Department of Fish and Wildlife

DESIGN GUIDELINES APPROVED FOR USE IN DESIGNING WATER CROSSINGS OVER FISH-BEARING WATERS IN WASHINGTON STATE

Evaluating scour at bridges. Hydraulic Engineering Circular No 18[1]

Notes for appropriate use to comply with WAC 220-660-190

May 8, 2015

Using these guidelines alone the designer could arrive at a plan for a bridge that complies with WAC 220-660-190 and RCW 77.57.030, or one that does not comply. The following notes should help the designer choose the right path to an acceptable plan.

1.1 purpose

The primary focus of HEC 18 is the safety and stability of a bridge. In many instances HEC 18 states that environmental concerns should be considered in design, but no analysis or criteria are developed to help the practitioner arrive at a design acceptable under WAC 220-660-190 and related chapters. Exceptions to this are noted below. WDFW recommends that the users of HEC 18 include design criteria that protect fish habitat. The basis for such criteria can be found in the **Water Crossing Design Guidelines[2] (WCDG)**, particularly Chapter 4: *Bridge Design for Habitat Protection.*

1.3 Comprehensive Analysis

HEC 18 says that "Inherent in the design of any countermeasure are an evaluation of potential environmental impacts, permitting for countermeasure installation, and redesign, if necessary, to meet environmental requirements. As shown in the flow chart, to be effective most countermeasures will require a monitoring plan, inspection, and maintenance." From WDFW's point of view, this is excellent advice and a requirement for an acceptable design. How you do this is not covered in HEC 18.

WDFW has advocated the use of alternative analysis for the design of water crossings. In this context, a designer may consider several different bridge lengths, foundation types, or abutment configurations, but they would evaluate not only scour depth, backwater elevation,

[1] Arneson, L.A., L.W. Zevenbergen, P.F. Lagasse, P.E. Clopper (2012). **Evaluating scour at bridges. Hydraulic Engineering Circular No 18**. Washington D. C, U. S. Dept. of Transportation, Federal Highway Administration: 340.
[2] Barnard RJ, Johnson J, Brooks P, Bates KM, Heiner B, Klavas JP, Ponder DC, Smith PD, Powers PD. 2013. **Water Crossings Design Guidelines**. Washington Department of Fish and Wildlife: Olympia, Washington.

cost, and the effects on adjacent landowners, but also debris and sediment transport, the evolution of plan and profile, and other direct effects to fish habitat. Then, when the alternatives are compared, one can judge their performance across all the applicable criteria.

2.1 Scour Design Philosophy and Concepts for New Bridges

WDFW finds risk-based analysis an acceptable method, but cautions that impacts to fish must be a part of the calculations. We understand that the designer's primary focus is a safe and reliable crossing and that more efficient structures can be designed if they consider the economic consequences of failure. However, in Washington State we have laws that protect fish and their habitat and risk associated with environmental impacts must play a role in these calculations.

WAC 220-660-190(4)a states that the bridge must pass the 100-year flood or an approved design flow. The designer may propose a different flow based on risk analysis, although justification for that flow must be given when applying for a Hydraulic Permit.

WDFW suggests that the interdisciplinary team should also include a geomorphologist (or someone familiar with river processes) to truly understand river conditions and potential impacts.

2.2 General Design Procedure

Step 5, reasonableness: Bridges in Washington cannot be designed solely on the basis of scour, but must also consider wood, sediment and ice passage (WAC 220-660-190(4)a) as well as lateral migration (WAC 220-660-190(4)c).

2.3.1 General

1. HEC 18 recommends 3 feet of freeboard, which is also what is required in WAC 220-660-190(4)f. Less clearance may be acceptable when properly justified.

2.3.3 Abutments

Guide banks and river training works are discouraged in Washington due to the potential negative effects on instream habitat.

2.4.1 Step 1: Determine Scour Analysis Variables

WDFW encourages the designer to use explore item 4 (pages 2.11 and 2.13) thoroughly. This list includes many of the categories used to develop what we call a reach analysis in the **WCDG,** Chapter 4, which was developed in part by following the analysis in **HEC 20**, Chapter 4, *Analysis Procedures for Stream Instability*. Together these documents will help the designer put together a study to understand river processes in the area around the bridge. Understanding river processes is at the core of a bridge design that avoids or minimizes impacts to fish. Both the **WCDG** and **HEC 20** river analysis are scalable to the size and complexity of the project and can be phased to accommodate scoping and design funding.

2.4.6 Step 6: Plot the Total Scour Depths and Evaluate the Design

Reevaluate the Bridge Design: the 6 questions here could also apply to environmental concerns. At a minimum, the designer should observe whether proposed bridge geometry will lead to impacts and explore ways to avoid or reduce them.

3.7 Lateral Shifting of a Stream

On page 3-16, HEC 18 states that "While it is difficult to evaluate the vulnerability of a bridge due to changes in planform, it is important to incorporate potential planform changes into the design of new bridges and design of countermeasures for existing bridges." This reflects WAC 220-660-190(4)d: "A person must design the bridge to account for the lateral migration expected to occur during the bridge's lifespan."

Chapter 5: Long-Term Aggradation and Degradation

Stream incision is endemic in many Washington tributary streams as an artifact of our young, actively evolving geology. Bridges should be placed on deep foundations to anticipate lowering streambed elevation, rather than relying on countermeasures in the future that could result in ongoing impacts.

6.2.2 Contraction Scour Cases

The calculation of contraction scour is summarizes one of the more significant effects of bridges on habitat. While designers are considering contraction scour, they should also think about the environmental impacts associated with channel constriction and floodplain isolation that are discussed in the **WCDG** pages 84 – 89. Two criteria are suggested there that may help quantify the potential effects of constriction on fish habitat. Contraction scour cases 1a and 1b should never be considered for a new or replacement bridge in Washington.

6.9 Scour At Open-Bottom Culverts

HEC 18 states that for open-bottom culverts "The natural bottom material is more environmentally attractive than a traditional closed culvert, particularly where fish passage is a concern." In Washington, almost all culverts that are considered fish passable have a stream bed inside (countersunk invert) so that there is essentially no practical difference between a closed culvert and a bottomless one. Provided the culvert is designed using an accepted method for fish passage, the type of culvert may be determined by considering other factors (cost, constructability, scour, etc).

Chapter 7: Pier Scour

WDFW recommends that all piers be placed on deep foundations to eliminate the need for countermeasures in the future that may cause impacts to fish and their habitat.

CHAPTER 9: Scour Analysis for Tidal Waterways.

The determination of the opening width for a bridge in a tidal (estuarine or nearshore) environment is a complex matter that should not be based solely on scour. In the **WCDG** Appendix D: *Tidally Influenced Crossings*, opening width can be determined through an alternatives analysis based on a hierarchy of benefits. Essentially, it is the benefits that are required to protect valued environmental services, and the practical requirements of the owner, that determined which alternative is optimally suited to the conditions.