MILL CREEK – SPOKANE TO PARK

PROJECT # 19-1614

BASIS OF DESIGN REPORT

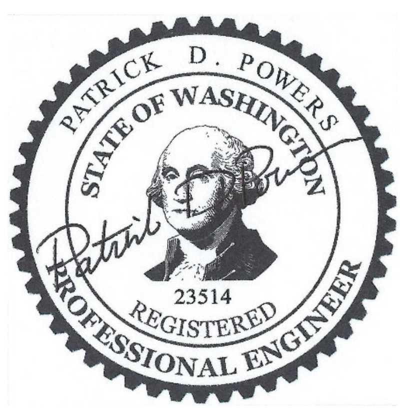
Prepared for

TSS

Prepared by

Waterfall Engineering

March 2022



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1 INTRODUCTION

This phase of the Mill Creek Fish Passage Project Extends from Spokane Street to Park Street (1344 feet). Just downstream of Spokane Street fish passage work was completed in 2013 and upstream of Park Street in 2019. This work will tie together a very long 4000 + reach in Mill Creek. At the downstream end the project starts at STA 51+00 which is a Reach Type 7 Section with a high center wall and flat overbanks (see Table 1). The purpose of the center wall is to guide flood flows around several bends in the channel without overtopping the right bank wall (super elevation). This reach type ends at STA 55+28. Then there is a 114-foot section without a center wall where the overbank slopes transition from flat to sloping (Reach Type 9). Continuing upstream the channel has bends so the center wall is included but the overbank slopes are now sloping to match the upstream portion of Reach Type 9. This section continues for 500 feet and then the center wall ends and there is 304 feet of Reach Type 3 Channel. This portion connects to work completed in 2019 just upstream of Park Street.

Reach Type	Length (ft)	Overbank Type	Status
6	360	Flat	Completed 2013 – Colville to Spokane
7	**428**	**Flat**	**Proposed Correction**
9	**114**	**Varies**	**Proposed Correction**
7	**500**	**Sloping**	**Proposed Correction**
3	**304**	**Sloping**	**Proposed Correction**
3	921	Sloping	Complete 2019 US Park Street

Table 1 – Summary of Reach Types and Lengths from Spokane to Park Street.

The proposed work crosses under four streets (Spokane, Palouse, Marcus, and Park). Marcus Street is just a foot bridge. The only bridge which has a space problem (for maintenance vehicles) is Park Street. To place the roughness panels the left overbank needs to be lowered (similar to work already completed at Clinton and Division Street.

2 PROPOSED DESIGN

The design for fish passage will be a continuation of previous work with baffles, roughness panels and resting pools. The fish passage route will remain on the left bank. This presents some special design challenges as the center wall takes up space (width) in the channel and in some areas, there is limited room for the fish passage portion and the minimum nine feet needed for Walla Walla County maintenance vehicles (Figure 1). In addition, for the Reach Type 7 Flat Overbank Section there is a 3-foot concrete footing which extends out from the wall. To account for this in areas with limited width two adjustments will be made to the typical design; 1) the roughness panels will extend into the trench portion (2.25 feet), as opposed to being aligned along the trench wall, and 2) portions of the footing wall will be cut back and reinforced concrete added to replace the portion removed.

For the Park Street Bridge, the left overbank will be lowered 1.5 feet to create a 9-foot-wide path for trucks with a minimum 7-foot vertical clearance.

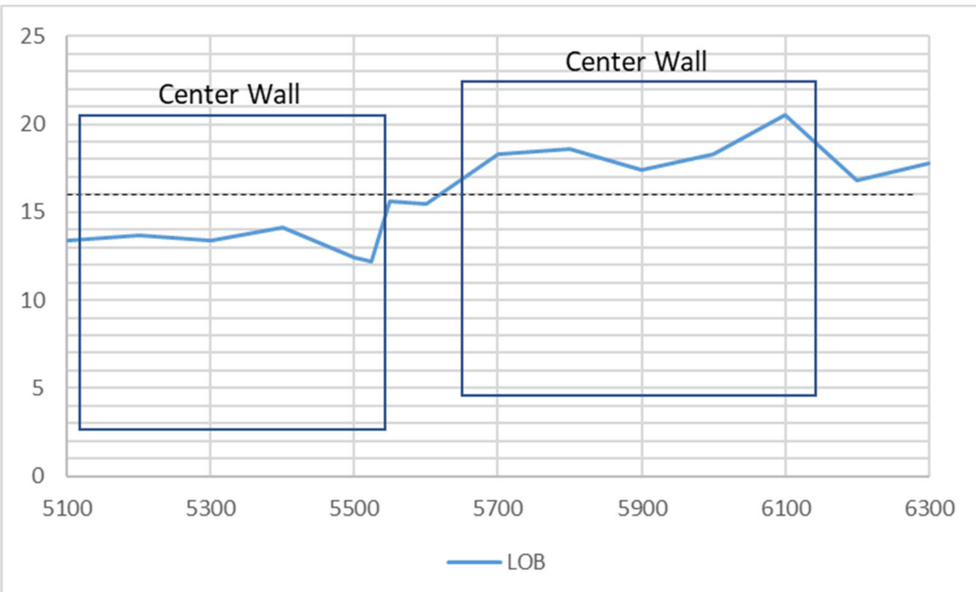

Figure 1 – Left over bank width. 16 feet is needed to provide space for the roughness panels and the 9-foot width for maintenance vehicles.

3 HYDRAULIC MODELING

A HEC RAS 1D model was created to analyze the existing and proposed conditions. The model has two split channels within the geometry to account for the center walls. The super elevation for flood flows will be modeled separately per past projects in the final design. The purpose of the model is to calculate fish passage velocities at the design flows and then to check for a no rise flood flow analysis. Resting pools are spaced based on providing passage for Bull Trout at 194 cfs.

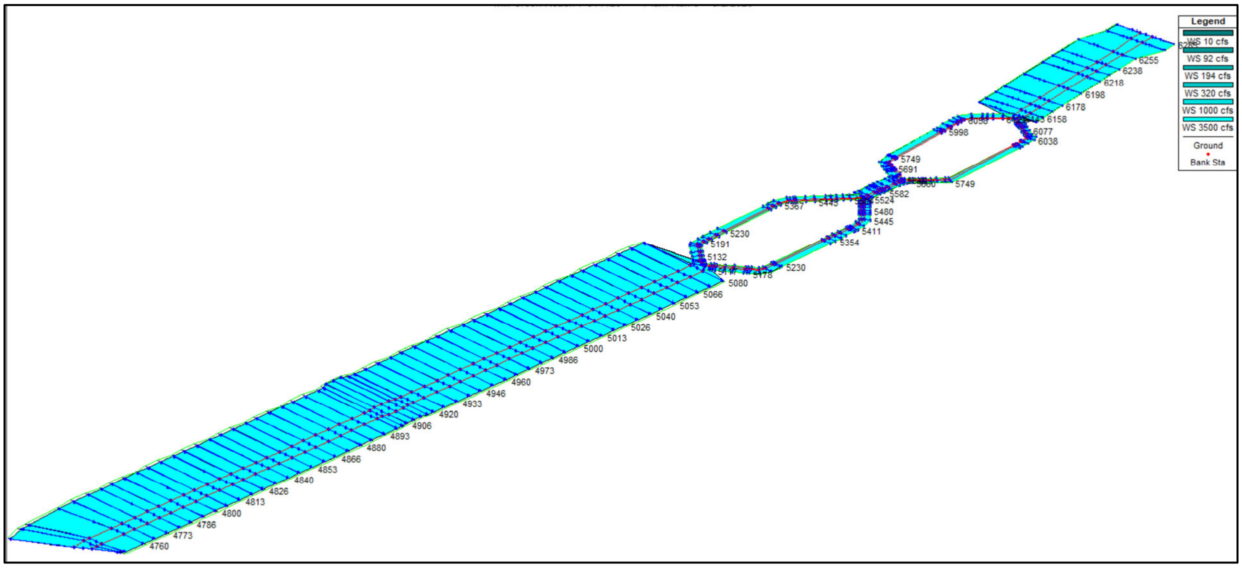

Figure 2 – HEC RAS 1D Model showing split channels.

For the baseline condition the HEC RAS model predicted velocities in the Reach Type 7 segments were lower than predicted (in the 3 to 4 fps range). Velocities were measured in the field at 142 cfs, and they ranged from 4 to 8 fps. The Manning's n roughness values were decreased by 25 percent to get the measured versus modeled values closer. This 25 percent reduction was also then added to the proposed trench n values. Manning's n values were adjusted based on data from the Physical Study (see Figure 3). The flow distribution on each side of the center walls was verified by field measurements at 142 cfs. It was determined by velocity measurements and flow calculations that the location of the center wall (center of channel) splits the flow 50/50.

At low flows 10 cfs to 60 cfs, the water depth is shallow enough relative to the baffle height that the baffles control the flow and velocities are quite low (1.5 to 2.5 fps). At 92 cfs, the baffle effectiveness is reduced, and velocities increase ranging from 5 to 7 fps (existing), and 2.5 to 3 fps in the roughened channel portion (proposed), Figure 4. At 194 cfs, velocities are 6 to 8 fps (existing) and 3 to 4 fps in the roughened channel (proposed), Figure 5. It is important to note that these are average velocities in the roughened channel portion and that (higher and lower) velocities exist throughout the roughened channel area. Especially down near the roughness elements, where velocities have been documented to be less than 1 fps. At 320 cfs the channel velocities range from 7 to 9 fps (existing) and 3.5 to 4 fps in the roughened channel portion, Figure 6. Fish energetics were calculated for 92, 194 and 320 cfs for the species and life stages identified in the original design criteria and based on the results resting pool spacing determined.

The design was then checked for the 100-year flood (3500 cfs) for a no-rise analysis. The resulting graph is shown in Figure 7.

Existing				
Reach Type 6				
Flow\Sta	-24	-11.5	-4.5	4.5
10	0.017	0.072	0.062	0.017
92	0.017	0.062	0.052	0.017
194	0.018	0.052	0.048	0.018
320	0.016	0.043	0.048	0.016
1000	0.026	0.026	0.026	0.026
3500	0.025	0.025	0.025	0.025
Reach Type 7L Flat				
Flow\Sta	-20.7	-7.5	-3	
5	0.017	0.052	0.017	
46	0.017	0.046	0.017	
97	0.018	0.038	0.018	
160	0.016	0.032	0.016	
500	0.026	0.026	0.026	
1750	0.024	0.024	0.024	
Above green values changed to the below (25%)				
		0.034		
		0.029		
		0.024		
Reach Type 9				
Flow\Sta	-25	-4.5	4.5	
5	0.017	0.052	0.017	
46	0.022	0.044	0.018	
97	0.023	0.033	0.022	
160	0.017	0.027	0.02	
500	0.016	0.03	0.016	
1750	0.012	0.016	0.018	
Reach Type 7L Trap				
Flow\Sta	-21.8	-4.5	0	
5	0.017	0.052	0.017	
46	0.017	0.034	0.017	
97	0.018	0.029	0.018	
160	0.016	0.024	0.016	
500	0.026	0.026	0.026	
1750	0.024	0.024	0.024	
Reach Type 3 US Existing				
Flow\Sta	-21.7	-4.5	4.5	
10	0.017	0.052	0.017	
92	0.022	0.044	0.018	
194	0.023	0.033	0.022	
320	0.017	0.027	0.02	
1000	0.017	0.02	0.018	
3500	0.015	0.015	0.015	

Proposed				
Reach Type 6				
Flow\Sta	-24	-11.5	-4.5	4.5
10	0.017	0.072	0.062	0.017
92	0.017	0.062	0.052	0.017
194	0.018	0.052	0.048	0.018
320	0.016	0.043	0.048	0.016
1000	0.026	0.026	0.026	0.026
3500	0.025	0.025	0.025	0.025
Reach Type 7L Flat				
Flow\Sta	-20.7	-9.8	-5.3	-3
5	0.017	0.072	0.062	0.017
46	0.017	0.062	0.052	0.017
97	0.018	0.052	0.048	0.018
160	0.016	0.043	0.048	0.016
500	0.026	0.026	0.026	0.026
1750	0.025	0.025	0.025	0.025
Above green values changed to the below (25%)				
			0.039	
			0.036	
			0.036	
Reach Type 9				
Flow\Sta	-20.7	-11.5	-4.5	4.5
10	0.017	0.072	0.062	0.017
92	0.018	0.062	0.052	0.018
194	0.015	0.052	0.048	0.015
320	0.016	0.044	0.047	0.016
1000	0.014	0.035	0.036	0.015
3500	0.014	0.022	0.026	0.014
Reach Type 7L Trap				
Flow\Sta	-21.8	-11.4	-4.5	
5	0.017	0.072	0.062	
46	0.018	0.062	0.039	
97	0.015	0.052	0.036	
160	0.016	0.044	0.035	
500	0.014	0.035	0.036	
1750	0.019	0.019	0.019	
Reach Type 3 US Proposed				
Flow\Sta	-21.7	-11.5	-4.5	
10	0.017	0.072	0.062	
92	0.018	0.062	0.052	
194	0.015	0.052	0.048	
320	0.016	0.044	0.047	
1000	0.014	0.035	0.036	
3500	0.019	0.019	0.019	

Figure 3 – Manning's n values used for the HEC RAS computations.

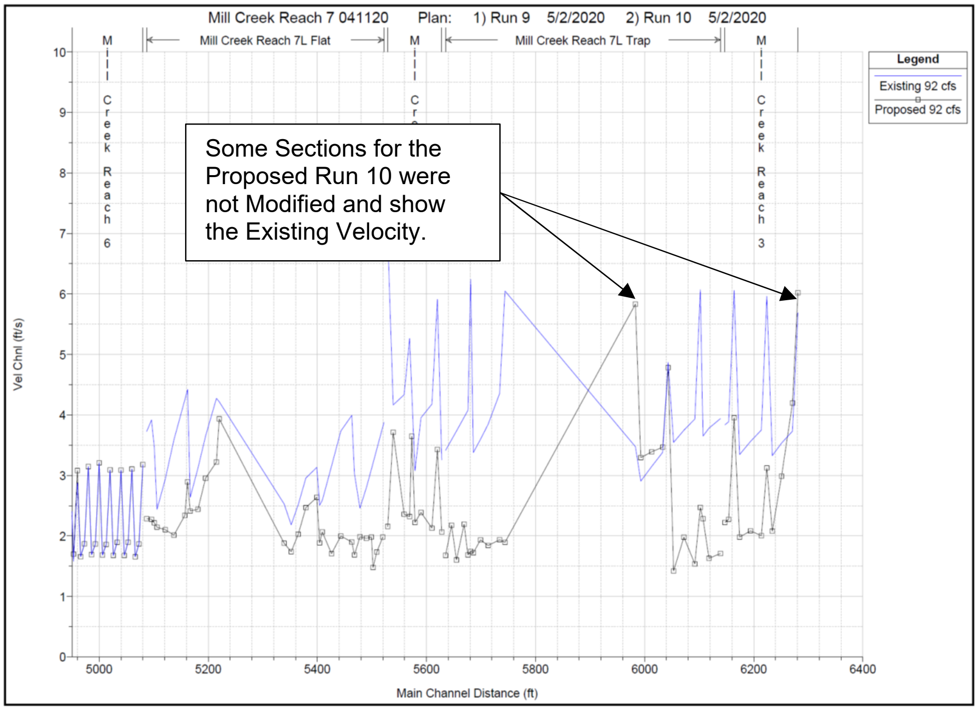

Figure 4 – Channel velocities at 92 cfs.

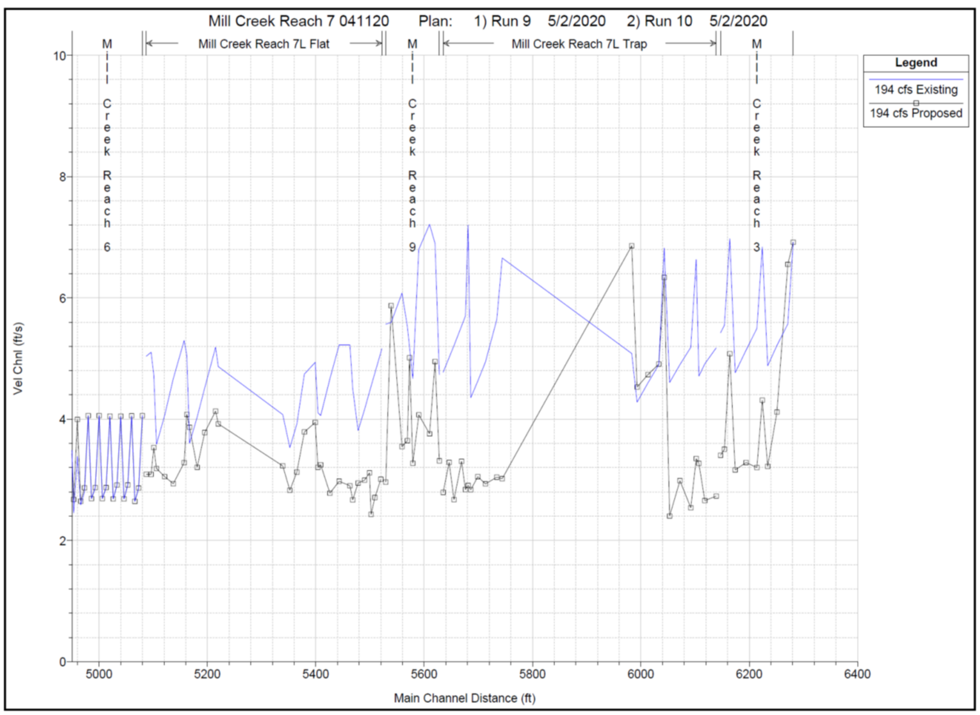

Figure 5 – Channel velocities at 194 cfs.

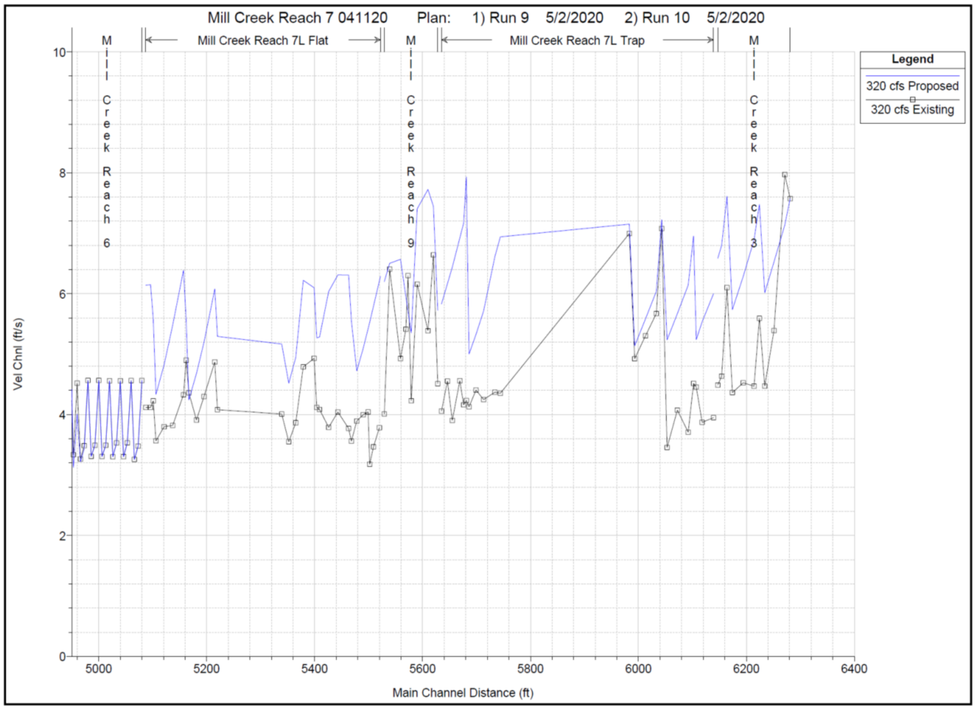

Figure 6 – 320 cfs channel velocities.

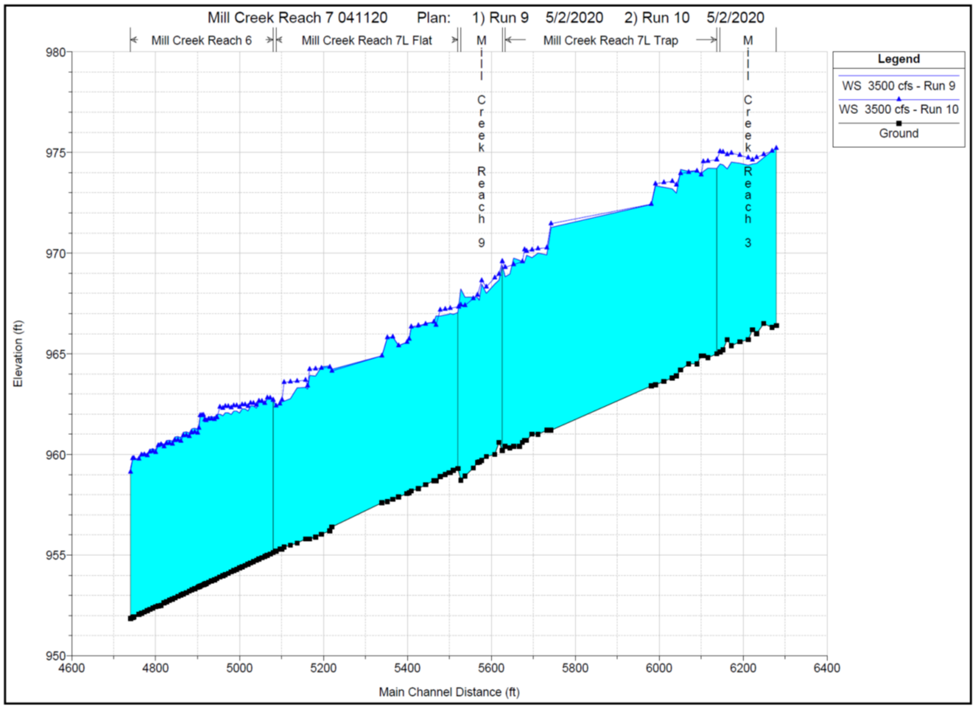

Figure 7 – Flood flow profile comparison (3500 cfs). Run 10 is existing and Run 9 is proposed.

4 COST ESTIMATE

This will be the fourth project constructed in Mill Creek of similar design. The cost estimates are based on actual costs and bids received and have been adjusted for inflation . The highest level of uncertainty involves two items, 1) construction access and staging and 2) pumping groundwater from the excavated areas, especially the pools. Each design has improved incrementally with regards to these two items. For this site, the potential for two access points and the development of an infiltration pond for sediment contaminated water is very encouraging. Coordination with landowners and the City will be required to further develop the details of this in the final design and bid documents. The estimated construction cost is $1,960,400 (Figure 9). This is a per foot project cost of $1446. Figure 8 shows the typical cost per foot from past projects.

						2022 Dollars	
Project	Year	Total Cost (taken from con	Contractor	Feet of construction	Cost Per Foot	Inflation 3%	Inflation at 7%
19-1613 Division to Roosevelt	2022	$ 1,876,865.36	Strider	1400	$ 1,340.62	$1,341	$1,341
19-1718 Park to Roosevelt	2021	$ 2,233,754.62	Strider	2200	$ 1,015.34	$1,045	$1,086
17-1305 Park to Otis	2019	$ 788,286.81	Mountain State Construction Co.	921	$ 855.90	$935	$1,049
13-1387R 9th Ave Extension	2016	$ 719,997.80	Royse Hydroseeding	1000	$ 720.00	$860	$1,080
11-1587 Spokane to Colville Street	2013	$243,698.60	Mountain State Construction Co.	350	$ 696.28	$909	$1,280
There was no groundwater to deal with, bone dry					Average	$937	$1,124
Groundwater was a problem					% increase	30%	16%
Only one access point							

Figure 8 – Construction costs per foot for projects from 2013 to 2022.

Mill Creek Passage - Spokane to Park Street - Cost Estimate									
Date:	3/21/2022								
By:	Waterfall								
Design Level:	Final								
Total Project Length (ft):	1356								
Resting Pools:	17								
Length w/o Resting Pools:	1152								
Roughness Panels:	116								
Baffles (7')	24								
Baffles (3')	46								
Bridge Ramps	1	Under Park							
Description	**Unit**	**CAD Quantity**	**t (in)**	**Mult**	**Bid Quantity**	**Cost**	**Amount**	**Sub Total**	***Comments***
Mob, Access and Water Management								$394,200	
Mobilization	L.S.	1		1	1	$144,000	$144,000		*Average 11% of construction costs minus panels*
Access to Flume	L.S.	1		1	1	$80,000	$80,000		
Sumps Pumps	L.S.	10		1	10	$3,000	$30,000		
Sediment Control	L.S.	1		1	1	$18,000	$18,000		
Site Restoration	L.S.	1		1	1	$15,000	$15,000		
Diversion Dam and Pipe	L.S.	670		1	670	$160	$107,200		
Concrete Demolition								$121,543	
Concrete Cutting: Slab and Wall	L.F.	2749		1	2749	$15.00	$41,235		
Concrete Cutting: 6' Baffles	ea.	7		1	7	$126.00	$882		
Concrete Cutting: 3' Baffles	ea.	10		1	10	$126.00	$1,260		
Concrete Removal	C.Y.	418		1.1	460	$170.00	$78,166		
Reinforced Concrete Form and Pour								$1,120,844	
Excavation and Disposal	C.Y.	721		1.1	793	$65.00	$51,552		
Gravel Backfill	C.Y.	117		1.2	141	$110.00	$15,504		
Roughness Panels (Form and Pour)	ea.	116		1	116	$3,100.00	$359,600		*Latest Cost from Narum*
Install Roughness Panels	ea.	116		1	116	$600.00	$69,600		
Install Roughness Elements	ea.	22		1	22	$150.00	$3,300		
CIP Concrete Total Amount	C.Y.	325		1.1	357	$1,700.00	$607,593		
Enclosure Curbs/Perpend. To Flow	C.Y.	10.5							
Enclosure Curbs/Parallel To Flow: Sloping	C.Y.	93.8							
Enclosure Curbs/Parallel To Flow: Flat	C.Y.	34.2							
7' Baffles	C.Y.	4.3							
3' Baffles	C.Y.	3.5							
Misc. Shapes	C.Y.	1.4							
Wall Footing Reshape	C.Y.	22.4							
Park Street	C.Y.	44.0							
Resting Pools	C.Y.	110.9							
Gravel Backfill for Drains	C.Y.	20		1.2	24	$65.00	$1,560		
Drain Pipe	L.F.	1000		1	1000	$3.21	$3,210		
Habitat Boulders	L.S.	51.0		1	51	$175.00	$8,925		
Construction Subtotal								$1,636,587	
Contingency	10%							$163,659	
Sales Tax	8.9%							$160,200	
Construction Total								$1,960,400	
Construction Management	8.0%							$156,800	
Insurnace								$20,000	
Project Total								$2,137,200	

Opinions of Probable Construction Cost

In providing opinions of probable construction cost, the Client understands that the Consultant (Chinook Engineering) has no control over the cost or availability of labor, equipment or materials, or over market condition or the Contractor's method of pricing, and the consultant's opinions of probable construction costs are made on the basis of the Consultant's professional judgment and experience. The Consultant makes no warranty, express of implied that the bids or the negotiated cost of the Work will not vary from the Consultant's opinion of probable construction cost.

Figure 9 – Construction Cost Estimate.

5 REFERENCES

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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

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P. Powers, B. Burns, K. Bates, J. Kidder. *Mill Creek Fish Passage Assessment.* Walla Walla, WA: Tri State Steelheaders Fisheries Enhancement Group, 2009.

Powers, P. *Mill Creek Fish Passage Conceptual Design Final Report.* Walla Walla: Tri State Steelheaders, 2010.

P. Powers, K. Kidder. *Mill Creek Fish Passage – N 9th Avenue Extension – Basis of Design Report. Appendix B.* Walla Walla: Tri State Steelheaders, 2014.

APPENDIX A – SITE PHOTOS

Photo 1 – Downstream end of project showing center wall and concrete footings just upstream of Spokane Street.

Photo 2 – View upstream from Colville Street with Spokane Street in background. This work completed in 2013.

Photo 3 – View upstream in Reach Type 7 with flat overbank showing 4.5-foot-wide trench and 3.5-foot-long baffle.

Photo 4 – View upstream of Reach Type 7 center wall with sloping overbanks and Engineer Jay Kidder of Chinook Engineering.

Photo 5 – View downstream of Reach Type 7 with sloping overbanks showing upstream end of wall and debris line. The foot bridge in the background is Marcus Street.


Photo 6 – 3500 cfs View of center wall with Marcus Street Footbridge in background.

Photo 7 – 3500 cfs flow view upstream towards Park Street.

APPENDIX B – ROUGHNESS PANEL DESIGN VALIDATION

This section presents data collected to validate the new roughness panels used for construction in 2021 on the reach from Otis Street to Division Street. They included making the fish resting pockets smaller and adding two new roughness elements in an area to even out the roughness (Photo 8

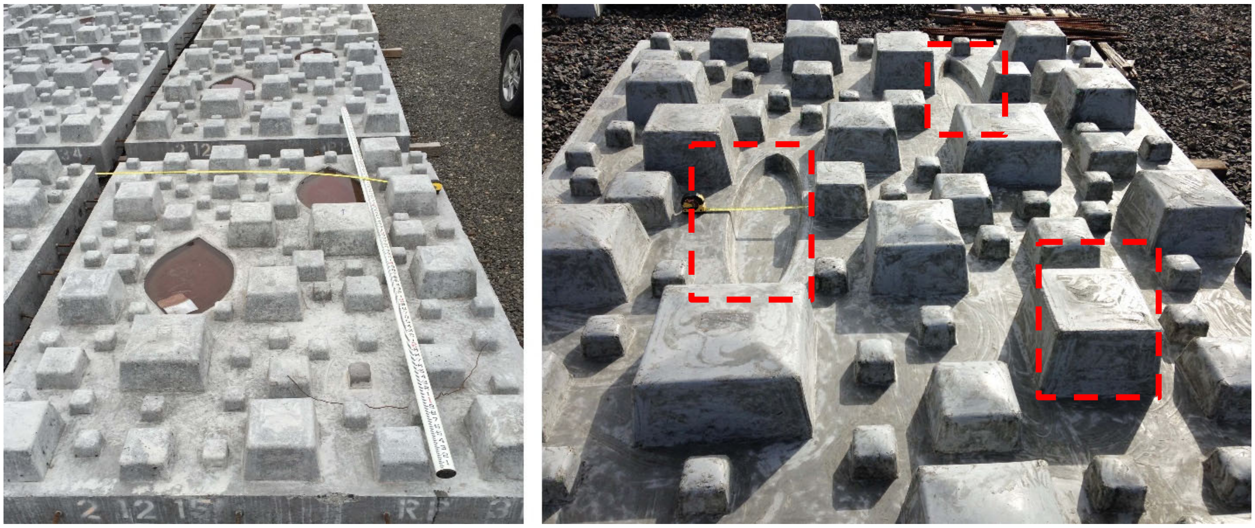


Photo 8 – Modified roughness panels. The left is the old panel, and the right is the new panel. Red dashed boxes denote area of changes.

Hydraulic data (depth and velocity) was collected on March 24, 2022. The stream flow varied from 216 to 234 cfs. Measurements were made to verify the vertical and horizontal velocity profiles within in the panels and resting pools.

<u>Horizontal Velocity Distribution</u>

The roughness panels are placed on a 5:1 slope. The height of the roughness elements varies from 2.5 to 6.5 inches. The water velocity along the panel is a function of water depth. Where the depth is two feet (4 x the roughness element height), the velocities are high as opposed to locations where the depth is two times the roughness panel height velocities are much lower. The average velocity at 220 cfs was 3.0 fps in the upper portion of the roughness panel and 4.2 fps in the lower portion of the panel. The upper and lower sections are defined at a depth of 1.5 feet. Overall, the average velocity for the entire panel was 3.6 fps. If the data for the sections under Merriam and Otis Street are removed, the average velocity in the upper roughness panel section is 2.6 fps. The average velocity from the model study was 3.6 fps at 194 cfs. So, in summary the roughness panels are performing better than was modeled to reduce velocities.

220 cfs														
	Model Study 194 cfs					Merriam		Otis						
Depth	230	218		**7889**	**7901**	**7649**	**7669**	**7286**	**7321**	**7509**	**7523**		**Ave**	**Ave**
0.5		2.9												
0.7					1.4	3.3							**2.4**	
0.8	2.1	3									2.5		**2.5**	
0.9	2.6			2.3	3.1	2.6			3.7				**2.9**	
1	3.1	3.9												
1.1	3.5			3.6			3.6			2.3			**3.2**	
1.2		3.9			2.7			2.3	4.4	3.4	3.9		**3.3**	
1.3	3.9													
1.4	3	5.7				4.6	3.8	3.7	3.5				**3.9**	
1.5	2.8	4		2.3							2.8		**2.6**	**3.0**
1.6					3.4								**3.4**	
1.7	4.2									3.2			**3.2**	
1.8		5.9		4.3									**4.3**	
1.9	4.2				4.4		5.1	4.7		5.3			**4.9**	
2	4.3										4.4		**4.4**	
2.2				4.8									**4.8**	**4.2**
Average	3.4	4.4	**3.9**	3.5	3.0	3.5	4.2	3.6	3.9	3.6	3.4	Ave	**3.6**	

Table 2 – Velocity data (fps) at different depths. Average velocity in the upper zone (depths 0.5 to 1.5 feet) of the roughness panel was 3.0 fps, and 4.2 fps in the lower zone (depth 1.5 to 2.2 feet).

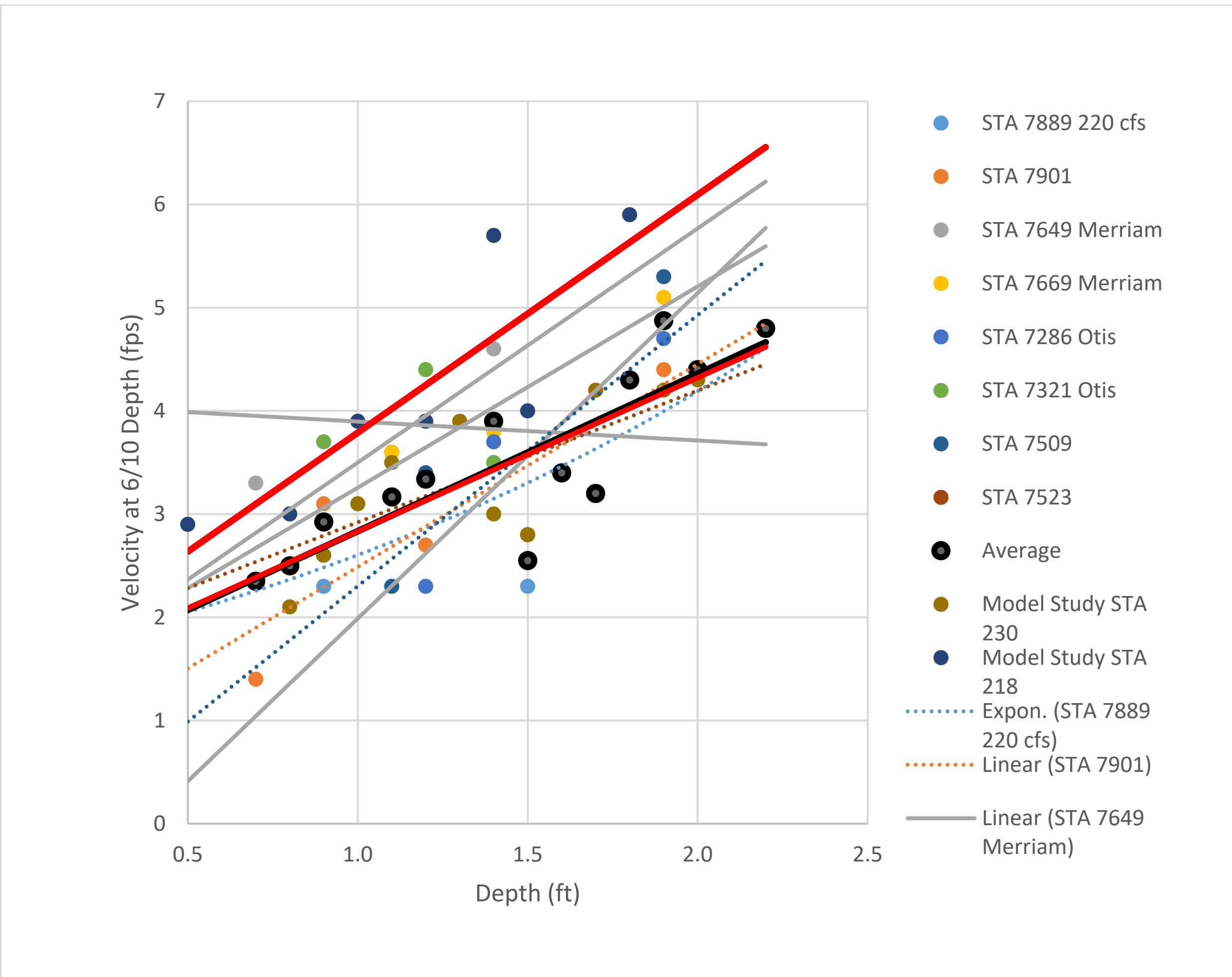


Figure 10 – Plot of velocity data from the eight sections in Table 2. The red lines are data from the original model study, black line is the average (difficult to see next to lower red line), and the dotted lines are the section taken under the Merriam and Otis Bridges.

Photo 9 – View downstream of the Merriam Bridge. Unlike the typical Reach Type 3 Channel the left overbank (truck path) is submerged and carries a lot of water which reduces the effectiveness of the boundary layer. On average the velocities in the roughness panel are 0.5 fps higher than sections with no overflow.

Photo 10 – View upstream showing roughness panel boundary layer. The velocity varies +- 0.3 fps parallel to the flow due to the standing waves which form every 15 to 20 feet from the baffles across the channel.

Vertical Velocity Distribution

The vertical variation is velocity near the bottom to the top water surface was also measured. Measurements made on the older panels showed a slight increase in velocity in the fish resting pockets, but the modifications appear to have eliminated this. The data shows that if fish swim near the top of the roughness elements or slightly below, the velocity can be less than the 3.6 fps average reported from the horizontal distributions. Downstream and below the roughness elements the velocities are less than 2 fps. This may be useful for small fish.

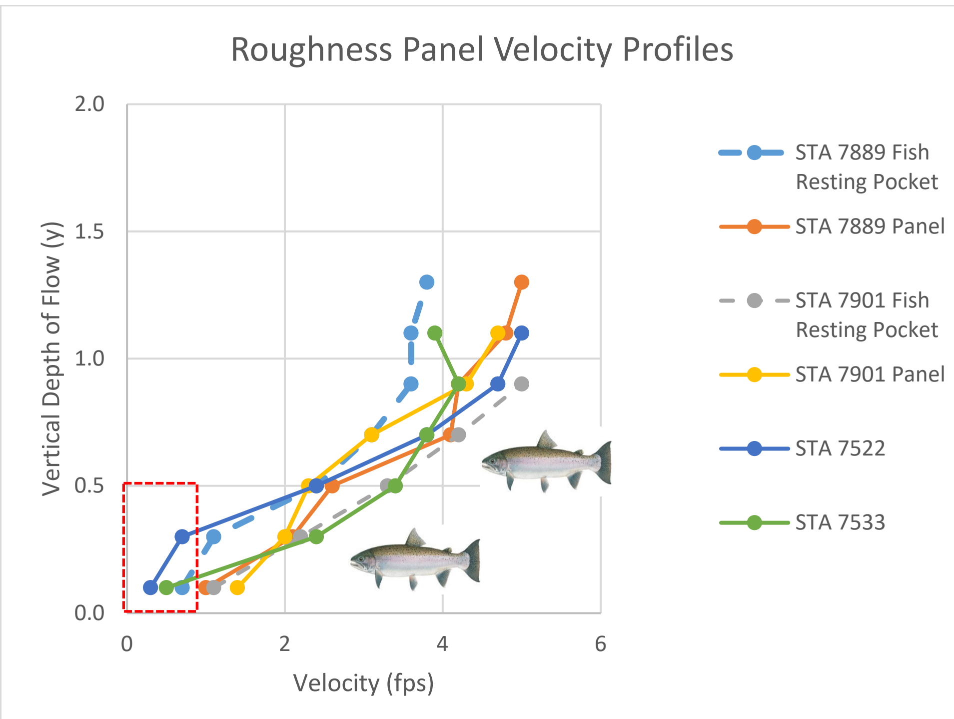
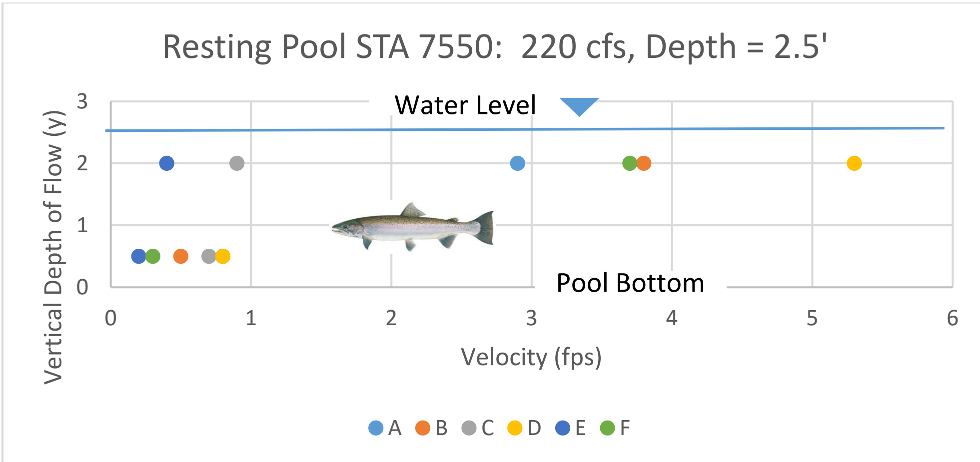


Figure 11 – Vertical variation in velocity. Dashed lines are measurements in the fish resting pockets.

Resting Pool Velocities

Depth and velocities were measured at two resting pools. The resting pool shape and size has not changed, and the results are similar to past measurements. In all points measured (A,B,C,D,E,F) the velocities near the bottom were less than 1 fps. Near the surface at points A and C the velocities are near 1 fps. In general, the resting pools are highly effective at providing low velocity resting areas at 220 cfs for approximately 75 percent of the pool volume.

Photo 11 –Resting Pool 5 just downstream of Merriam Street. Velocities on the left side of the photo are 6 to 8 fps, but only 1 to 2 fps in the pool.



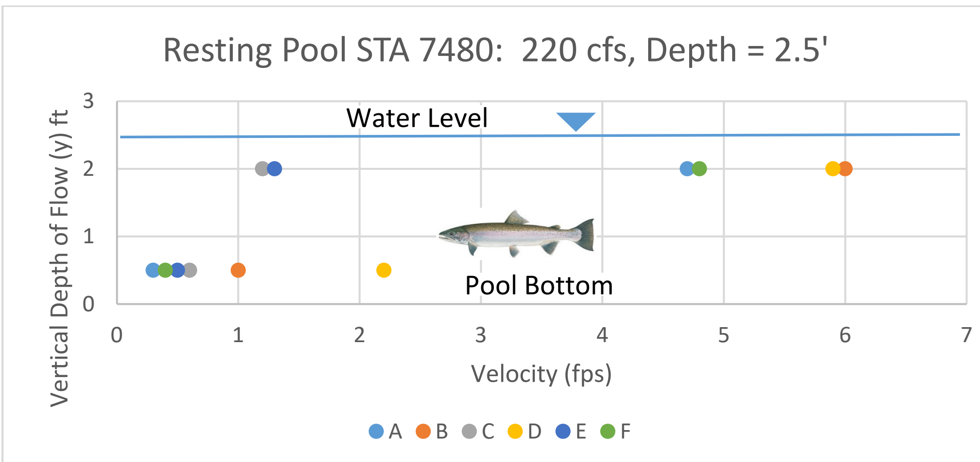


Figure 12 – Velocities in the resting pools at 220 cfs.