CHUMSTICK CREEK CULVERT – RM 0.48 – MOTTELER ROAD
PROJECT # 19-1584

BASIS OF DESIGN REPORT

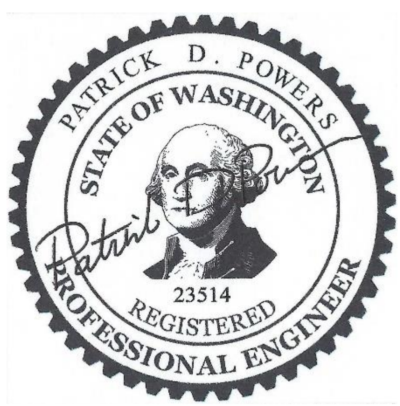
Prepared for

RCO
CCNRD

Prepared by

Waterfall Engineering

10/16/20
Revised 12/23/20



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1 DESIGN ALTERNATIVES

Chumstick Creek is a tributary to the Wenatchee River. At creek mile 0.48 the creek flows through a pipe arch culvert (10.9 foot span by 6.9 foot rise, see Figure 1). This culvert was assessed by WDFW as a fish passage barrier due to slope (1.25 percent). Funding for this project was approved through the Brian Abbott Fish Barrier Removal Board (FBRB). The landowner upstream and downstream of the culvert is Motteler Orchards, LLC. The culvert is within a 60-foot Chelan County Easement (Motteler Road). A Correction Analysis Form was completed by Waterfall Engineering and Chelan County Natural Resources Department (Appendix A). Two options were identified, and the bridge option was selected by the FBRB Fish Passage Design Team.

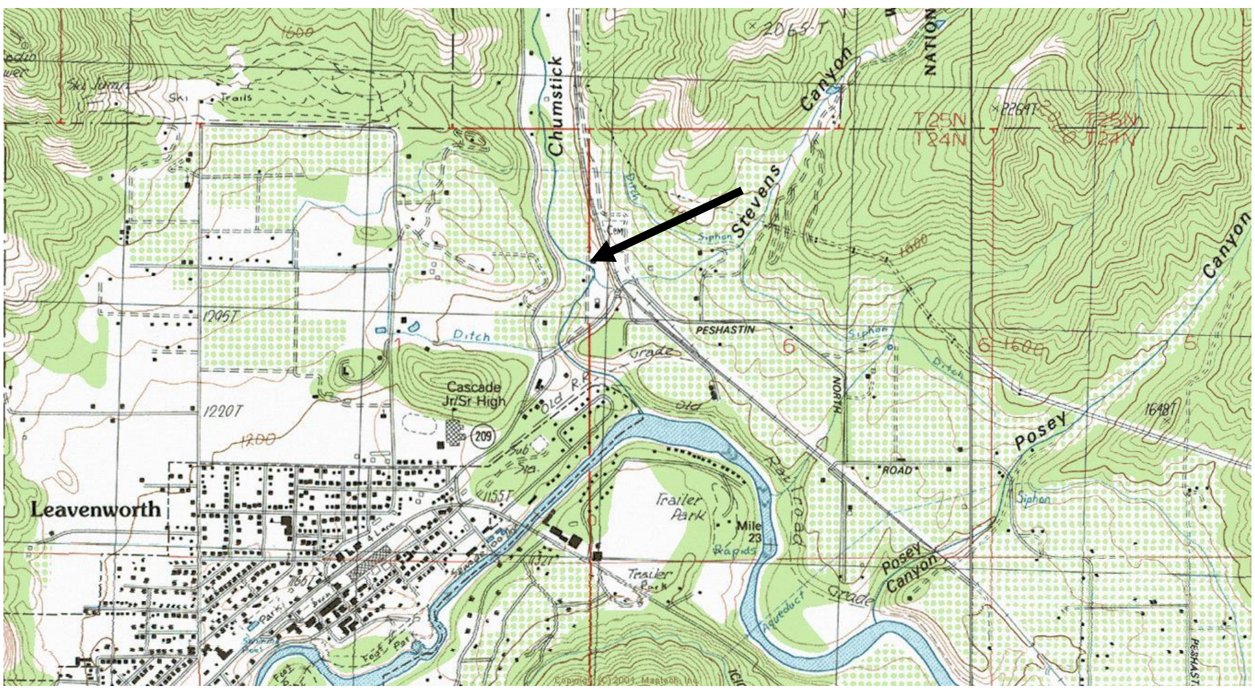

Figure 1 – Motteler Culvert Location.

2 HYDROLOGY AND CHANNEL WIDTH

Chumstick Creek upstream of the culvert has a basin area of 46 square miles. The mean annual rainfall is 32 inches per year. The Washington State Department of Ecology maintains a stream gage near the mouth of Chumstick Creek (45C060). Data is available from 2003 to the present.

Flows were recorded every 15 minutes. Peak flow data was plotted with using the Weibull Plotting Position.

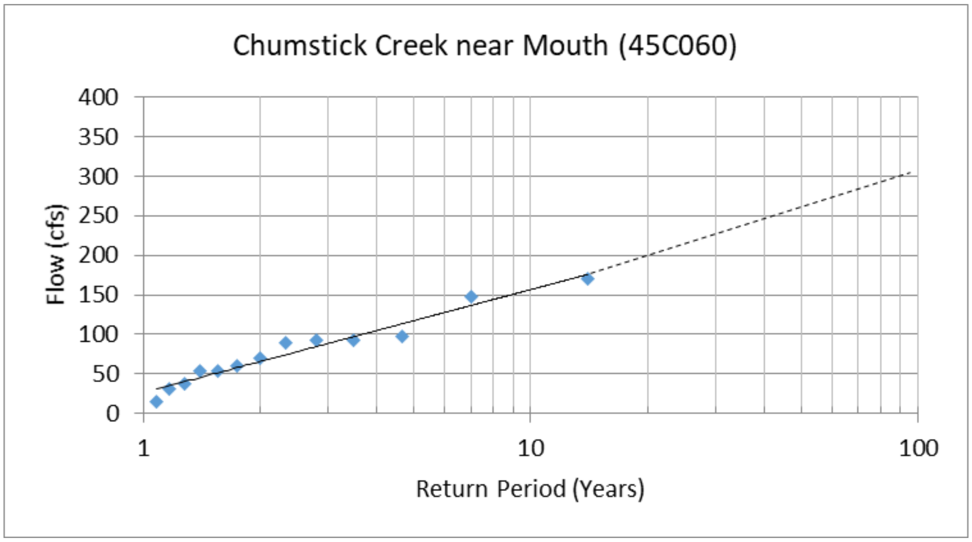

Figure 2 – Chumstick Creek near Mouth – Weibull Plotting of highest 15 minutes flows recorded from 2003 to 2018.

From Figure 2 the 2-year flood is estimated at 73 cfs and the 100-year flood was extrapolated to a value of 310 cfs. These flows were used to model the existing conditions in the stream channel upstream and downstream of the culvert. The final design provides 3 feet of clearance at a flow of 310 cfs.

Channel widths were measured upstream and downstream of the culvert in a location away from the effects of the culvert. The average bank full width was measured at 18 feet.

3 SCOUR ANALYSIS

Methodology for the scour analysis comes from U.S. Department of Transportation Federal Highway Administration Hydraulic Engineering Circular No. 18, Evaluating Scour at Bridges (HEC No. 18), and Circular No. 20, Stream Stability at Highway Structures (HEC No. 20). From Table 2.1 (HEC No. 18) the minimum scour design flood frequency is the 100-year flood. The estimated 100-year flood is 310 cfs. Flow, depth and velocity were all modeled using a HEC RAS 1D Model. The proposed design is to install the bridge at such a span, that depth, velocity and top width will be the same as the natural channel so there is no constriction at the bridge (see Figure 3). The HEC RAS Output files are provided in Appendix C.

The design plans show a water top width of 23 feet at the 2-year flood and 32 feet at the 100-year flood. From the data in Figure 3, the calculated water surface top width varies from 14.9 to 16 feet, and at the 100-year from 27.3 to 37.3. Based on these width values there will not be any contraction of flow at the bridge.

		Q2 = 73 cfs					Q100 = 310 cfs				
	CAD STA	Depth	Velocity	Top Width	Flow Area	Shear	Depth	Velocity	Top Width	Flow Area	Shear
	30.0	1.7	4.2	13.0	17.2	0.8	3.7	6.6	17.0	46.7	1.5
	39.5	1.4	4.6	14.0	16.0	0.9	3.5	6.4	21.0	49.1	1.2
	81.0	1.3	3.9	17.0	18.5	0.7	3.3	5.3	25.0	59.2	0.8
	116.7	2.1	2.5	19.0	29.8	0.2	4.1	4.4	36.0	74.5	0.4
	145.5	2.3	2.7	16.0	27.2	0.3	4.4	4.4	43.0	79.4	0.4
	191.5	1.3	5.0	13.0	14.6	1.1	3.1	7.9	18.0	39.7	1.9
	231.9	1.7	3.0	20.0	24.2	0.4	3.8	4.2	31.0	75.5	0.5
	259.5	1.5	2.0	29.0	36.5	0.2	3.7	3.0	33.0	104.5	0.3
	321.1	1.9	5.6	14.0	13.0	1.5	3.4	8.0	20.0	38.8	2.3
	346.5	1.9	6.8	8.0	10.8	2.0	3.7	7.8	34.0	50.9	1.2
	360.9	2.7	3.1	15.0	24.1	0.3	3.9	7.0	25.0	51.0	1.0
Bridge	384.4	1.6	5.9	11.0	12.3	1.7	3.4	8.6	16.0	36.2	2.7
Bridge	436.9	2.5	2.2	17.0	32.6	0.2	4.7	3.9	27.0	82.1	0.4
	480.2	2.2	2.3	20.0	31.1	0.2	4.5	3.6	38.0	92.8	0.3
	520.1	1.2	5.6	13.0	13.0	1.5	3.1	7.6	22.0	42.2	1.6
	577.8	1.7	3.2	17.0	23.2	0.4	3.6	4.7	79.0	80.8	0.2
	635.4	4.0	1.8	17.0	39.9	0.1	6.0	3.9	34.0	86.9	0.3
	647.3	2.1	6.2	10.0	11.8	1.7	4.0	7.7	34.0	49.5	1.1
	680.8	2.7	3.4	16	21.67	0.5	4.5	4.5	52.0	83.8	0.4
	731.2	3.4	1.6	20	45.58	0.1	5.3	3.4	49.0	103.8	0.2
	Overall	**2.1**	**3.8**	**16.0**	**23.2**	**0.7**	**4.0**	**5.6**	**32.7**	**66.4**	**0.9**
	US Culvert	**2.4**	**3.8**	**14.9**	**24.2**	**0.8**	**4.2**	**5.7**	**37.3**	**69.1**	**0.9**
	DS Culvert	**1.7**	**3.7**	**16.0**	**21.1**	**0.6**	**3.7**	**5.6**	**27.3**	**60.6**	**1.0**

Figure 3 – HEC RAS Output for the 2-year and 100-year flood.

Two types of scour need to be assessed for a bridge placement 1) Contraction scour and 2) long term scour. Contraction scour occurs when the flow area of the stream at flood stage is reduced by the bridge. As documented above there is no contraction scour. For long term scour the channel downstream of the culvert was analyzed based on (HEC No. 20) Section 6.4 Vertical Channel Stability. These calculations were done assuming no large wood in the channel. Section 6.4 uses calculations for incipient motion, shear stress and channel armoring. A pebble count was done for Chumstick Creek. The pebble count consisted of 50 pebble samples from two locations, one upstream and one downstream of the culvert (see Figure 4). The channel slope downstream of the culvert is 1.6 percent and 0.9 upstream. The gradient is controlled by some gravel and cobble but mostly from tree roots and large woody debris in the channel.

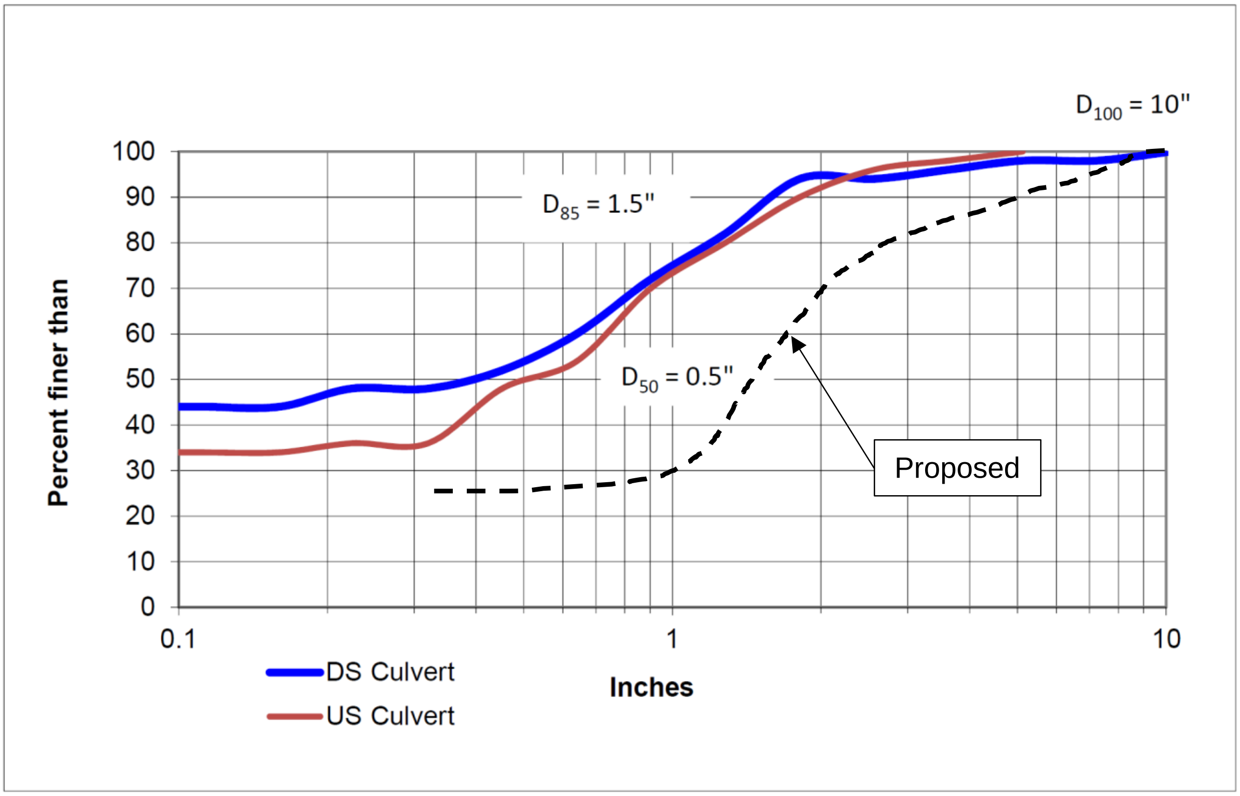

Figure 4 – Pebble Count for Chumstick Creek upstream and downstream of the culvert. The black dashed line is the proposed sediment size the channel under the bridge.

From the HEC RAS output the shear stress in the proposed bridge area at the 100-year flood averages 0.3 lbs./sq. ft. From Figure 5 the estimated sediment particle size for incipient motion is 0.9 inches. Looking at the Pebble Counts from Figure 4, this is about the D_{70} pebble size.

The gradation curve from Figure 4, indicates that 70 percent of the bed material is smaller than or equal to this particle diameter. Therefore, 30 percent of the bed is courser than the critical particle size, and armoring is possible (greater than the 5 percent threshold). From Equation 6.16 (HEC No. 20), the estimated depth of scour at which an armor layer can form is approximately 4.2 feet. It is critical to remember how the vegetation and large woody debris in the natural channel play a major role in preventing channel scour, but under the bridge where vegetation and large woody debris placement may be problematic some increase in sediment size is needed to address potential scour.

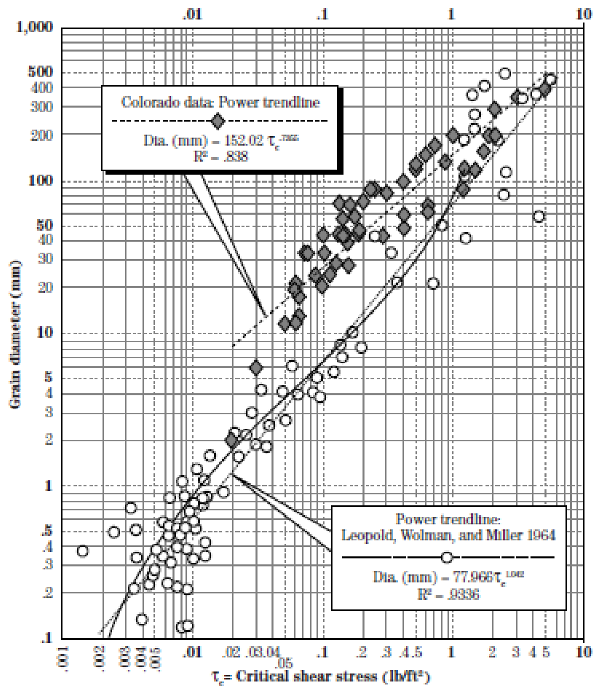

Figure 5 – Figure 11-11 from Rosgen Geomorphic Channel Design (Shields Relationships)

To prevent future, scour the bed material under the bridge will be increased slightly from the natural sediment size. The following gradation is proposed for the material under the bridge. In addition, the riprap revetment to protect the bridge footings will extend 3 feet below the proposed bed elevation. The scour depth calculated for this sediment gradation is 0.8 feet. Three feet of scour protection is designed for the riprap placement.

	Sediment Size (inches)		
	Ave	Max	Min
D16	0.5	1.3	1.0
D50	1.5	4.0	3.2
D84	3.8	10.0	8.0
D100	9.4	25.0	20.0

Figure 6 – Proposed sediment size for channel under bridge.

4 BRIDGE FOUNDATION DESIGN

The bridge foundation design uses concrete spread footings placed on top of a geotextile wrapped bearing mat. Both the footing and mat are protected from 100-year flood by installing a rock riprap revetment (2.5 feet thickness) along both slopes. The Riprap will withstand shear stress values up to 6 lbs/sq. ft. As noted in the scour analysis the predicted shear stress is 0.3

lbs/ sq ft. The riprap will extend 3 feet below the design streambed elevation. The streambed under the bridge is designed to be stable at the 100-year flood due to the imported streambed size with an estimated maximum scour depth of 0.8 feet.

A geotechnical report was prepared by Aspect Consulting (Appendix D). The recommended maximum applied soil capacity was estimated at 2000 psf. They recommend 6 inches of crushed rock compacted over 2 feet of quarry spalls for the bridge footing foundation. The soil bearing calculations are provided in Figure 7.

Check bearing capacity of spread footing	
Pre-Cast Sill Width (ft)	**2.5**
Pre-Cast Sill Depth (ft)	**1.5**
Pre-Cast Sill Length (ft)	**16**
Pre-Cast Sill Weight (lb/sq ft):	**9000**
Crushed Rock	**63000**
Deadload (lbs):	**50000**
Liveload(lbs):	**90000**
Total Weight (lbs):	221000
Total Load per footing (lbs):	151000
Pre-Cast Sill Bearing Needed (lbs/sq ft):	3775
Rock Bearing Pad Width (ft):	**6**
Rock Bearing Pad Length (ft):	**18**
Bearing Pressure Below Rock Pad (lbs/sq ft)	**1398**
Factor of Safety	**2.7**
Allowable soil pressure:	**2000**
Factor of Safety for Soil	**1.4**

Figure 7 – Soil Bearing Calculations.

5 BRIDGE STRUCTURAL DESIGN

The bridge will be provided by Big R Manufacturing or other bridge vendor. The design is a single lane steel bridge, 14-foot-wide with a span of 50 feet. The load rating is HL-93. The design uses weathering steel. The final driving surface will be crushed surfacing. Drawings and calculations will be provided once a bridge vendor is selected.

6 REFERENCES

Bates, Ken. 2003. *Design of Road Culverts for Fish Passage*. Washington State Department of Fish and Wildlife.

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, WA. http://wdfw.wa.gov/hab/ahg/culverts.htm

National Marine Fisheries Service (NMFS). 2008. *Anadromous Salmonid Passage Facility Design.*

U.S. Department of Transportation. 2012. Evaluating Scour at Bridges – Fifth Edition. Hydraulic Engineering Circular No. 18.

U.S. Department of Transportation. 2012. Stream Stability at Highway Structures – Fourth Edition. Hydraulic Engineering Circular No. 20.

APPENDIX A – CORRECTION ANALYSIS FORM (CAF)

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APPENDIX B – SITE PHOTOS

Photo 1 – View downstream of culvert outlet.


Photo 2 – View to the north of Motteler Road and house.


Photo 3 – View of paved road portion to the south.

APPENDIX C – HYDRAULIC MODEL

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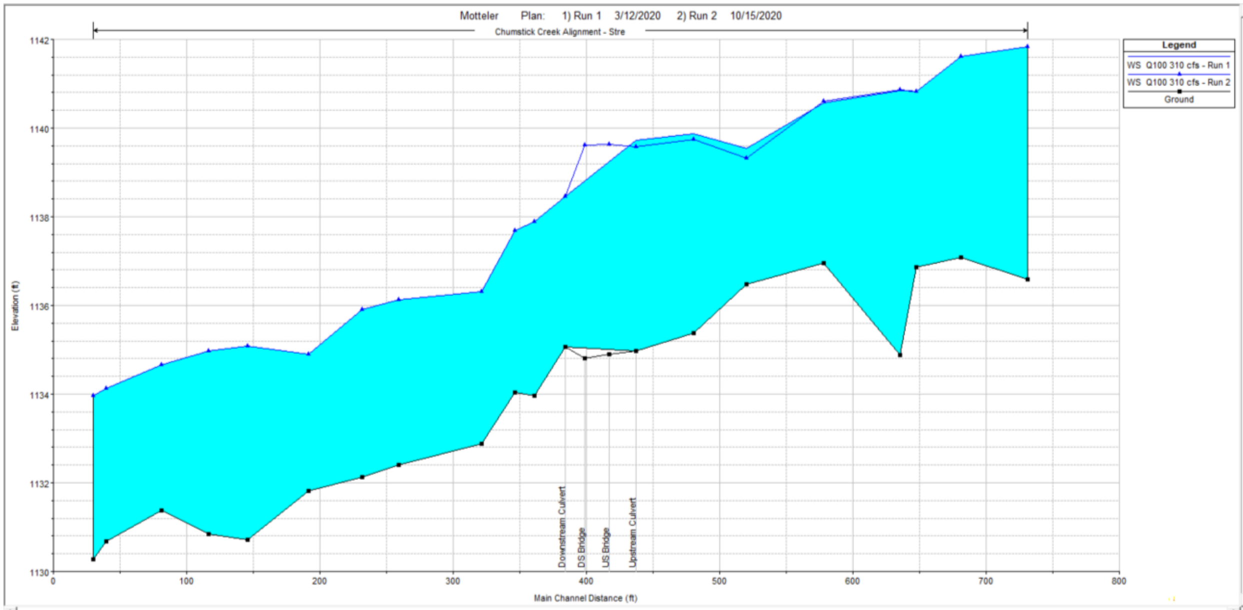

Figure 8 – HEC RAS 1D Water Surface Profiles for Chumstick Creek at Motteler Road. The bridge is located from STA 399 to STA 417. Run 1 is existing (without the undersized culvert) and Run 2 is proposed with the bridge.

Profile Output Table - Pat

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HEC-RAS Plan: Run 2 River: Chumstick Creek Reach: Alignment - Stre Profile: Q100 310 cfs

Reach	River Sta	Profile	Q Total (cfs)	W.S. Elev (ft)	Min Ch El (ft)	Max Chl Dpth (ft)	Vel Chnl (ft/s)	Top Width (ft)	Shear Total (lb/sq ft)	Froude # Chl
Alignment - Stre	30	Q100 310 cfs	310	1134.0	1130.3	3.7	6.6	17	1.5	0.7
Alignment - Stre	39.51	Q100 310 cfs	310	1134.1	1130.7	3.5	6.4	21	1.2	0.7
Alignment - Stre	81.02	Q100 310 cfs	310	1134.7	1131.4	3.3	5.3	25	0.8	0.6
Alignment - Stre	116.72	Q100 310 cfs	310	1135.0	1130.8	4.1	4.4	36	0.4	0.4
Alignment - Stre	145.5	Q100 310 cfs	310	1135.1	1130.7	4.4	4.4	43	0.4	0.4
Alignment - Stre	191.49	Q100 310 cfs	310	1134.9	1131.8	3.1	7.9	18	1.9	0.8
Alignment - Stre	231.86	Q100 310 cfs	310	1135.9	1132.1	3.8	4.2	31	0.5	0.4
Alignment - Stre	259.45	Q100 310 cfs	310	1136.1	1132.4	3.7	3.0	33	0.3	0.3
Alignment - Stre	321.08	Q100 310 cfs	310	1136.3	1132.9	3.4	8.0	20	2.3	1.0
Alignment - Stre	346.49	Q100 310 cfs	310	1137.7	1134.0	3.7	7.8	34	1.2	0.8
Alignment - Stre	360.92	Q100 310 cfs	310	1137.9	1134.0	3.9	7.0	25	1.0	0.7
Alignment - Stre	384.39	Q100 310 cfs	310	1138.5	1135.1	3.4	8.6	16	2.7	1.0
Alignment - Stre	399	Q100 310 cfs	310	1139.6	1134.8	4.8	2.8	34	0.2	0.3
Alignment - Stre	417	Q100 310 cfs	310	1139.6	1134.9	4.7	2.9	33	0.3	0.3
Alignment - Stre	436.9	Q100 310 cfs	310	1139.6	1135.0	4.6	4.1	26	0.4	0.4
Alignment - Stre	480.19	Q100 310 cfs	310	1139.7	1135.4	4.4	3.7	36	0.3	0.4
Alignment - Stre	520.08	Q100 310 cfs	310	1139.3	1136.5	2.8	8.4	19	2.1	1.0
Alignment - Stre	577.84	Q100 310 cfs	310	1140.6	1137.0	3.7	4.7	81	0.2	0.5
Alignment - Stre	635.37	Q100 310 cfs	310	1140.9	1134.9	6.0	3.8	35	0.3	0.3
Alignment - Stre	647.32	Q100 310 cfs	310	1140.8	1136.9	4.0	7.7	34	1.1	0.8
Alignment - Stre	680.84	Q100 310 cfs	310	1141.6	1137.1	4.5	4.5	52	0.4	0.5
Alignment - Stre	731.18	Q100 310 cfs	310	1141.8	1136.6	5.3	3.4	49	0.2	0.3

Figure 9 – HEC RAS 1D Model Hydraulic Output Data for the 100-year flood. Red box are the sections under the bridge.

APPENDIX D – GEOTECHNICAL REPORT