APPENDIX Y

CONSIDERATIONS FOR DESIGN AND PLACEMENT OF STREAM CROSSINGS

TYPES OF CROSSINGS[1]

- The number of stream crossings should be minimized.
- If a crossing is necessary, structures that maintain to the extent possible the existing streambed and bank conditions are preferable; therefore, bridges spanning streams are preferable to other structures.
- If a culvert is necessary, open bottom structures are preferable to closed bottom structures.
- If a closed bottom culvert is necessary, box culverts, elliptical, or pipe arch culverts are preferable to round pipe culverts, because round pipes generally reduce stream width to a much larger degree than the aforementioned structures, causing long term upstream and downstream passage limitations (see physical considerations below).
- Offsetting Multiple Culverts—If multiple culverts are necessary, it is recommended that the culvert inverts be offset vertically and only one culvert be designed to provide passage during low flow conditions and the additional culverts be used to pass the higher flow events (see Figure Y.1). Therefore, the low flow culvert will be the only culvert, in a series of two or more culverts, designed to provide fish passage during low flows and shall meet the physical requirements of passage above.

BIOLOGICAL CONSIDERATIONS[2]

- Contact the area WDNR fisheries manager prior to design and construction to minimize impacts[3]

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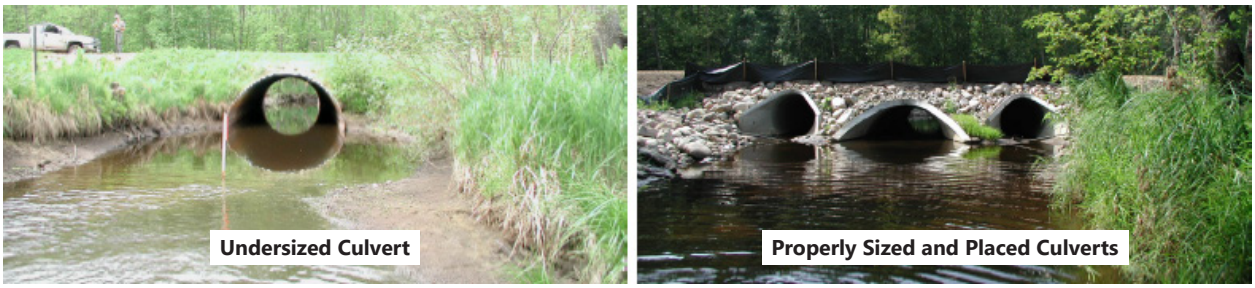
[1] *Department of Fish and Game, Division of Ecological Restoration,* Massachusetts Stream Crossings Handbook*, Editors: Amy Singler, Brian Graber, and Carrie Banks, Writing and design: biodrawversity (www.biodrawversity.com), 2nd Edition, June 2012, www.mass.gov/eea/docs/dfg/der/pdf/stream-crossings-handbook.pdf*

[2] *British Colombia Ministry of Forests,* Fish-stream crossing guidebook, *For. Prac. Br., Min. For., www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/Guidetoc.htm, Victoria, B.C. Forest Practices Code of British Columbia guidebook, 2002.*

[3] *UW-Extension and WDNR,* Fish Friendly Culverts*, 2002.*

Figure Y.1
Considerations for Culvert Design and Placement



Source: Minnesota Department of Natural Resources

- Species of fish present (coldwater, warmwater, threatened, endangered, species of special concern)
- Life stages to potentially be impacted
- Migration timing of affected species/life stages (e.g., adult spawning times should be avoided)

PHYSICAL CONSIDERATIONS[4]

It is important to note that in order to achieve the minimum physical criteria outlined below, the culvert(s) will need to be oversized as part of the design to ensure adequate long-term fish passage as well as the ability to pass the design period rainfall event.

It is understood that it may not be possible to achieve some of the minimum passage criteria below based upon specific on-site conditions or constraints, however, the closer the designed and completed culvert can meet these criteria the better the long-term passage and overall sustainability of the fishery will be in this region.

Provide Adequate Depth

- Slope—Culvert should be installed with a slope that matches the riffle slope as measured in the thalweg[5] (see Minnesota DNR guidelines)[6]
- Water Depth and Velocity—Water depths and velocities should be comparable to those found in the natural channel at a variety of flows. Depths should maintain the determined thalweg depth at any point within the culvert during low flow periods (see Minnesota DNR guidelines).
- Installation Below Grade—The culvert should be installed so that the bottom of the structure is buried to a depth equal to 1/6th the bankfull width of the stream (up to two feet) below the natural grade line elevation of the stream bottom (see Minnesota DNR guidelines). The culvert should then be filled to stream grade with natural substrates. The substrates should consist of a variety of gravel ranging from one to four inches in diameter and either mixed with nonuniformly laid riprap or uniformly placed alternate riprap baffles, large enough to be stable during the culvert design discharge, which will ensure stability of substrates during high flow events.

[4] *Washington Department of Fish and Wildlife, Habitat and Lands Program, Environmental Engineering Division,* Fish Passage Design at Road Culverts: A Design Manual for Fish Passage at Road Crossings, *Washington, March 3, 1999.*

[5] *The thalweg is the lowest point of the streambed.*

[6] *Minnesota DNR,* Best Practices for Meeting DNR General Public Waters Work Permit GP *2004-0001, March 2006.*

Provide Adequate Width and Openness

- Crossing Span (see Massachusetts Stream Crossings Handbook):[7]
    - General—Spans channel width (a minimum of 1.2 times the bankfull with of the stream).
    - Optimum—Spans the streambed and banks (at least 1.3 times the bankfull width) with sufficient capacity to provide dry passage for wildlife (see Figure Y.2). Culvert width shall match the bankfull width (minimum) of the existing channel.
- Openness (see Massachusetts Stream Crossings Handbook):[8]
    - General—Openness ratio (cross sectional area/crossing length) of at least 0.82 feet. The crossing should be wide and high relative to its length.
    - Optimum—Openness ratio of at least 1.64 feet and minimum height of six feet. If conditions significantly reduce wildlife passage near a crossing (e.g. steep embankments, high traffic volumes, or other physical barriers), maintain a minimum height of eight feet and openness ratio of 2.46 feet.

Provide Adequate Resting Areas

- Length—Culverts that exceed more than 75 feet in length need to provide additional resting areas (e.g., installation of baffles or weirs) within the culvert to facilitate passage.[9]

Inlet and Outlet Protection

- Align the culvert with the existing stream alignment (e.g., 90 degree bends at the inlet or outlet should be avoided, even though this will increase culvert length, see Minnesota DNR guidelines).[10]
- The low flow culvert should be centered on the thalweg of the channel to ensure adequate depths inside the culvert.
- Provide grade control where there is potential for head-cuts that could degrade the channel.
- It may be necessary to install riprap protection on the outside bank below the outlet to reduce bank erosion during high flow events.

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[7] *Department of Fish and Game,* Massachusetts Stream Crossings Handbook, *June 2012.*

[8] *Ibid.*

[9] *Thomas Slawski and Timothy Ehlinger, "Habitat Improvement in Box Culverts: Management in the Dark?,"* North American Journal of Fisheries Management*, Volume 18:676-685, 1998.*

[10] *Minnesota DNR, March 2006 op.cit.*

Figure Y.2
Key Features that Promote Fish and Wildlife Passage

Source: Department of Fish and Game, Massachusetts Stream Crossings Handbook, *June 2012*