Optimal Culvert Designs for Aquatic Organisms and Stream Connectivity

What Was the Need?
Minnesota’s 140,000 miles of roads and approximately 92,000 miles of streams and rivers meet at tens of thousands of places. Culverts are a cost-effective solution to allow traffic to cross over smaller waterways. Historically, culverts have been designed with the safe passage of vehicles in mind. Recently, a state and national appeal for the safe passage of fish and other aquatic organisms, as well as for waterway integrity and connectivity, has influenced culvert design.

MnDOT has supported many research projects examining fish and aquatic organism passage (AOP) through culverts, and nationally, a number of published resources exist on appropriate design. Because of the variety of ecological regions in the state, the range of culvert geometries and many other factors, no single solution can accommodate AOP through culverts statewide. A comprehensive culvert design guide was needed to inform designers about solutions that can effectively facilitate the movement of fish and other aquatic organisms in Minnesota while maintaining healthy streams.

What Was Our Goal?
The objective of this project was to produce a comprehensive and accessible culvert design guide that could be used by Minnesota practitioners to design culverts for AOP and stream connectivity. The guide would provide the following benefits:

• More efficient culvert design and permitting process for AOP.
• A central definition of typical designs, which would improve contractors’ familiarity with designs and lower construction costs.
• Avoidance of designs that could be detrimental to the natural environment.
• Avoidance of designs likely to lead to roadway damage and need for repairs.
• Fishery improvement through increased stream connectivity.

What Did We Do?
To determine the scope of the guide, researchers worked with experts from the Minnesota Department of Natural Resources (DNR), the U.S. Forest Service and others with knowledge of civil engineering, AOP and stream geomorphology.

They then sought information for the guide from a wide range of authoritative resources. A literature search examined current and past research by the research team and others; guidance documents from federal agencies; guidance from other states; permit requirements from the DNR and other agencies; and databases of fish populations, stream attributes and culvert data. The literature search also sought to reveal gaps in knowledge where further research specific to Minnesota was needed.

Additionally, researchers surveyed a cross section of highway design engineers and managers from MnDOT, county and city agencies, resource agencies and engineering consultant to identify current design practices for AOP and stream connectivity, and the degree of their effectiveness.
What Did We Learn?
The project resulted in the Minnesota Guide for Stream Connectivity and Aquatic Organism Passage Through Culverts, a thorough guide for culvert designers, hydraulic engineers and others involved in culvert design and construction in Minnesota. Topics addressed in the guide include:

• The need for culvert designs that include AOP and stream connectivity, as well as the current regulatory context.
• An overview of culvert design, categories of design methods that incorporate AOP and waterway connectivity, and a list of best practices.
• Site characteristics, analysis and tools related to energy dissipation, hydraulic analysis for AOP and sediment transport.
• A design method selection chart, information on certain designs and references for further information.
• Further guidance about design issues such as multiple barrel and floodplain culverts, grade control, retrofits and other cost considerations.

What’s Next?
The culvert design guide will be made available to users online. Future considerations for this project include an associated webinar and efforts to coordinate information presented in the guide with expectations and permitting requirements of MnDOT departments charged with culvert creation and implementation. Additional research is underway to assess culverts and fish passage with respect to storm vulnerability and future hydrologic scenarios.