidelines for Bridge Size Culverts
    - Hydrotechnical Design Guidelines for Stream Crossings

2. The following equation is applied to determine the depth of flow in the typical channel for the fish passage design discharge (FPDD). The depth is in turn applied to the Manning's equation used in the Hydrotechnical Design Guideline for Stream Crossings.

    $$Y_{95} = 0.8 - 34.3 * S, \ S < 0.017$$
    $$\text{if } S \geq 0.017, \text{ then } Y_{95} = 0.2$$

3. Compare the section averaged velocities in the culvert with the typical channel velocity using the FPDD calculated in Step 2. The velocity should be equal to or less than the velocity in the typical channel at all cross-sections in the culvert.

    If the velocity is not less than or equal to the channel velocity, consider minor modifications to the design that will achieve the desired velocities such as minor adjustments to the culvert slope, increases to the pipe roughness, use of multiple or different shapes of pipes. If the culvert velocity still exceeds the channel velocity, proceed to Section 2.

    Note: It may be difficult to get velocities in the pipe less than or equal to the culvert velocity if the culvert is very long or if the slope is greater than 0.8 - 1.0%.

4. As in Section 3, compare the velocity in the upstream transition zone with the typical channel velocity. Consider if modifications are needed such as lengthening the transition (flattening the slope) or creating additional roughness or resting zones.

    Note: The water surface profile calculated in the model is not a true representation; the flow is smoother. Also, as the depth of flow decreases in this zone; the Manning's roughness (n) increases (see Table 1).

5. If the target velocities are met, finalize the design. Otherwise, proceed to Section 2 Alternate Hydraulic Design.

2 ALTERNATE HYDRAULIC DESIGN: SUBSTRATE HOLDERS AND VELOCITY DISSIPATION

Substrate holders are structures installed in a culvert to retain substrate. The substrate provides additional bed/culvert roughness, enabling fish to swim through the entire length of the culvert without reaching exhaustion. This method is typically effective for long culverts where backwater effects, from embedment/burial, are lost, and on slopes in the order of 0.8% to 5%.

Substrate holders are designed to hold an engineered streambed in the culvert while allowing for natural sediment transport processes to occur in the stream. To minimize the intrusion into the active flow area, substrate holders should be sized as follows:

- for culverts ≤ 3 m in diameter, install 200 mm high weirs with Class 1M rock riprap, and
- for culverts > 3 m in diameter, install 300 mm high weirs with Class 1 rock riprap.

The maximum spacing of the substrate holders is equivalent to the substrate holder height divided by the slope of the culvert. Spacing may be reduced for ease of installation, such as for installation on circumferential seams, with a minimum spacing of 7 m.

The riprap between the substrate holders must be sufficiently interlocked to minimize riprap movement. The average thickness of the rock should be equivalent to height of the substrate holder. As the height of the substrate holders is less than the maximum riprap diameter, some riprap will protrude into the flow area, providing flow variations and resting zones for utilization by fish. Pitrun gravel may be installed in the voids to reduce interstitial flow.

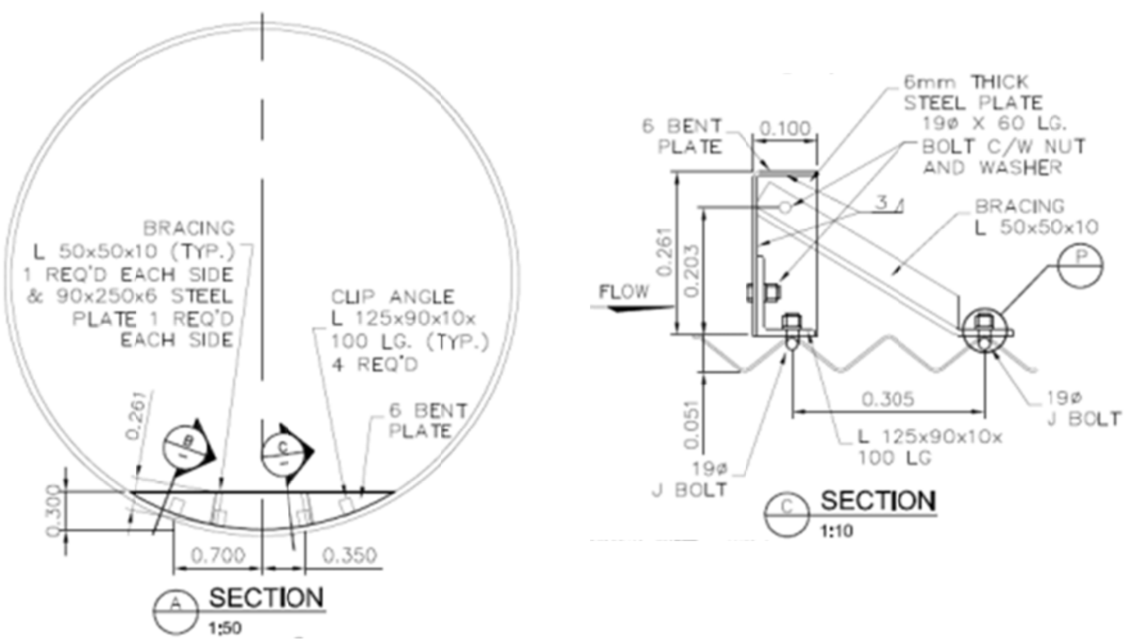
Complete the fish passage analysis as per Section 1 with the following modifications. The culvert will have a higher Manning's roughness due to the rock riprap installation. Table 1 provides guidance on the selection of roughness for the analysis (relative to FPDD). Use of the roughness is sensitive to the flow depth and requires iterative calculations to select the appropriate roughness. Ensure the culvert cross section is modified to account for the inactive flow area where the rock is located; this is accommodated in the newest version of FlowProfile.

Substrate holders should not be required through the entire length of the culvert and are to be installed where the velocity in the culvert approaches and exceeds the typical channel velocity. Conduct a sensitivity analysis for the full spectrum of flows expected on designs that have substrate holders added to ensure that the design performs as per the Design Guidelines for Bridge Size Culverts. With the addition of substrate, it is acceptable to have the section averaged velocities in the culvert slightly higher than the stream average velocity due to highly roughened bed providing low velocity and resting zones.

A bridge or multi-pipe solution may be required for sites with excessive velocities that cannot be sufficiently reduced through the addition of substrate. Examples include steep streams with slopes in excess of 5% and in wide, shallow streams. Fish passage principles with respect to depth and velocity may need to be checked for these sites.

Table 1: Relative Roughness Parameters (assume Y≈R)

R	n - Class 1M (k ~ 0.7 m)	n - Class 1 (k ~ 1.2 m)
0.1	0.161	
0.2	0.079	0.141
0.3	0.064	0.095
0.4	0.057	0.079
0.5	0.053	0.071
0.6	0.050	0.065
0.7	0.048	0.062
0.8	0.047	0.059
0.9	0.046	0.057
1.0	0.045	0.055
1.1	0.044	0.054
1.2	0.044	0.053
1.3	0.043	0.052
1.4	0.043	0.051
1.5	0.042	0.050



Example of substrate holder