Department of Fish and Wildlife

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

AASHTO Highway Drainage Guidelines [1]

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

May 6, 2015

Since the **AASHTO Highway Drainage Guidelines** are intended for a national audience they do not specifically include the Washington State fish protection requirements of WAC 220-660-190 and RCW 77.57.030. The following notes should help the designer use the **Highway Drainage Guidelines** to develop a plan that is acceptable under these rules and obtain a Hydraulic Project Approval (HPA).

This review covers primarily Chapters 4, 7, and 10, although there are relevant portions of Chapter 6. Considering that all water crossings over fish bearing waters in Washington will require fish passage and habitat protection, the designer should first read **Chapter 10, EVALUATING HIGHWAY EFFECTS ON SURFACE WATER ENVIRONMENTS**.

Chapter 4: HYDRAULIC DESIGN OF CULVERTS. This chapter does not contain criteria or design elements for the movement of fish. It cannot, therefore, be used by itself to design a culvert in fish-bearing waters of Washington State. The comments below can be used to help prevent impacts to fish life.

Section 4.1:

Due to the severe hydraulic conditions at the inlet, culverts in fish-bearing streams in Washington are not designed to be submerged during floods.

Section 4.2.4

AASHTO recognizes local jurisdiction over fish passage. Recommended criteria for design and construction area available in WAC 220-660-190 and WDFW's **Water Crossing Design Guidelines**[2].

[1] AASHTO (2007). **Highway Drainage Guidelines.** American Association of State Highway and Transportation Officials, Washington, DC.

Section 4.3.2

Even though the authors recognize the adverse effects of culverts not aligned with the natural profile, several alternatives are shown, Figure 4-3, that would lead to impacts to the stream and impaired fish passage. Alternative profiles "depressed inlet," "sidehill locations," and the split gradient culvert shown at the bottom of the figure, would not be acceptable in Washington. "Channel change gradient modification," and "degrading channel" are two alternatives that could be chosen to solve channel adjustment problems (please see Chapter 7 in **Water Crossing Design Guidelines**).

Section 4.4.1.5

Multiple barrel culverts are discouraged in Washington. Debris accumulation and poor sediment transport cause impaired stream function, potential fish passage barriers and repeated maintenance (aquatic disturbance).

Section 4.5

Culverts in Washington are not designed solely on the basis of hydraulic capacity. The designer must also consider the passage of fish, sediment and debris, which nearly always control type, size and location.

Sediment transport is never seriously evaluated in Chapter 4. Considering that culverts most often fail from sediment or debris occlusion, the designer may want to use a method that accounts for these functions.

Section 4.7.4

The authors again recognize local authority for fish passage and recommend early coordination with agencies. Following the criteria in WAC 220-660-190(6)a or (6)b is probably the easiest way to comply with state requirements.

Culverts with baffles are discourage and are permitted under WAC 220-660-200, Fish Passage Improvement Structures. Regular inspection and maintenance are required.

Weirs in the adjacent channel constitute a fishway and are permitted under WAC 220-660-200 and require regular inspection and maintenance.

Multiple barrel culverts are discouraged (note above).

[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.

Section 4.9

Of the three options for debris control, retaining it upstream of the culvert is not acceptable in Washington, except in rare circumstances where passing it would cause unavoidable harm downstream. Passing debris should be a major factor in culvert design in Washington State.

Debris control structures generally fail to provide uninterrupted fish passage and would not comply with current code and law.

Chapter 6: HYDRAULIC ANALYSIS AND DESIGN OF OPEN CHANNELS

Section 6.3.2.2

AASHTO suggest that "Alternative transverse encroachments should be evaluated in the location phase of planning to assure consideration of hydraulic, economic, and environmental concerns." WDFW considers this the best method to determine the most appropriate design.

Figure 6-3 shows undesirable features relating to traverse encroachments. WDFW agrees that these are undesirable encroachment for the following cases which are likely to have impacts to fishlife.

(B) *Reverse curvature in channel*: Manipulation of the channel planform to create perpendicular, or otherwise advantageous bridge alignments requires channel hardening (revetments) makes the channel assume a shape that will require repeated maintenance to sustain.

(C) *Extreme skew*: As discussed in Chapter 10, bridges with extreme skew will be susceptible to hydraulic and sediment transport problems and will require repeated maintenance to sustain.

(D) *Extreme encroachment on stream:* This configuration will interfere with floodplain functions and will require substantial abutment protection and interfere with sediment and wood transport. The **WCDG** Chapter 4 *Design of Bridges for Habitat Protection* has methods to evaluate the degree of encroachment and its effect on habitat (main channel velocity ratio).

Chapter 7 HYDRAULIC ANALYSIS FOR THE LOCATION AND DESIGN OF BRIDGES

Many of the principles expressed in this chapter with respect to stream processes and biological considerations are similar to those in WAC 220-660-190 and Chapter 4 in the **Water Crossing Design Guidelines**. In order to develop a plan that avoids impacts to fishlife, the designer's task will be to balance these principles against the other requirements of the structure and its cost.

Section 7.1

AASHTO says that, "Bridges enable watercourses to maintain the natural function of flow conveyance and sustain aquatic life." In order for this to be true, however, the role of other stream processes must be recognized and formalized as design criteria. In later sections of this chapter many of these processes are clearly defined.

Section 7.2.1

We appreciate the wide scope of the bulleted list of factors associated with a bridge's location and suggest that the designer not neglect natural resources (fishlife) and environmental considerations (stream processes, wetlands, floodplains) in order to arrive at an appropriate plan.

"Many aspects of the environmental assessment made in connection with site selection are also related to the hydraulic design of a stream crossing." A true statement.

Section 7.2.3

These same observations are used in WDFW code and guidance on bridges: "The environmental considerations for the hydraulic and physical aspects of water quality at alternative sites are the same concerns that the hydraulics engineer has historically addressed in evaluating the relative merits of alternative locations. These include the effects of the crossing on velocities, water surface profiles, velocity and flow distribution, scour, bank stability, sediment transport, aggradation and degradation of the channel, and the supply of sediment to the stream or water body. The hydraulics engineer must evaluate the potential effect of these factors on the crossing and the potential effects of the crossing site on the environment."

In this section AASHYO says a biologist assesses the effect of site selection on habitat but the engineer develops alternatives. In order to protect fish, there must be good communication between biologist and engineer. We observe that a lack of respect, and unwillingness to compromise, often destroys the collaboration necessary for a properly designed bridge.

Section 7.2.4

"Early coordination with other agencies will reveal areas of mutual interest and offer opportunities to conserve public funds and to resolve conflicts between highway agency plans and those for water resources development and resource protection and preservation." We encourage early coordination.

Section 7.2.5

The discussion on stream morphology is adequate and the suggested references are good. We recommend Chapter 4 in the **Water Crossing Design Guidelines** for the Washington perspective and the many references suggested there. At this stage is it unclear how this information is used in bridge design.

The observations made in this section (7.2.5.1 – 3) are generally in keeping with accepted stream analysis and we agree should be taken into consideration in bridge planning and location.

Section 7.2.7

The role of nearshore and estuaries in the marine ecosystem in general, and fish life in particular, has long been recognized. More recently, the dramatic loss of these habitats to development has led to higher levels of protection for existing nearshore areas and the need to restore lost or degraded habitat. Crossing design will often play a role in protection and restoration. A method to evaluate alternatives is outlined in Appendix D: *Tidally Influenced Crossings* in the **Water Crossing Design Guidelines**.

Section 7.2.8

These observations concerning levees are insightful and important. Notwithstanding the earlier statement that designers should be wary of restoration planning that is never realized, bridge design should not preclude levee (dike) setback where it is seriously being considered.

Section 7.2.9

Replacement, repair, and rehabilitation, and decision surrounding these actions, have caused much controversy between WDFW and bridge owners. The **Water Crossing Design Guidelines** recommend an alternative analysis to help with decision-making: “When evaluated over this broad range of factors, decisions concerning an older bridge can be made in a rational atmosphere and readily explained to funding and natural resource agencies. It benefits all parties if the bridge owner presents a comprehensive assessment rather than simply proposing the repairs.” (**WCDG**, p. 97)

Section 7.3.5

This is a robust program for collecting channel information. It probably leaves readers wondering how far they have to go into this topic. The **WCDG** suggests a tiered approach to what we call reach analysis, pages 74-78.

The transport of sediment and wood is important in Washington streams. This is not really addressed in this section, but it is in the following section on Environmental Data.

It is unclear how this analysis informs design.

Section 7.6.1

Water crossing owners are required to protect fish and their habitat when they design new or replacement structures. How you do this is left up to the designer. You can either use the recommended design criteria for bridges in WAC 220-660-190 or in Chapter 4 of the **WCDG.** Or you can supply analysis and documentation that shows the design will protect fish. The design criteria in this section does not contain specific references to fish, habitat, or the stream processes that create and support fish habitat. Without specific criteria, all the data collection and analysis recommended in the preceding sections will not guarantee a design that meets Washington State law and code.

Chapter 10: EVALUATING HIGHWAY EFFECTS ON SURFACE WATER ENVIRONMENTS

Section 10.1

The introduction embodies many of the principles of environmentally responsible crossing design expressed in WDFW guidelines and code. The statement that "Generally, engineering drainage design practices that protect the environment also protect the highway" is in keeping with WDFW's position that protecting fish and their habitat is an essential part of responsible crossing design.

Section 10.1.2

AASHTO suggest early integration of technical information into the planning process. This has been a primary motivation for the development of the Aquatic Habitat Guidelines in general, and specifically the **Water Crossing Design Guidelines**. WCDG Chapter 4, *Bridge Design for Habitat Protection* was written to help the designer understand our approach *before* they apply for funding.

Section 10.1.3

"Environmentally sensitive surface waters" are not a special case in Washington. All waters of the State are protected under the Hydraulic Code (WAC 220-660) and require a permit for aquatic projects (HPA).

Section 12.1.5

We understand the concept of a "threshold value" but use the term *measurable impact*, or the point at which mitigation sequencing would begin (avoid,

minimize, mitigate). Measurable impact means that the project will degrade fish habitat in a way the we can measure, either through modeling, comparison to a reference reach, or because similar projects have had similar effects. One could also monitor the finished project, although this would occur after the project is permitted and constructed.

Section 10.1.6

The concept of "Reversible and Irreversible Effects" does not exist under Washington law. When there is a measurable impact, the applicant must avoid, minimize or mitigate. The closest we come to reversible is "temporary."

Section 10.1.8

The interrelationship of stream processes is recognized here, but elsewhere (e.g. Section 10.1.3) factors are categorized in ways that diminish this interconnectedness. We suggest a geomorphological approach to the design of water crossings as a way to promote this.

Section 10.1.10

This is a very important paragraph. We have always promoted clear and detailed plans and specifications for channel design, habitat features and sediment specification. Often in the case of water crossings, the replacement project is done solely to eliminate a fish passage barrier, but the heart of the project – the stream channel – gets short shrift in the plans and specs.

Section 10.2.1.1

The Surface Water Inventory is, in many ways, equivalent to the reach analysis that we recommend in Chapter 4 of the **WCDG**.

Including floodplain features in this inventory, as suggested, is essential for the design of bridges over rivers with connected floodplains.

"Surface water inventories should include the geographic area affected by the highway and must not be limited to only the highway right-of-way." This caution is often ignored and leads to disagreements about the scope and impacts of a given project.

The concept of cumulative changes and threshold values is discussed here and should be considered carefully by the designer.

Another important statement is that, "The significance of a long-term effect of a highway improvement on the floodplain environment may not be readily

apparent." AASHTO recommends a comparison of pre- and post-project conditions and WDFW encourages that as well.

Section 10.2.2.1

This section discusses sediment as a water quality concern (e.g. construction site runoff) and does not address fluvial sediment concerns. Unfortunately, this is not discussed elsewhere in Ch. 10 to a degree that we feel is necessary for the design of water crossings, particularly culverts. Unconstrained sediment transport is a basic requirement for water crossings in Washington and the designer should make sure that is it adequately studied.

Section 10.2.4

WDFW agrees with the scope of biological effects on the floodplain, riparian, and the stream itself. However, it is not clear how to tailor such an analysis to a project, what to do with it, or how it might influence design.

WDFW agrees that if a project design is modified to accommodate biological concerns that it is justified by site-specific analysis. This is the basis of "measurable impact."

Section 10.3

And we wholeheartedly agree with the statement: "Where mitigative measures are not cost effective, the temptation is to forego any protective measures and accept the possibility of a measurable deterioration in the surface water environment. This decision, however, may be contrary to the requirements of any cognizant regulatory agencies." When this section talks about "cost effectiveness" we suggest that costs be evaluated in a comprehensive way across a range of alternatives. While some factors cannot be monetized, this does not mean that they cannot be evaluated. We have promoted the use of an index value to compare alternatives (for example in the **WCDG** App D, *Estuarine Opening Geomorphology - Hierarchy of Benefits*).

Section 10.3.1

The first bulleted list should include the processes that support these features.

Section 10.3.1.3

In Washington, crossing structures must provide passage for fish, sediment and wood. It is rare that a crossing significantly decreases flood peaks because our tributary streams are in young geology, relatively steep and confined, and do not create enough storage to significantly decrease flood peaks.

Section 10.4.1

The mitigation baseline in Washington is the current conditions, except at water crossings where the existing condition may not meet passage criteria or provide for basic habitat protection.

The statement that, ”A perceived need to provide for fish passage through a highway structure may be negated by natural or constructed stream barriers” is not true in Washington. Existing barriers do not, in themselves, negate the need for fish passage.

Section 10.4.2

All water crossings in fish-bearing waters must provide passage in Washington.

Generally, crossings are not designed on the basis of the swimming ability of fish. There are exceptions and these are handled under WAC 220-660-200 Fish Passage Improvement Structures.

Section 10.4.3

Crossing should maintain equilibrium gradient unless there is existing reach level instability.

Section 10.4.3.1

Generally, there should be no delay under any circumstances.

All life stages are roughly equal in their contribution to survival.

Section 10.4.3.2

Projects that use velocity as a criteria for fish passage should comply with the provisions in WAC 220-660-200. This method is discouraged in Washington.

Section 10.4.3.5

Please see WAC 220-660-190(2), which requires passage for fish at all flows when they are expected to move and the maintenance of expected stream processes through the crossing.

The first bulleted list in this section: With the exception of items 4 and 5, all of these alternatives must be permitted under WAC 220-660-200.

Multiple barrel culverts are not recommended for Washington streams due to debris and sediment issues. Manipulation of culvert geometry is not

recommended because of the interference with expected stream processes. All culverts permitted under WC 220-660-190 are countersunk.

Section 10.4.3.5.1

The "satisfactory profile" in Fig 10-10 would not meet the requirements of WAC 220-660-190 and is not recommended to provide the passage of fish, sediment and wood. It could be part of a hydraulic fish passage design under WAC 220-660-200, although not recommended.

Fig 10-11 was once a common method to retrofit barrier culverts but has been found to have many problems. Generally, it does not meet the requirements of WAC 220-660-190 and is not recommended to provide the passage of fish, sediment and wood. It could be part of a hydraulic fish passage design under WAC 220-660-200, although not recommended.

Section 10.4.3.5.2

In order to comply with WAC 220-660-190, a culvert must be embedded, as shown in Figure 10-12. All culverts in WA are backfilled with streambed material similar to that found in the adjacent channel. The span and clearance inside these culverts is not discussed in this chapter. A reasoned method must be provided that justifies the size of the culvert with respect to WACs 220-660-190 or 220-660-200.

Section 10.4.3.5.3

Baffles are Fish Passage Improvement Structures and permitted under WAC 220-660-200. Please see **WCDG** Chapter 6 *Hydraulic Design Option* for baffle design methods used in Washington. Baffles are not recommended for culverts with a slope >3.5% and with headroom <5 ft.

The baffle arrangement in Fig 10-15 is not recommended for fish passage in WA. Please see Figure 6.1 in the **WCDG**.

Section 10.4.3.5.4

Vertical slot fishways are Fish Passage Improvement Structures and permitted under WAC 220-660-200.

Section 10.4.4

This chapter is relevant to water crossings when a new channel is created adjacent to a new structure or through it (as in the case of a bridge). Many of the observations and values expressed in the first few pages of this chapter are in keeping with the protection of fishlife as require by Washington law.