CEDAROCK CONSULTANTS, INC.

MEMORANDUM

Date: August 14, 2019

To: Peter Kahn – Costco Wholesale Corporation
Ed Sewall – Sewall Wetland Consulting

From: Carl Hadley

Subject: Recommended Culvert Sizing Analysis
Mosher Creek and Tributary – 2514 and 2520 Lake Stevens Road

Introduction

This memo provides the basis and analysis for sizing three replacement culverts for an unnamed tributary to Mosher Creek (Figure 1). Under the proposed action, three private stream crossings with undersized CMPs will be removed and replaced with fish-passable culverts or bridges.

The goal of this analysis was to identify widths for new culverts that will provide unimpeded fish passage, and will pass all flow, sediment, and debris up to the 100-year event. Sizing was based on the Stream Simulation method discussed in WDFW's Water Crossing Design Guidelines (2013)[1].

Physical Channel Conditions

The channel in question was surveyed on July 29, 2019 by Carl Hadley, a professional fisheries biologist with over 30 years of experience in the Pacific Northwest. The channel was walked for about 100 feet upstream (north) and 50 feet downstream of the site. The watercourse is relatively small (ranging from 4 to 6 feet at BFW). All flow passes through several 8-inch culverts without flooding. Some channelization, culverting, and evidence of dredging were also noted. Several large wetlands are present which provide flow continuation.

The channel north of the affected reach consists of Wetland "D", an approximately 2.7-acre Category II headwater wetland (Figure 1). All flow from the wetland drains to the south through an 8-inch culvert to the Mosher Creek tributary. The wetland water level drops in the summer below the discharge pipe and the Mosher Creek tributary goes nearly dry with some minor groundwater present in places. Channel water depths in the winter range from 1 to 3 inches with an organic/dirt and small gravel substrate. The channel gradient ranges from flat (0%) to just over 10 percent in places.

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[1] Barnard, R. J., J. Johnson, P. Brooks, K. M. Bates, B. Heiner, J. P. Klavas, D.C. Ponder, P.D. Smith, and P. D. Powers (2013), **Water Crossing Design Guidelines**, Washington Department of Fish and Wildlife, Olympia, Washington. http://wdfw.wa.gov/hab/ahg/culverts.htm

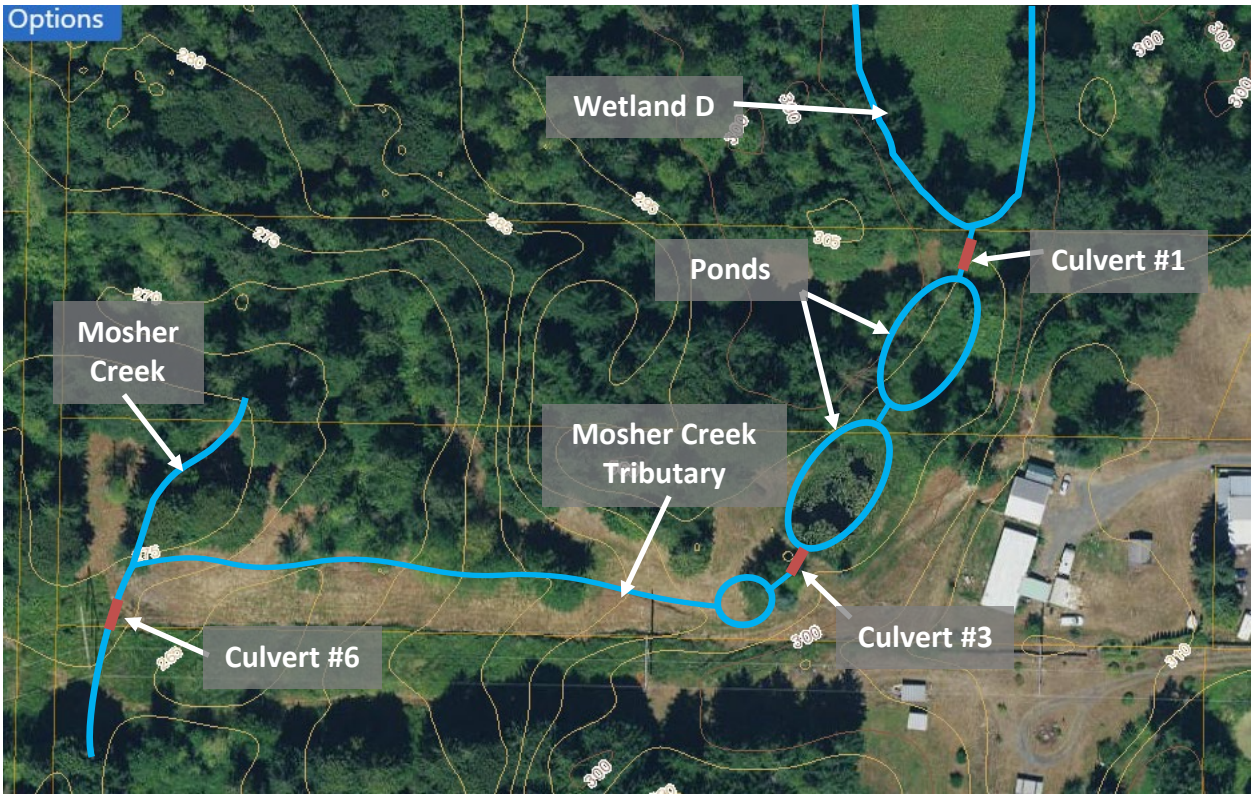

Figure 1. Stream culverts to be replaced (2017 photo).

The tributary terminates about 900-feet downstream of Wetland "D" where it merges with Mosher Creek in a large shallow emergent wetland. Culvert Crossing #6 is located in Mosher Creek just downstream of the confluence. Mosher Creek in this area has a BFW of about 6-feet with a depth of about 1-foot. The channel is buried in dense reed canarygrass.

Fish Use

The tributary channel dries up during the summer while Mosher Creek retains some minor flow. Mosher Creek provides year-round juvenile coho and resident trout habitat. The tributary and Wetland "D" may provide juvenile coho winter habitat if the various blockages are removed. The channel provides no habitat or potential use by federally listed species (Chinook, steelhead, bull trout). Local, state, and federal databases show the nearest documented use by listed species occurs more than a mile downstream of the site.

Culvert Sizing Analysis

The Stream Simulation method utilizes bankfull channel width to calculate the width of the channel bed within the culvert per the following equation:

$$W_{culvert\ bed} = 1.2W_{ch} + 2\ (in\ feet)$$

W_{ch} is the average bankfull channel width over the crossing area and 200 feet upstream and downstream. Bankfull channel width is measured as the lateral extent of the water surface at the elevation required to completely fill the channel to a point above which water would enter the floodplain or intersect a terrace or hillslope[2, 3].

As noted above, the existing channel is modified and interrupted by numerous large wetlands (Figure 1). Bankfull width measurements were made in the least disturbed areas upstream and downstream of each crossing where wide wetlands weren't present.

Crossing #1

The crossing is located between two large wetlands with only about 10 feet of channelized flow within more than 100-feet upstream or downstream (Figure 2). Because this area has contained all flow since the crossing was built, the existing profile will be used to create the new crossing. Bankfull width at the crossing is 4.2 feet. This results in a minimum channel bed width within the culverts of 7.0 feet:

$$W_{culvert\ bed} = 1.2\ (4.2) + 2 = 7.0\ feet$$

Final culvert width will depend on the type of culvert that is selected. With a three-sided box, an 7-foot internal width should be adequate to contain the channel and a suitable flood zone. A pipe arch would likely require a wider diameter as the maximum pipe width will be buried and the channel bed will be located higher up in the narrower portion of culvert.

Crossing #3

Crossing #3 drains a large pond upstream. About 50-feet of channelized flow is located immediately downstream (Figure 3). Three bankfull width measurements were made in this area with an average of 4.5 feet (range from 4.0 to 5.0 feet). This results in a minimum channel bed width within the culverts of 7.4 feet:

$$W_{culvert\ bed} = 1.2\ (4.5) + 2 = 7.4\ feet$$

Final culvert width will depend on the type of culvert that is selected. With a three-sided box, an 8-foot internal width should be adequate to contain the channel and a suitable flood zone. A pipe arch would likely require a wider diameter as the maximum pipe width will be buried and the channel bed will be located higher up in the narrower portion of culvert.

[2] Washington Forest Practices Board. 2004. Board manual: standard methods for identifying bankfull channel features and channel migration zones, Section 2. Washington Department of Natural Resources, Forest Practices Division. Olympia.

[3] IBID. Water Crossing Design Guidelines (Appendix C).

Figure 2. Crossing Area #1 – Existing conditions.

Figure 3. Crossing Area #3 – Existing conditions in channel just downstream of existing culvert.

Crossing #6

This crossing is located over Mosher Creek and consists of a partially buried culvert located in fill through a wetland (Figure 4). A defined channel is present in the wetland and three bankfull width measurements were made with an average of 5.7 feet (range from 5.0 to 6.0 feet). This results in a minimum channel bed width within the culverts of 8.8 feet:

$$W_{culvert\ bed} = 1.2\ (5.7) + 2 = 8.8\ feet$$

Final culvert width will depend on the type of culvert that is selected. With a three-sided box, an 9-foot internal width should be adequate to contain the channel and a suitable flood zone. A pipe arch would likely require a wider diameter as the maximum pipe width will be buried and the channel bed will be located higher up in the narrower portion of culvert.

Figure 4. Crossing Area #6 – Existing conditions at Crossing #6.

Bankfull Channel Width Estimate Using WDFW Regression Equation

For comparative purposes, a regression equation developed by WDFW that correlates watershed area (WA), average annual precipitation (AAP), and bankfull channel width was used.

$$W_{ch} = 0.95 * WA^{0.45} AAP^{0.61}$$

Tributary

A watershed area upstream of the two culvert locations on the tributary of 22 acres (0.03 sq.mi.) was calculated based on LIDAR imagery provided by Snohomish County. An average annual

rainfall of 45 inches was provided on an isopluvial map created by Oregon State University using the PRISM model.

$$W_{ch} = 0.95*(0.03)^{0.45}(45)^{0.61} = 2.1 \text{ feet}$$

This is considerably less than the measured average bankfull channel width of 4.1 feet giving us confidence that the measured average provides a suitable, if not conservative estimate.

Mosher Creek

The watershed area upstream of the culvert location on Mosher Creek is approximately 229 acres (0.36 sq.mi.).

$$W_{ch} = 0.95*(0.36)^{0.45}(45)^{0.61} = 6.1 \text{ feet}$$

This is in line with the measured average bankfull channel width of 5.7 feet giving us confidence that the measured average provides a suitable, if not conservative estimate.

Culvert Height

WAC 220-110-070(1)(e) (Hydraulic Code Rules) requires stream crossings to "pass the 100-yr flow with consideration of debris likely to be encountered." These small very low gradient streams are unlikely to carry significant debris loads, especially larger pieces of woody debris. There is not enough energy to move a log with a rootball or long branches, especially since there is no indication that water depths exceed about 8-inches. A distance of 18 to 24-inches above OHW (or about 2- to 2.5 feet above the channel bed), should be more than enough to pass expected debris.