Race Lagoon Tributaries Crossing Race Road

Fish Passage Culvert Replacement for Culverts 1893 and 1894; RCO 22-1089

Basis of Design, Hydraulics, HECRAS Analysis Report

Preliminary Design

8-30-2024

Prepared by

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CHINOOK ENGINEERING

The technical material and data contained in this report were prepared under the supervision and direction of the undersigned, whose seal as a professional engineer licensed to practice as such in the State of Washington, are affixed below.

4-15-2024

Jay S. Kidder, P. E.

Civil Engineer

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1. Introduction

Purpose of the Basis of Design Report

This Basis of Design Report, BOD Report, is prepared and revised to set the goals for the restoration of fish passage at the subject site. It presents fish passage solutions for the Race Lagoon Road Crossings.

Purpose of the BOD Report: The BOD Report serves as a critical document that outlines the foundational principles and objectives for the restoration of fish passage at the project site. It essentially sets the goals and guidelines for the entire project.

Development Phases: The BOD Report is prepared and revised at several key phases of the project, including the 30% and 60% design completion phase. At the 60% design completion phase, the report presents final solutions for addressing the road crossing fish passage issue, which is the key aspect of ensuring fish passage.

Iterative Nature: The report is described as "iterative," meaning that it evolves and is updated throughout the project's lifecycle. This is because, as the project progresses through different phases like Preliminary Design, Final Design, and As Built Record, new information becomes available, and adjustments may be needed to achieve the project's goals effectively.

Preliminary Design: During the Preliminary Design phase, the report undergoes further refinement as more detailed information is gathered and analyzed for the preferred solution. This phase often involves the development of more concrete plans and specifications.

Final Design: In the Final Design phase, the report is finalized with specific engineering details, construction plans, and materials specified. It ensures that the project is ready for implementation.

As Built Record: After the project is constructed, the BOD Report continues to be relevant during the As Built Record phase. Any changes or variations from the original design are documented here, providing a historical record of what was actually built.

In summary, the BOD Report is a dynamic and essential document that guides the restoration of fish passage at the project site. It outlines project goals, presents various design concepts, and evolves through multiple phases of the project, from initial planning to final construction, to ensure that the objectives are met effectively and that changes are documented for future reference.

This basis of design report has been revised to the Preliminary Design submittal phase.

Project Goals

The Skagit Fisheries Enhancement Group and Island County Public Works are working to replace two fish barrier culverts, culvert 1893 and 1894, under Race Road near Coupeville, WA and remove a private crossing immediately downstream of Culvert #1894.

Removal of these fish passage barriers will open critical rearing habitat for juvenile salmonids including ESA-listed Threatened Chinook as well as pink, coho, and chum salmon. These two coastal streams drain to Race Lagoon which has been identified as important pocket estuary habitat for out-migrating salmon from the Skagit, Stillaguamish, and Snohomish Rivers. Pocket estuaries and small coastal streams such as these provide important feeding, resting, and refuge habitat as juvenile salmon transition from freshwater to saltwater habitat.

These culverts were identified during the Culvert Prioritization Inventory conducted by SFEG and Island County during which time a Chinook smolt was found in the stream above culvert #1893 in the February 2020 field season. In addition, SFEG has been working with local landowners who are open to additional wetland and riparian restoration upstream of these culverts as a future project. This grant would fund the design of two fish passable structures at culverts 1893 and 1894. Fish passage barrier removal is one of the most rapid and cost-effective ways of increasing the amount of accessible habitat for salmon. In addition, the small private culvert crossing is recommended to be removed and the stream restored at that location. An alternative access from the private property adjacent to Race Road will be proposed for construction.

Excerpted from project goals on PRISM.

Site Description

The site is located on the eastern side of Whidbey Island in Island County, Washington. Race Road travels across two small ephemeral tributaries to Race Lagoon adjacent to Saratoga Passage in the Salish Sea. The pocket lagoon has been identified as a primary location for refuge and rearing habitat for Chinook salmon.

Race Road at this site runs east and west. The 2 culverts are approximately 500 feet apart from each other and are oriented in opposite skewed orientations to Race Road.

Each culvert is a corroded corrugated metal pipe formed from galvanized steel. The West culvert, 1893, is deformed and approximately 36 inches in diameter. The east culvert, 1894, is corroded and 18 inches in diameter.

Both culverts are partial barriers to fish passage. A small amount of bed material is present in both culverts.

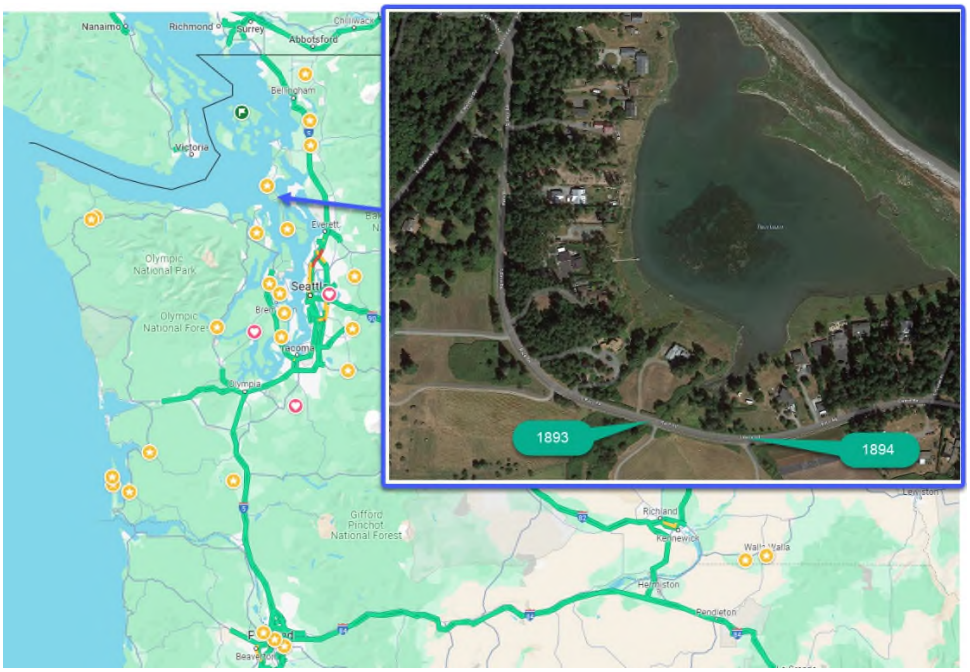


Figure 1 Vicinity map showing Washington State, Salish Sea, and Whidbey Island. Race Lagoon and Race Road located on the East side of the island adjacent to Saratoga Passage.

Figure 2 Race Lagoon estuary below Culvert West 1893.

Figure 3 The inlet of the Eastern culvert looking downstream.

Skagit Fish Enhancement Group; Race Lagoon Passage - Culverts #1893 & 1894 (#22-1089)

Attachment #500186, 1893 US inlet.jpg

Figure 4 The inlet of the Western culvert looking downstream.

Figure 5 The outlet of the Western culvert.

2. Hydrology and Hydraulics

The initial design of the subject culverts is based on the Washington Department of Fish and Wildlife, WDFW, stream simulation conceptual geometry with a hydraulic design verification.

The BFW dimensions in this reach are as shown in the simple calculator following in the figure below which calculates a draft proposed culvert size or bridge span based on the stream width and using initially the Washington Department of Fish and Wildlife stream simulation and the side slopes beneath a bridge.

	Race Road 1894 East Smaller		Culvert Geometry					Bridge Geometry					
Site	Bankfull width Measurements, feet	Average Bankfull width	Culvert Stream Simulation Width	Additional Width Conditions for debris	Culvert Span Chosen	Use this Culvert Span		Depth to Cr invert from bot cord of bridge	Stream Bottom Width required	Side Slopes	Skew Angle	Span with no Skew	Bridge Span Length with Skew
US	6.5												
	6												
	5.5												
	10												
	12												
	12												
	13												
Up stream		9.3	13.1	1.5	14.6	14.6		5	12	2	0	32	32
DS	5												
	4												
	6												
	5	BFWc Grand Average	8.1	BFWc Grand Average Span Width			11.7						
	6			Climate Change Factor Adjusted Span			1.07	12.5					
	11												
	11												
Downstream													
		6.857142857	10.2	1.5	11.7	11.7		5	12	2	0	32	32

Figure 6 Preliminary width calculations for the east culvert.

Race Road 1893 West Larger			Culvert Geometry				Bridge					
Site	Bankfull width Measurements, feet	Average Bankfull width	Culvert Stream Simulation Width	Additional Width Conditions for debris	Culvert Span Chosen	Use this Culvert Span	Depth to Cr invert from bot cord of bridge	Stream Width required	Side Slopes	Skew Angle	Bridge Span with no Skew	Bridge Span Length with Skew
Up stream	6											
	7.5											
	10.5											
	15											
	14											
	14											
Up stream		11.2	15.4	1.5	16.9	16.9	3	7.5	2.5	0	22.5	23
	5											
	6											
	5.5											
	7	BFWc Grand Average	9.0		BFWc Grand Average	12.8						
	10.5		Climate Change Factor Adjusted Span			1.07	13.7					
Downstream												
		6.8	10.2	1.5	11.7	11.7	3	7.5	2.5	0	22.5	23

Figure 7 Preliminary width calculations for the West culvert.

Given the geometry proposed and including later described adjustments for climate change in the year 2080, the calculated culvert spans for the Eastern culvert and the Western culvert are 12.5 feet and 14 feet respectively.

Hydrology at the two stream crossings

The following section describes the hydrology of the subject reach and is based on the work by , Mastin, M.C., 2016, etal. for ungaged catchments in Washington using regression analysis. In addition , basin characteristics were delineated and reported using the USGS Streamstats on line software for that purpose, Version 4..

Due to unforeseen changes in the flow rates in the upper areas of the watershed upstream and required climate change scenarios from WDFW¸ the Washington Department of Fish and Wildlife document, WDFW, Incorporating Climate Change into the Design of Water Crossing Structures, 2016, the design flow rate value is calculated to be Q design with climate change 100 year event equal to Qd100cc East = 7.5 cfs and the Qd100 cc West = 14 cfs.

See the Hydrology section in the appendix for details.

Established Culvert Width

The USGS Stream Stats program referenced above estimates an average bankfull channel width of 8.0’ and 9’ respectively for the culverts, east and west, 1894 and 1893, (it notes that the parameters are outside of the suggested range and were extrapolated). These figures were confirmed in the field with WDFW personnel.

Then by using the WDFW Climate Change Model for channel width it recommends a 7% increase in channel width for the 2080 timeframe at the site which increases the width to 8.56 feet and 9.63 feet respectively for the two culverts. During preliminary design for WDFW stream simulation methods this will require a culvert span of approximately 12.5’ and 14’.

The culvert material has been chosen as a concrete box culvert. The concrete sections will contain keyways and weldments and be placed on a compacted subgrade of gravel, and the stream simulation streambed will be constructed within the upturned U shaped precast concrete sections, upon completion of the stream bed construction the concrete traffic lids will be placed on the top, and the road fill will be compacted around the structure. After that the road will be constructed and replaced with asphalt surfacing.

After the culvert sizing was completed with WDFW Stream Simulation methods, the sizes were checked for culvert size and stream bed design using the United States Forest Service Fish Crossing, known as FishXing. Output determined that the proposed culvert designs are 100% fish passable. This is presented in Appendix A.

Pebble Count at Site Reach

The following figure describes the pebble count sizing for the reachs at the two Race Lagoon tributary crossings. This pebble count describes the stream bed characteristics along a stream profile of approximately 600 lineal feet and was determined during the survey of the stream reach.

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	10	9.17	9.17
0.25 - 0.50	10	9.17	18.35
0.50 - 1.0	10	9.17	27.52
1.0 - 2.0	15	13.76	41.28
2.0 - 4.0	10	9.17	50.46
4.0 - 5.7	15	13.76	64.22
5.7 - 8.0	10	9.17	73.39
8.0 - 11.3	10	9.17	82.57
11.3 - 16.0	8	7.34	89.91
16.0 - 22.6	5	4.59	94.50
22.6 - 32.0	2	1.83	96.33
32 - 45	2	1.83	98.17
45 - 64	2	1.83	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

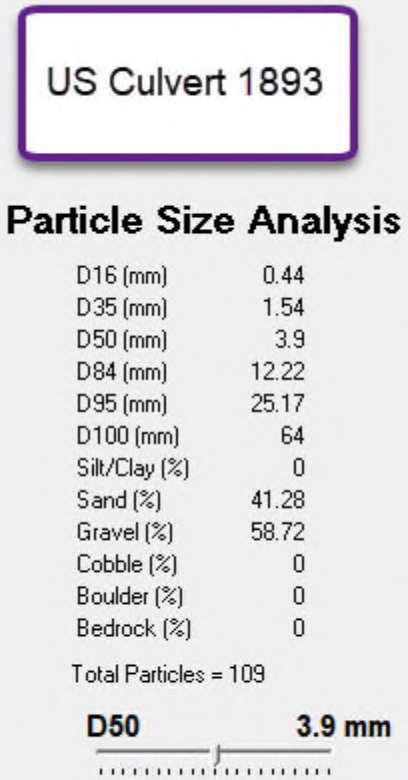


Figure 8 Race Lagoon Tributary 1893, pebble count data at the road crossing site showing the D5, D15, D84, D95 % finer diameters. This clearly shows a clayey silt base to the stream bed with fine gravel present locally in the riffle reaches.

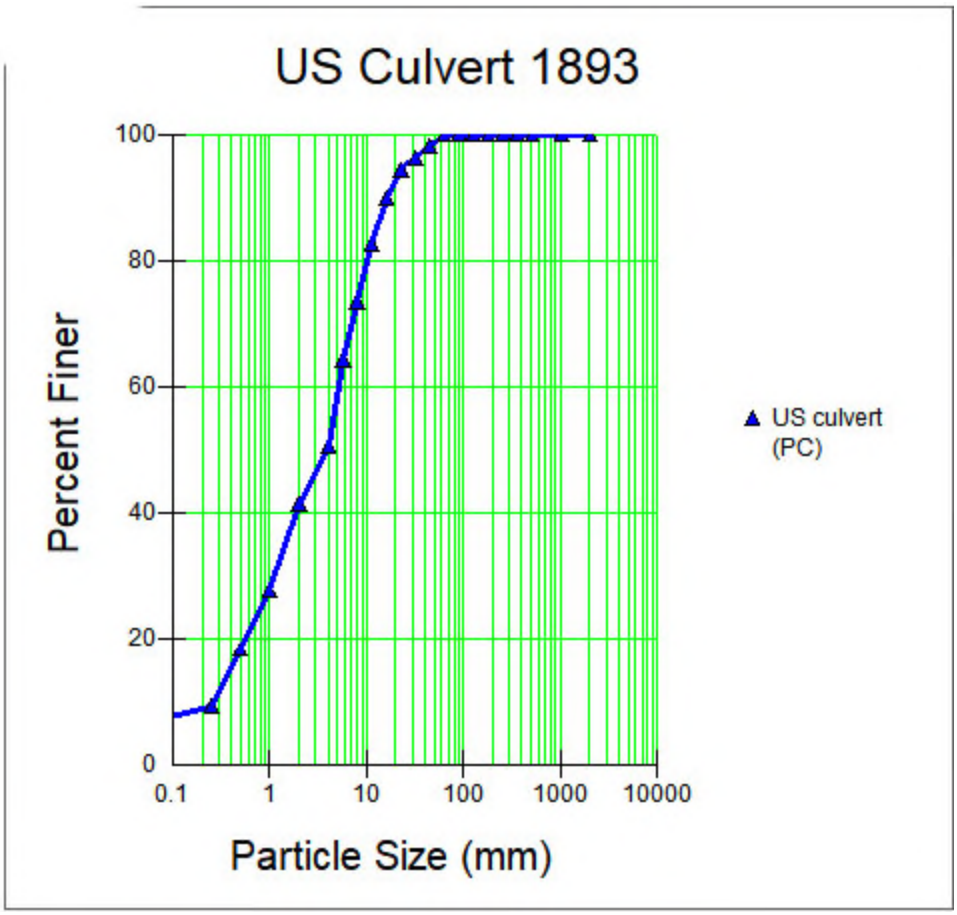


Figure 9 Race Lagoon Tributary 1893, sediment distribution curve at the road crossing site. Showing the clayey silt base to the stream bed.

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	5	5.81	5.81
0.25 - 0.50	5	5.81	11.63
0.50 - 1.0	10	11.63	23.26
1.0 - 2.0	15	17.44	40.70
2.0 - 4.0	15	17.44	58.14
4.0 - 5.7	10	11.63	69.77
5.7 - 8.0	11	12.79	82.56
8.0 - 11.3	5	5.81	88.37
11.3 - 16.0	5	5.81	94.19
16.0 - 22.6	2	2.33	96.51
22.6 - 32.0	2	2.33	98.84
32 - 45	1	1.16	100.00
45 - 64	0	0.00	100.00
64 - 90	0	0.00	100.00
90 - 128	0	0.00	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

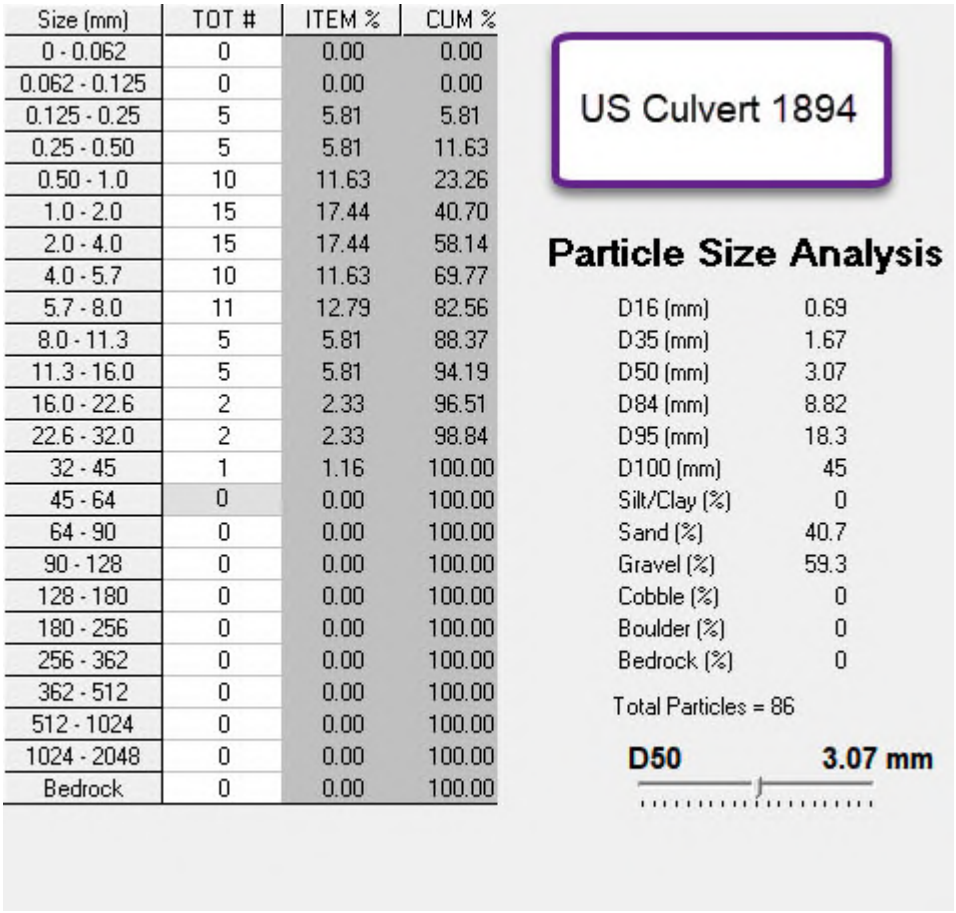


Figure 10 Race Lagoon Tributary 1894 East, pebble count data at the road crossing site showing the D5, D15, D84, D95 % finer diameters. This clearly shows a clayey silt base to the stream bed.

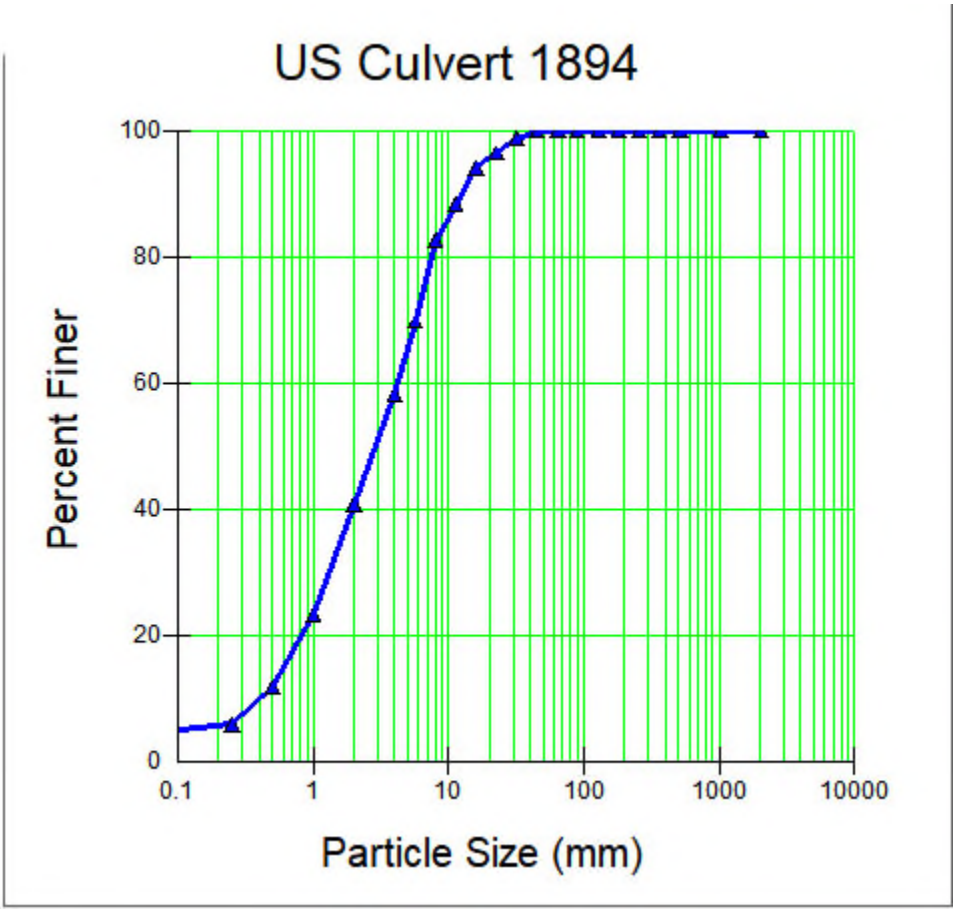


Figure 11 Race Lagoon Tributary 1894, sediment distribution curve at the road crossing site. Showing the clayey silt base to the stream bed.

3. Hydraulic Modeling for the crossing sites

Preliminary design hydraulic modeling was performed for the design of the stream crossings with an assumed low flow channel constructed in the stream simulation streambed of each culvert. A one-dimensional HEC-RAS model was prepared for this cross section and used to determine the water surface elevations, water velocities, Froude number, and stream energy values for tractive force evaluations and scour depths.

Flow contraction at the cross section as shown is not present due to the constructed size of the 2 culverts at the 2 tributaries.

Channel bed widths have been established in preliminary design initially by the WDFW stream simulation method established for culvert crossings. The bed width is established at 14' and 12.5' for a stream simulation approach design and the resultant construction contract documents will show the stream bed width as approximately this dimension. The ordinary High-Water Line, OHWL event, or Q 2-year return with climate change flow rate is noted to be 2 cfs and 8 cfs respectively in the East and West culverts. A low-flow stream shape will be incorporated into both the stream crossings at culvert East and West.

The following table was used to calculate and model the stream geometry in the HEC-RAS and in the U.S. Forest Service, USFS, Fish Xing software application shown in the appendix.

Name of Culvert	Return Interval (years)	Flow Rate (cfs)
Culvert West 1893	2	3.72
Culvert East 1894	2	1.99
Culvert West 1893	100	14
Culvert East 1894	100	7.5

Table 1 Stream flows shown for each culvert and return intervals used in the HECRAS Modeling and Fish Xing Modeling.

Q 100 Flood Hydraulic Characteristics

Site characteristics for the proposed culvert sites have been evaluated for tractive force and scour potential of sediment within the culvert and will result in the governing sizes of the gradation of streambed sediments within the culvert. This will be modeled using a triangular channel cross section with a low flow channel.

See the following screen shots for the results to HEC-RAS calculations. The stream cross section below the bridge is shown and then the resultant calculation follows.

The road cross section for each tributary is shown and is shown wrapped around the upstream face of each of the culverts in the screenshots. Note the exaggerated vertical scale.

The model includes the approximation for climate change of an additional 1.5 feet above the mean high higher water, MHHW, elevation for the highest estimated tide at Race Lagoon. The MHHW elevation is noted to be 9.05 feet NGVD88 plus an additional 1.5 feet provides the estimated elevation of the high tide in race Lagoon in the year 2080, with a **50% chance of occurrence**, to be 10.55 feet. A three feet increase is the value for a 1% chance of occurrence. The elevation predicted increase of 1.5' was used in the HECRAS model to consider if a tidal influence occurred at the culvert crossings. Also, whether a tidal prism inundated the far side of the road crossing into the upstream fields to the south.

The modeling indicates that no tidal prism crosses the road at either of the culvert crossings. However, Culvert West 1893 west shows a backwater characteristic due to the future high tides at the high flow 100 year return occurrence.

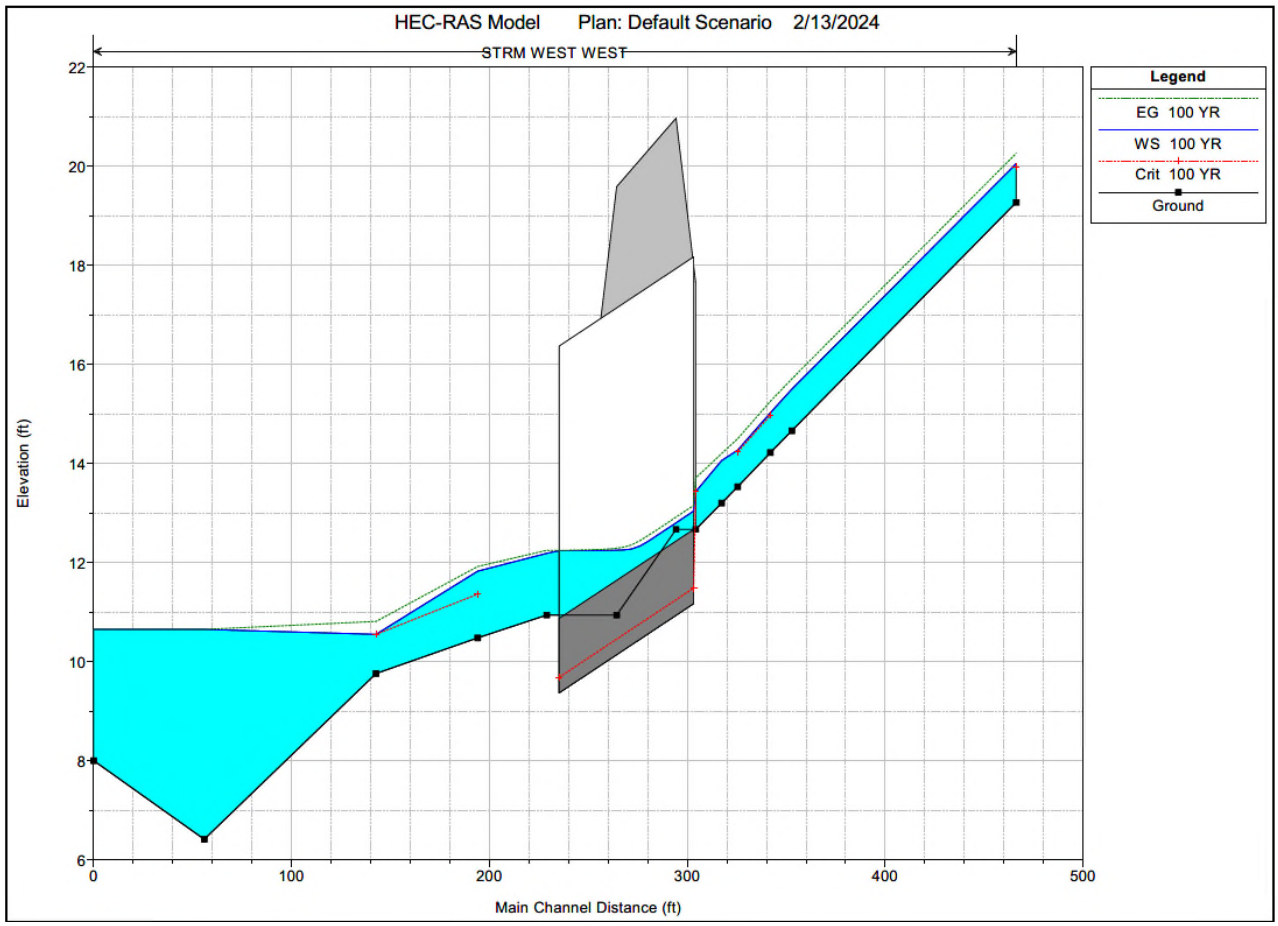


Figure 12 HECRAS output for Culvert West 1893, showing the 100 year water surface elevation in light blue.

HEC-RAS Plan: Default Scenario River: STRM WEST Reach: WEST

Reach	River Sta	Profile	Q Total	W.S. Elev	Crit W.S.	Vel Chnl	Froude # Chl	Shear Chan	Power Chan
			(cfs)	(ft)	(ft)	(ft/s)		(lb/sq ft)	(lb/ft s)
WEST	1000	2 YR	3.72	19.67		2.37	0.74	0.71	1.68
WEST	1000	100 YR	14.00	20.05	19.99	3.65	0.86	1.40	5.11
WEST	999	2 YR	3.72	15.06		2.59	0.81	0.85	2.20
WEST	999	100 YR	14.00	15.50		3.66	0.83	1.38	5.05
WEST	998.6	2 YR	3.72	14.65	14.58	2.37	0.72	0.70	1.65
WEST	998.6	100 YR	14.00	15.02	14.97	3.86	0.89	1.56	6.02
WEST	998	2 YR	3.72	13.89	13.87	2.67	0.90	0.95	2.53
WEST	998	100 YR	14.00	14.27	14.24	3.89	0.91	1.59	6.17
WEST	997.9	2 YR	3.72	13.63		2.02	0.61	0.51	1.02
WEST	997.9	100 YR	14.00	14.06		3.02	0.68	0.93	2.82
WEST	997.7	2 YR	3.72	13.04	13.04	2.98	1.00	1.18	3.52
WEST	997.7	100 YR	14.00	13.43	13.43	4.19	1.00	1.87	7.83
WEST	996.48		Culvert						
WEST	996	2 YR	3.72	11.63		1.30	0.34	0.19	0.25
WEST	996	100 YR	14.00	12.19		1.98	0.39	0.37	0.73
WEST	995	2 YR	3.72	10.91	10.91	3.19	1.00	1.30	4.14
WEST	995	100 YR	14.00	11.83	11.36	2.44	0.45	0.55	1.33
WEST	994	2 YR	3.72	10.64		0.92	0.21	0.09	0.08
WEST	994	100 YR	14.00	10.55	10.55	4.09	1.01	1.81	7.41
WEST	993	2 YR	3.72	10.65		0.04	0.00	0.00	0.00
WEST	993	100 YR	14.00	10.65		0.16	0.02	0.00	0.00
WEST	992	2 YR	3.72	10.65		0.04	0.00	0.00	0.00
WEST	992	100 YR	14.00	10.65		0.15	0.02	0.00	0.00

Table 2 HECRAS tabular output for Culvert West 1893 for 100 year and 2 year return intervals.

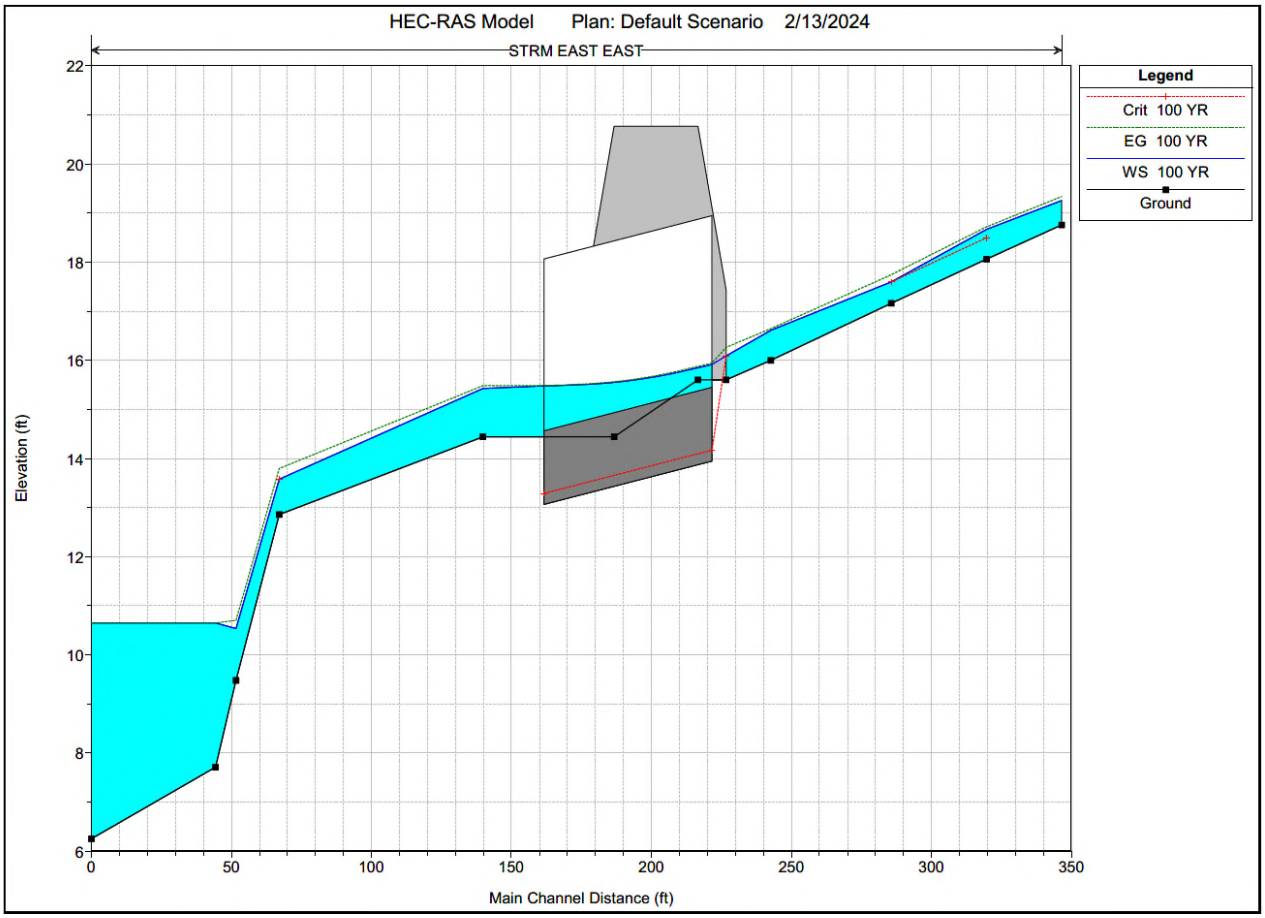


Figure 13 HECRAS output profile of water surface for the 100 year return interval at the Culvert East 1894.

HEC-RAS Plan: Default Scenario River: STRM EAST Reach: EAST

Reach	River Sta	Profile	Q Total	W.S. Elev	Crit W.S.	Vel Chnl	Froude # Chl	Shear Chan	Power Chan
			(cfs)	(ft)	(ft)	(ft/s)		(lb/sq ft)	(lb/ft s)
EAST	1008	2 YR	1.99	19.00	18.97	1.80	0.77	0.50	0.90
EAST	1008	100 YR	7.50	19.25		2.28	0.74	0.67	1.51
EAST	1007.6	2 YR	1.99	18.39	18.27	1.20	0.44	0.20	0.24
EAST	1007.6	100 YR	7.50	18.67	18.50	1.79	0.50	0.38	0.67
EAST	1007	2 YR	1.99	17.37	17.37	2.26	1.01	0.81	1.83
EAST	1007	100 YR	7.50	17.60	17.60	3.07	1.00	1.22	3.74
EAST	1006	2 YR	1.99	16.32		1.07	0.41	0.16	0.18
EAST	1006	100 YR	7.50	16.61		1.52	0.43	0.27	0.41
EAST	1005	2 YR	1.99	15.83	15.83	2.42	1.00	0.89	2.17
EAST	1005	100 YR	7.50	16.09	16.09	3.39	1.00	1.40	4.76
EAST	1004.51		Culvert						
EAST	1004	2 YR	1.99	15.00		1.34	0.40	0.22	0.30
EAST	1004	100 YR	7.50	15.43		1.93	0.45	0.39	0.76
EAST	1003	2 YR	1.99	13.24	13.24	2.78	1.00	1.08	3.00
EAST	1003	100 YR	7.50	13.58	13.58	3.74	1.01	1.62	6.06
EAST	1002	2 YR	1.99	10.64		0.74	0.15	0.06	0.04
EAST	1002	100 YR	7.50	10.54		3.27	0.72	1.12	3.66
EAST	1001	2 YR	1.99	10.65		0.02	0.00	0.00	0.00
EAST	1001	100 YR	7.50	10.65		0.06	0.01	0.00	0.00
EAST	1000	2 YR	1.99	10.65		0.02	0.00	0.00	0.00
EAST	1000	100 YR	7.50	10.65		0.06	0.01	0.00	0.00

Table 3 HECRAS tabular output for the Culvert East 1894 for the 100 year and 2 year return intervals.

4. Construction Costs

Construction costs are estimated using professional judgement and experience in the current construction industry. At this phase of preliminary design costs are higher than anticipated bids will be due to the uncertainty of costs and inflation. These costs include an 8% annual inflation factor.

Race Road Culvert Replacements Construction Costs rev 4-15-2024

Summary	
Site West: 14' x 4.67' x 64' Concrete Box Culvert	$1,031,417
Site East: 12.5' x 5.67' x 72' Concrete Box Culvert	$1,255,371

Figure 14 Summary of estimated construction costs for the Race Lagoon Road crossings.

Chinook Engineering
Opinion of Probable Construction Costs
Race Road Culvert Replacements Construction Costs rev 4-15-2024
Site West: 14' x 4.67' x 64' Concrete Box Culvert

Project Name: Race Road Culvert Replacements Construction Costs rev 4-15-2024
Chinook Project #: 22457
Date: 04/15/24

Estimate By: Jay S. Kidder, PE
Stream: Race Road Culvert Replacements Construction

Annual Construction Inflation Factor Applied to Construction Total	8.00%

Description	Unit	Quantity	Cost	Amount	Sub Total
Mobilization / Site Preparation					
Mobilize	L.S.	1	$65,000.00	$65,000	
Access and Traffic control	L.S.	1	$25,000.00	$25,000	
Stream Bypass	L.S.	1	$0.00	$0	
Erosion Control	L.S.	1	$5,000.00	$5,000	
Dewater and foundation water contr	EA	2	$4,000.00	$8,000	
Fish Removal	L.S.	1	$0.00	$0	
Utilities 811, and Pothole & Replace	LS	1	$15,000.00	$15,000	
MOBILIZATION / SITE PREP SUB TOTAL					$118,000
Excavation					
Grubbing and disposal on site	ACRES	0.11	$10,000.00	$1,148	
Tree falling stumps to remain	EA	0	$650.00	$0	
Excavation, Common, at culvert with end haul	C.Y.	1138	$85.00	$96,688	
Cut asphalt	LF	136	$6.00	$816	
Cut and demolish asphalt end haul	Ton	31	$80.00	$2,481	
EXCAVATION SUB TOTAL					$101,132
Culvert Installation					
Culvert Base Precast Conc.	CY	63	$2,300	$144,474	
Culvert Traffic Slab top, Conc.	CY	36	$2,300	$81,778	
Culvert Ends, Conc.	CY	4	$2,300	$9,030	
Install, crane or large excav.	L.S.	1	$18,000	$18,000	
Culvert disposal	EA	1	$2,000.00	$2,000	
Culvert Weld tabs	EA	128	$30	$3,840	
Backfill against culvert, CSBC	CY	1340	$85	$113,904	
Subgrade & Compaction subgrade	C.Y.	69	$85	$5,843	
Geotextile	SY	142	$9.50	$1,351	
Quarry Spalls and ditching	Ton	60	$150	$9,000	
Fill Road base crushed gravel	C.Y.	141	$110	$15,507	
Resurface with HMA Class A	Ton	46	$120	$5,529	
CULVERT INSTALLATION SUB TOTAL					$410,255
Channel Work HPA Req'd					
Streambed Gravel, Fishmix grade	C.Y.	7	$110.00	$815	
Culvert backfill in barrel	C.Y.	117	$110.00	$12,833	
Culvert Habitat Boulders	Ton	32	$110.00	$3,520	
Revegetation	LS	1	$4,000.00	$4,000	
CHANNEL WORK SUBTOTAL					$21,168
CONSTRUCTION TOTAL					$702,600
Sales Tax	8.80%				$61,829
Admin/Planning	8.00%				$56,208
Permits	9.00%				$63,234
Engineering Design	15.00%				$105,390
Engineering Construction Manage.	6.00%				$42,156
Soils Lab Testing		0	$2,000.00		$0
PROJECT TOTAL					$1,031,417

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 or implied that the bids or the negotiated cost of the Work will not vary from the Consultant's opinion of probable construction cost.

Figure 15 Construction cost estimate West 1893 culvert crossing at Race Lagoon.

Chinook Engineering

Opinion of Probable Construction Costs

Race Road Culvert Replacements Construction Costs rev 4-15-2024

Site East: 12.5' x 5.67' x 72' Concrete Box Culvert

Project Name: Race Road Culvert Replacements Construction Costs rev 4-15-2024
Chinook Project #: 22457
Date: 04/15/24
Estimate By: Jay S. Kidder, PE
Stream: Race Road Culvert Replacements Construction

Inflation Factor Applied to 8.00%

Description	Unit	Quantity	Cost	Amount	Sub Total	
Mobilization / Site Preparation						
Mobilize	L.S.	1	$65,000.00	$65,000		
Access and Traffic control	L.S.	1	$25,000.00	$25,000		
Stream Bypass	L.S.	1	$0.00	$0		
Erosion Control	L.S.	1	$5,000.00	$5,000		
Dewater and foundation water contr	EA	2	$4,000.00	$8,000		
Fish Removal	L.S.	1	$0.00	$0		
Utilities 811, and Pothole & Replace	LS	1	$15,000.00	$15,000		
MOBILIZATION / SITE PREP SUB TOTAL					$118,000	
Excavation						
Grubbing and disposal on site	ACRES	0.11	$10,000.00	$1,148		
Tree falling stumps to remain	EA	0	$650.00	$0		
Excavation, Common, at culvert with end haul	C.Y.	1264	$85.00	$107,431		
Cut asphalt	LF	136	$6.00	$816		
Cut and demolish asphalt end haul	Ton	31	$80.00	$2,481		
EXCAVATION SUB TOTAL					$111,876	
Culvert Installation						
Culvert Base Precast Conc.	CY	71	$2,300	$162,533		
Culvert Traffic Slab top, Conc.	CY	40	$2,300	$92,000		
Culvert Ends, Conc.	CY	4	$2,300	$9,030		
Install, crane or large excav.	L.S.	1	$18,000	$18,000		
Culvert disposal	EA	1	$2,000.00	$2,000		
Culvert Weld tabs	EA	144	$30	$4,320		
Backfill against culvert, CSBC	CY	1485	$85	$126,194		
Subgrade & Compaction subgrade	C.Y.	69	$85	$5,843		
Geotextile	SY	142	$9.50	$1,351		
Quarry Spalls and ditching	Ton	60	$150	$9,000		
Fill Road base crushed gravel	C.Y.	150	$110	$16,541		
Resurface with HMA Class A	Ton	46	$120	$5,529		
CULVERT INSTALLATION SUB TOTAL					$452,341	
Channel Work HPA Req'd						
Cut Roots and clean up	C.Y.	5	$65.00	$325		
Fish mix stream sed. and cobble	CY	15	$110.00	$1,650		
Excavation, Channel change	C.Y.	9	$80.00	$693		
Streambed Gravel, Fishmix grade	C.Y.	7	$110.00	$815		
Culvert backfill in barrel	C.Y.	124	$110.00	$13,689		
Culvert Habitat Boulders	Ton	32	$110.00	$3,520		
Revegetation	LS	1	$4,000.00	$4,000		
Channel Change Excavation ~200'	CY	173	$80.00	$13,867		Revison 4-15-2024
Streambed Gravel, Fishmix grade	CY	93	$110.00	$10,185		
LWD 12" dbh	EA	12	$1,200.00	$14,400		
Revegetation	LS	1	$4,000.00	$4,000		
				$42,452		
CHANNEL WORK SUBTOTAL					$109,596	
CONSTRUCTION TOTAL					$855,158	
Sales Tax	8.80%				$75,254	
Admin/Planning	8.00%				$68,413	
Permits	9.00%				$76,964	
Engineering Design	15.00%				$128,274	
Engineering Construction Manage.	6.00%				$51,309	
Soils Lab Testing		0	$2,000.00		$0	
PROJECT TOTAL					$1,255,371	

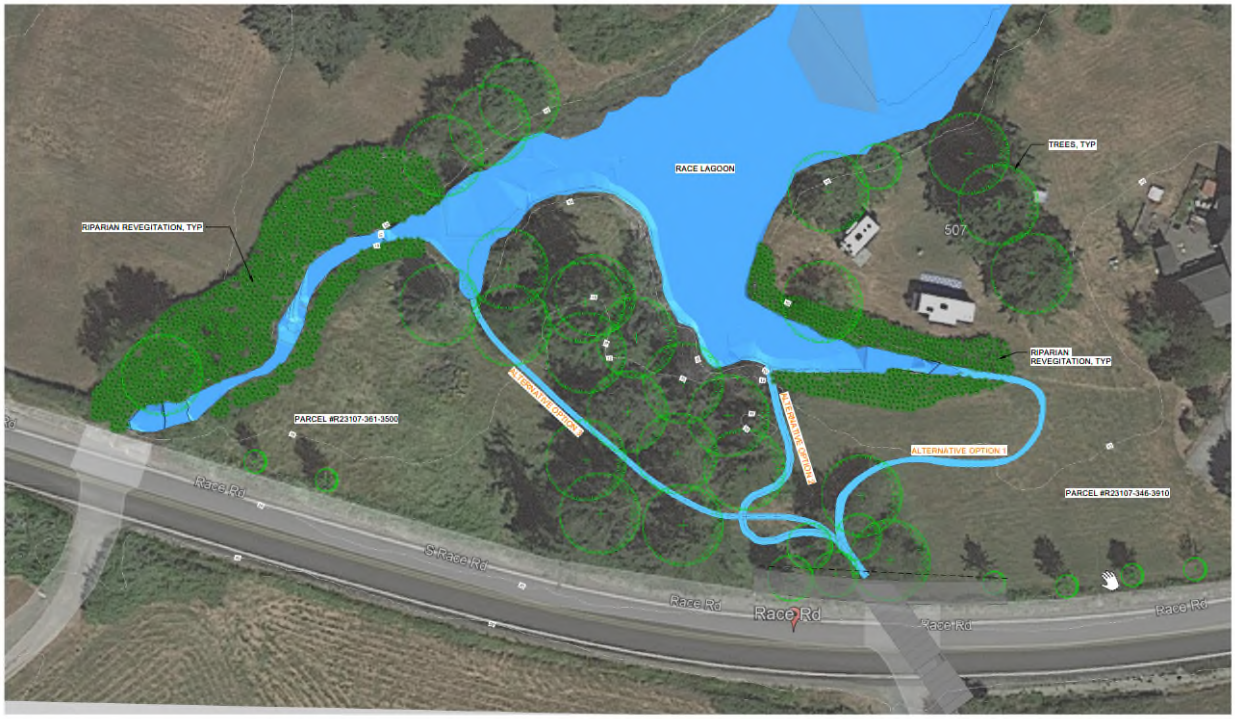
Opinions of Probable Construction Cost

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 or implied that the bids or the negotiated cost of the Work will not vary from the Consultant's opinion of probable construction cost.

Figure 16 Construction cost estimate East 1894 culvert crossing at Race Lagoon.

5. Alternative Alignments at East Culvert 1894

Several alternative stream alignments were considered for the downstream connection below the proposed culvert identified as 1894, from the downstream invert of the proposed culvert to the connection with the estuary. The locations and lengths vary and display different slopes.



Site - Overall 1 C-1
1" = 20'-0"

The following figures show the alignment alternative and stream profile that identifies the length and slope. The cross section of alternative is shown as a generic trapezoidal section. Future design would include flats and flood plains, bends, and widening and include the addition of Large Woody Debris, LWD, to form habitat and pool refuge. The identification of the large trees was mapped to allow for avoidance when the excavated stream alignment is created. The trees will be protected during construction and steep banks will be avoided to protect roots.

The first alignment, Alternative 1 shows the addition of LWD and is located the furthest east. The other alignments are progressively shown to the westward.

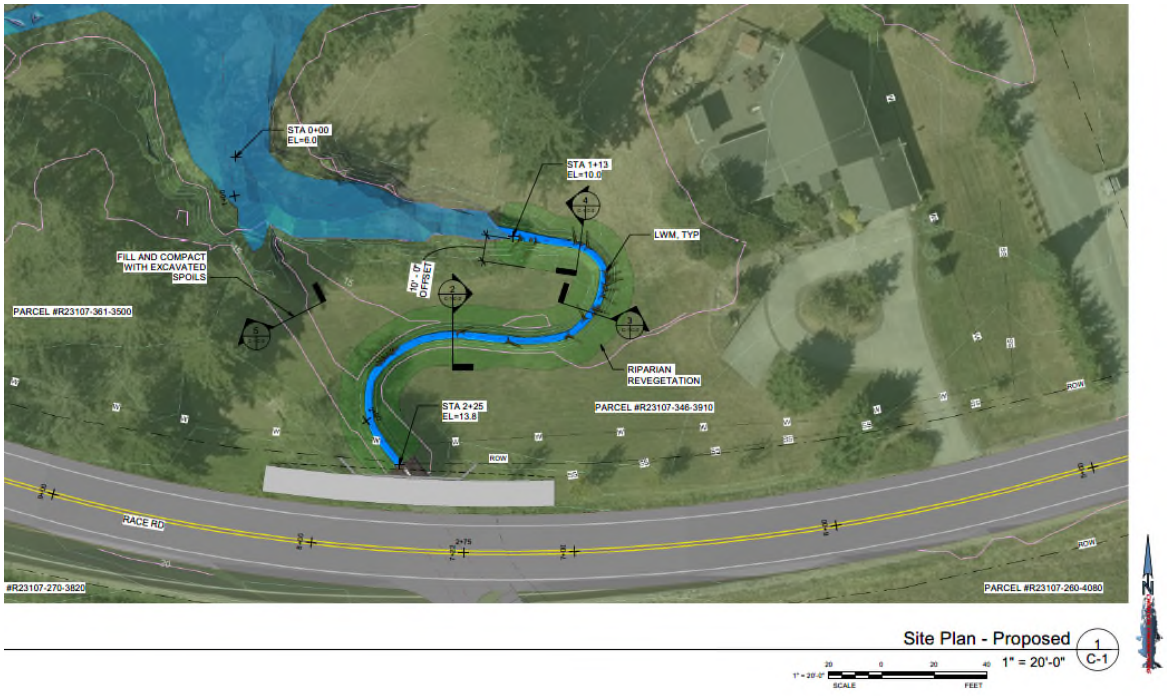


Figure 17 Optional Channel Change proposal showing the construction of a newly restored channel around the steep fish passage exit from the Race Lagoon.

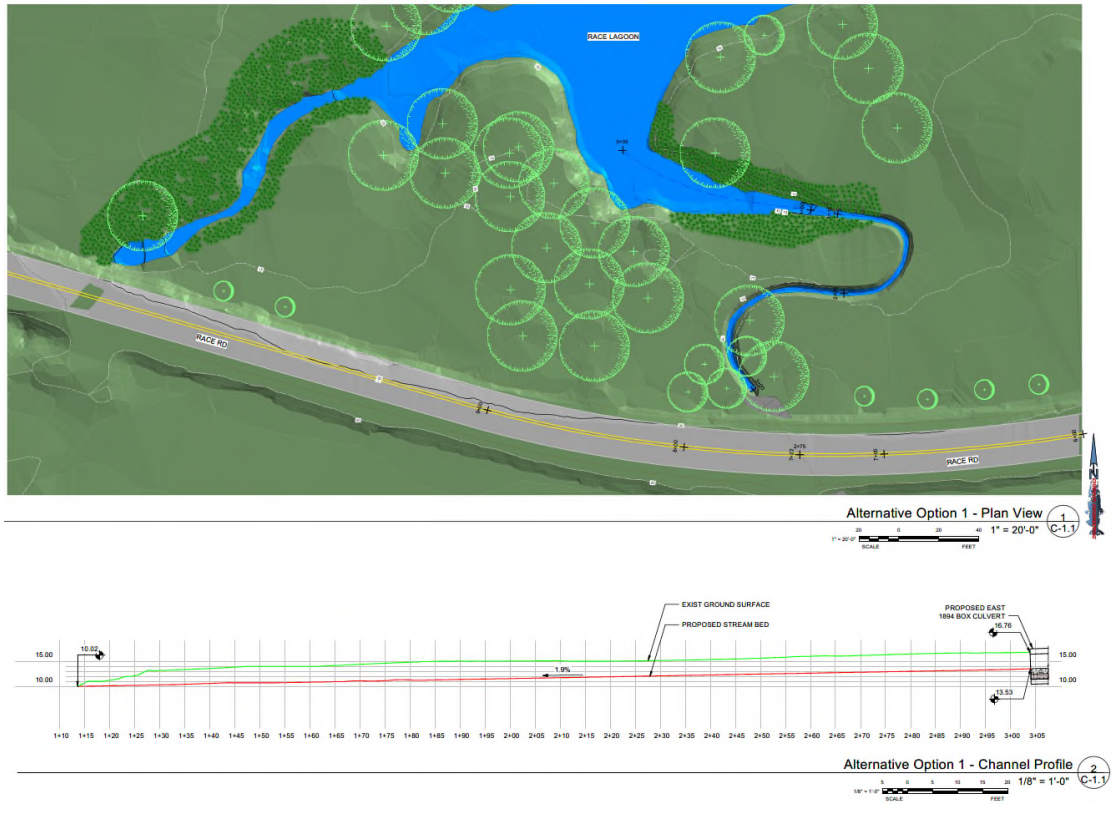


Figure 18 Optional Channel Change proposal showing the Alignment Alternative 1 and the associated Profile.

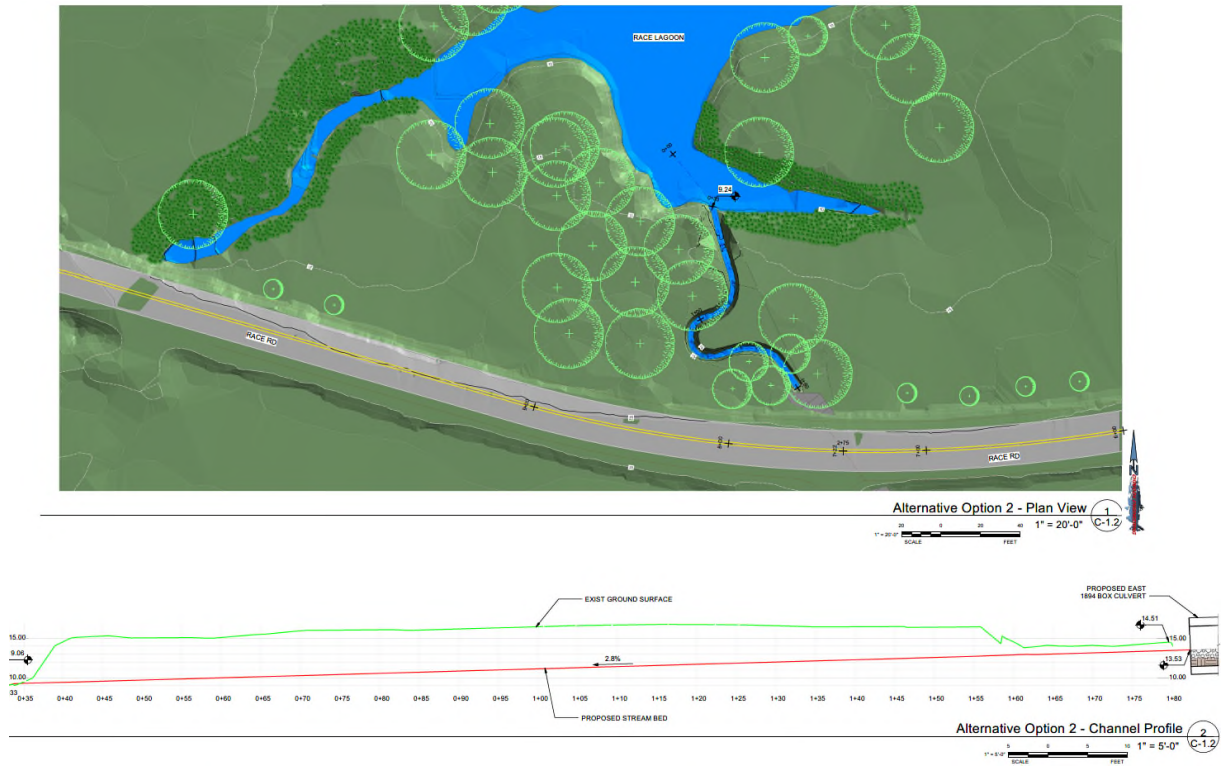


Figure 19 Optional Channel Change proposal showing the Alignment Alternative 2 and the associated Profile.

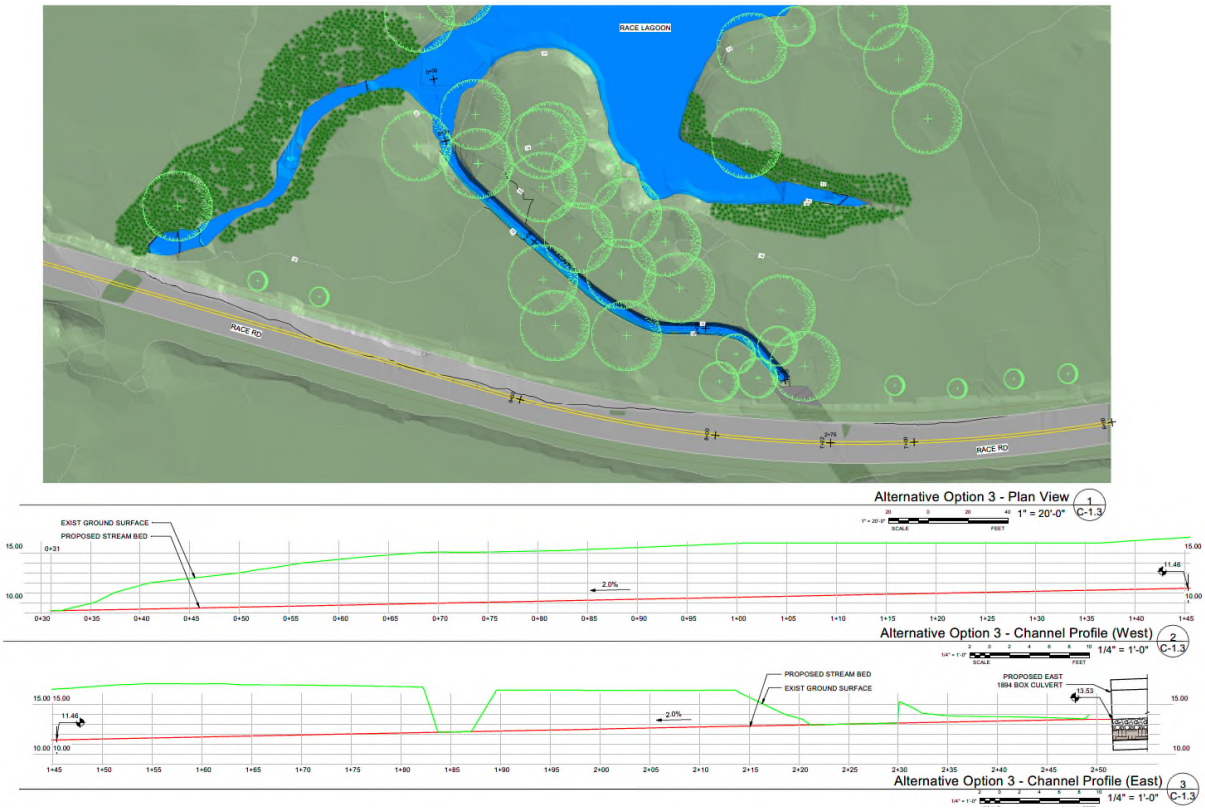


Figure 20 Optional Channel Change proposal showing the Alignment Alternative 3 and the associated Profile.

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7. Appendices

Appendix A stream simulation memo by Chinook Engineering

CHINOOK ENGINEERING

860 Windrose Drive
Coupeville, WA 98239

Telephone (360) 672-5528

Memorandum

Date: January 8, 2024

From: Jay S. Kidder, P.E.
To: Alison Studley, Executive Director SFEG

Subject: Race Road Culvert Replacement Project hydrology and Hydraulics memo together with fish crossing and stream simulation dimensions

---

Hi Allison,

Please find attached a memo that presents the several design tools that I use to size culverts properly for fish passage. The results are shown attached. This may initiate discussions as to the actual size used in the design.

These tools include the Streamstats online program from the USGS to provide the best estimate of stream flow for the 2 watersheds, 1893, and 1894; an Excel spreadsheet that solves the stream simulation calculation for Washington state; the Washington State Department of Fish and Wildlife climate change modifier for culverts and stream crossings; and the U.S. Forest Service FishXng output.

I use these tools to design for culverts in the stream, starting with the bank full width measurements then use the spreadsheet for the appropriate size culvert replacement, which is then modified by the climate change increase for the year 2080, and then double check sizing using the U.S. Forest Service FishXng program. All the earlier culvert spans and barrier measurements are shown as well.

Give me a call if you need anything else such as revising the drawings again. My phone number is 360-672-5528.

Thank you,
Jay Kidder

https://chinookengineering.sharepoint.com/sites/RaceRoadCulvertReplacements1893-1894/Shared Documents/BOD/Fish Crossing and Stream Simulation Memo.docx

Crossing Report for Race Road Large West 1893

Project: Hydraulics and FishXing

Table 1. Project Summary for Hydraulics and FishXing

File Name	Crossing Name	Stream Name	Culvert Length	QLP	QHP	% Passable
Race Road large West	Race Road Large West	unnamed	56 ft	4.3 cfs	16.5 cfs	100.0%
small Race Road.xng	Race Road Small Culve	unnamed	74 ft	2.3 cfs	8.9 cfs	100.0%

Crossing Location Information

Crossing Name: Race Road Large West 1893
Stream Name: unnamed
Road: Race Road

FishXing V3.0 2006

Biological Data
Fish Length: 8 cm
Minimum Water Depth: 0.1 ft
Prolonged Swimming Speed: 5.1 ft/s
Prolonged Time to Exhaustion: 20 min
Prolonged Notes:
Oncorhynchus tshawytscha
Chinook salmon
Length: 71.35 to 84.79 cm
Temp: 12.5 Deg C
Speed Range: 4.1 - 6.43 ft/s
Fish Body Depth: 0.06 ft

Burst Swimming Speed: 5.3 ft/s
Burst Time to Exhaustion: 10 s
Burst Notes:
Oncorhynchus tshawytscha
Chinook salmon
Length: 50.8 to 96.5 cm
Temp: 18.9 to 19.4 Deg C
Fish Body Depth: 0.06 ft
Fish Metrics Calculated

Leaping Speed: 16.8 ft/s
Velocity Reduction Factors:
Inlet: 1.00
Barrel: 1.00
Outlet: 1.00

Crossing Installation Data
Culvert Type: 13 X 7 ft Box
Material: Concrete
Installation: Embedded
Countersunk Depth: 2.3 ft
Natural Bottom Roughness Coefficient: 0.05
Culvert Length: 56 ft
Culvert Slope: 3.36%
Culvert Roughness Coefficient: 0.013
Natural Bottom Roughness Coefficient: 0.05
Inlet Invert Elevation: 12.31 ft
Outlet Invert Elevation: 10.43 ft
Inlet Headloss Coefficient (Ke): 0.7

FishXing V3.0 2006

Design Flows

Low Passage Flow: 4.3 cfs

High Passage Flow: 16.5 cfs

Tailwater Information

Tailwater Option: Tailwater Channel Cross-Section

Channel Bottom Slope: 3.4%

Outlet-Pool Bottom Elevation: 10.43 ft

Table 2. Tailwater Cross Section Data.

Station (ft)	Elevation (ft)	Roughness Coefficient
0.00	18.00	0.055
4.00	10.43	
18.00	10.43	
22.00	18.00	

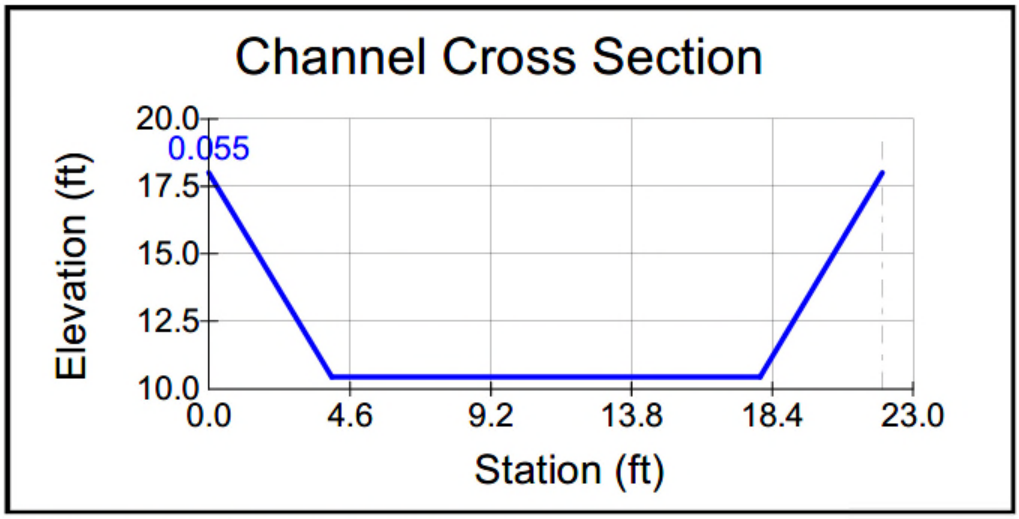


Figure 1. Channel Cross Section at Tailwater Crest.

FishXing V3.0 2006

Table 3. Tailwater Rating Table Information.

Discharge (cfs)	Tailwater Elevation (ft)	Wetted Perimeter (ft)	Cross-Sect. Area (sq. ft)	Composite Roughness Coefficient
0.0	10.4	0.00	0.00	0.000
0.8	10.5	14.16	0.98	0.055
3.6	10.6	14.38	2.39	0.055
7.8	10.7	14.61	3.82	0.055
13.1	10.8	14.84	5.25	0.055
19.4	10.9	15.06	6.70	0.055
26.7	11.0	15.29	8.15	0.055
34.8	11.1	15.52	9.62	0.055
43.8	11.2	15.74	11.09	0.055
53.5	11.3	15.97	12.58	0.055
63.9	11.4	16.19	14.08	0.055
75.0	11.5	16.42	15.58	0.055
86.8	11.6	16.65	17.10	0.055
99.2	11.7	16.87	18.63	0.055
112.2	11.8	17.10	20.17	0.055
125.8	11.9	17.33	21.72	0.055
140.0	12.0	17.55	23.28	0.055
154.8	12.1	17.78	24.85	0.055
170.1	12.2	18.00	26.44	0.055
186.0	12.3	18.23	28.03	0.055
202.4	12.4	18.46	29.63	0.055
219.3	12.5	18.68	31.24	0.055
236.7	12.6	18.91	32.87	0.055
254.6	12.7	19.13	34.50	0.055
273.0	12.8	19.36	36.15	0.055
291.9	12.9	19.59	37.80	0.055
311.3	13.0	19.81	39.47	0.055
331.1	13.1	20.04	41.15	0.055
351.4	13.2	20.27	42.83	0.055
372.2	13.3	20.49	44.53	0.055
393.4	13.4	20.72	46.24	0.055
415.1	13.5	20.94	47.96	0.055
437.2	13.6	21.17	49.69	0.055
459.7	13.7	21.40	51.43	0.055
482.7	13.8	21.62	53.18	0.055
506.1	13.9	21.85	54.94	0.055
530.0	14.0	22.08	56.71	0.055
554.2	14.1	22.30	58.50	0.055
578.9	14.2	22.53	60.29	0.055
604.0	14.3	22.75	62.09	0.055
629.6	14.4	22.98	63.91	0.055
655.5	14.5	23.21	65.73	0.055
681.9	14.6	23.43	67.57	0.055
708.7	14.7	23.66	69.41	0.055
735.9	14.8	23.89	71.27	0.055
763.5	14.9	24.11	73.14	0.055
791.5	15.0	24.34	75.02	0.055
819.9	15.1	24.56	76.90	0.055

FishXing V3.0 2006

Discharge (cfs)	Tailwater Elevation (ft)	Wetted Perimeter (ft)	Cross-Sect. Area (sq. ft)	Composite Roughness Coefficient
848.7	15.2	24.79	78.80	0.055
877.9	15.3	25.02	80.71	0.055
907.5	15.4	25.24	82.63	0.055
937.5	15.5	25.47	84.56	0.055
968.0	15.6	25.69	86.50	0.055
998.8	15.7	25.92	88.46	0.055
1030.0	15.8	26.15	90.42	0.055
1061.6	15.9	26.37	92.39	0.055
1093.6	16.0	26.60	94.37	0.055
1126.0	16.1	26.83	96.37	0.055
1158.8	16.2	27.05	98.37	0.055
1192.0	16.3	27.28	100.39	0.055
1225.6	16.4	27.50	102.41	0.055
1259.6	16.5	27.73	104.45	0.055
1294.0	16.6	27.96	106.50	0.055
1328.7	16.7	28.18	108.55	0.055
1363.9	16.8	28.41	110.62	0.055
1399.4	16.9	28.64	112.70	0.055
1435.4	17.0	28.86	114.79	0.055
1471.7	17.1	29.09	116.89	0.055
1508.5	17.2	29.31	119.00	0.055
1545.6	17.3	29.54	121.12	0.055
1583.1	17.4	29.77	123.25	0.055
1621.0	17.5	29.99	125.39	0.055
1659.4	17.6	30.22	127.54	0.055
1698.1	17.7	30.45	129.71	0.055
1737.1	17.8	30.67	131.88	0.055
1776.6	17.9	30.90	134.07	0.055
1816.5	18.0	31.12	136.26	0.055

FishXing V3.0 2006

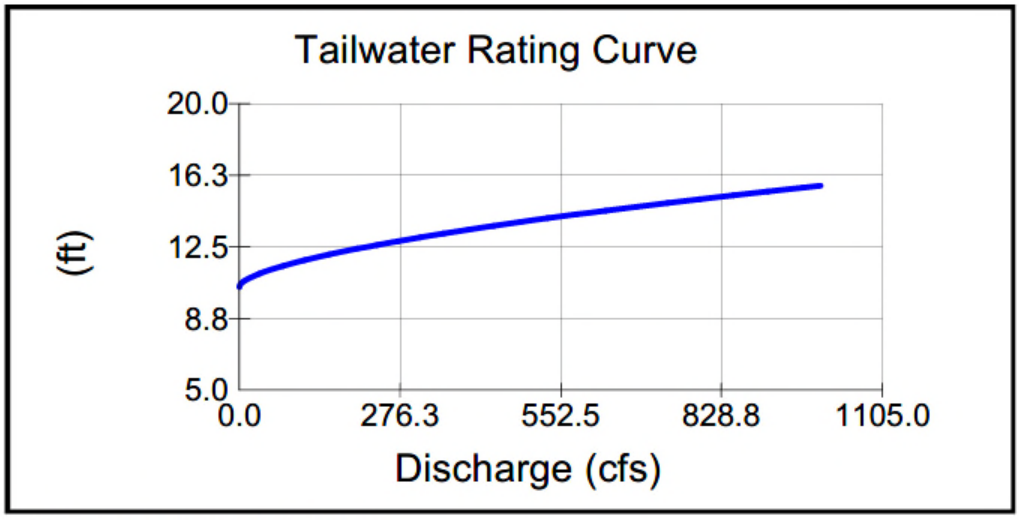


Figure 2. Tailwater Rating Curve

Table 4. Fish Passage Summary.

Fish Passage Summary	
Low Passage Design Flow	4.30 cfs
High Passage Design Flow	16.50 cfs
Percent of Flows Passable	100.0 %
Passable Flow Range	4.30 to 16.50 cfs
Depth Barrier	None
Leap Barriers	None
Velocity Barrier	None
Pool Depth Barrier	None

Table 5. Culvert Summary for 4.30 cfs.

Summary for Q = 4.30 cfs	
Normal Depth (ft)	0.19
Critical Depth (ft)	0.15
Headwater Depth (ft)	0.36
HW/D	0.08
Inlet Velocity (ft/s)	2.32
Tailwater Depth (ft)	0.19
Outlet Water Surface Drop (fl	0.00
Prolonged Swim Time (min)	0.28
Burst Swim Time (s)	0.00
Barrier Code	NONE

FishXing V3.0 2006

Table 6. Culvert Profiles for 4.30 cfs.

	Profiles for Q = 4.30 cfs				
Dist Down Culvert (ft)	Depth (ft)	Velocity Average (ft/s)	Velocity Occupied (ft/s)	Swim Mode	Barrier Type
0	0.36	0.00	0.00	Prolonged	NONE
3	0.19	2.32	2.31	Prolonged	
5	0.19	1.78	1.77	Prolonged	
8	0.19	1.78	1.77	Prolonged	
11	0.19	1.78	1.77	Prolonged	
14	0.19	1.78	1.77	Prolonged	
17	0.19	1.78	1.77	Prolonged	
20	0.19	1.78	1.77	Prolonged	
23	0.19	1.78	1.77	Prolonged	
26	0.19	1.78	1.77	Prolonged	
29	0.19	1.78	1.77	Prolonged	
32	0.19	1.78	1.77	Prolonged	
35	0.19	1.78	1.77	Prolonged	
38	0.19	1.78	1.77	Prolonged	
41	0.19	1.78	1.77	Prolonged	
44	0.19	1.78	1.77	Prolonged	
47	0.19	1.78	1.77	Prolonged	
50	0.19	1.78	1.77	Prolonged	
53	0.19	1.78	1.77	Prolonged	
56	0.19	1.77	1.77		

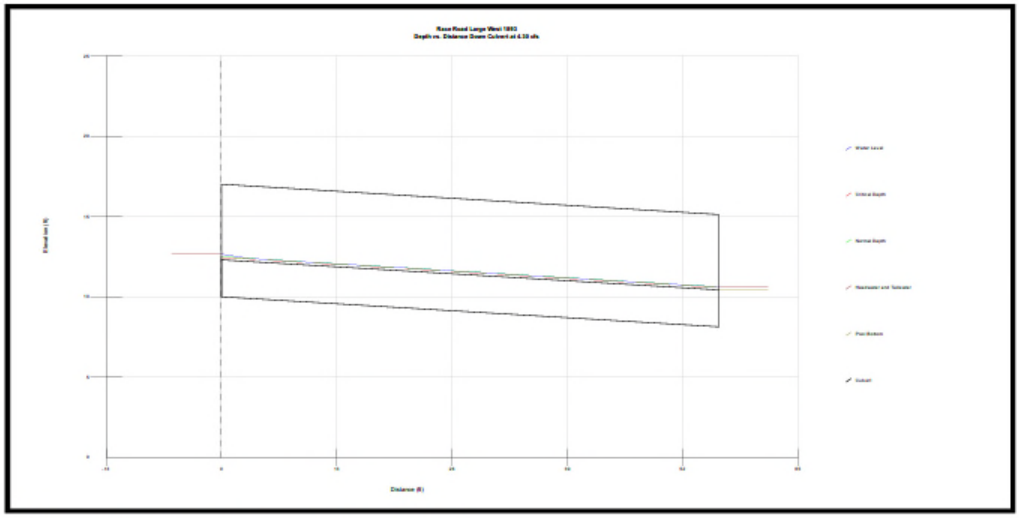


Figure 3. Water Surface Profile at 4.3 cfs

FishXing V3.0 2006

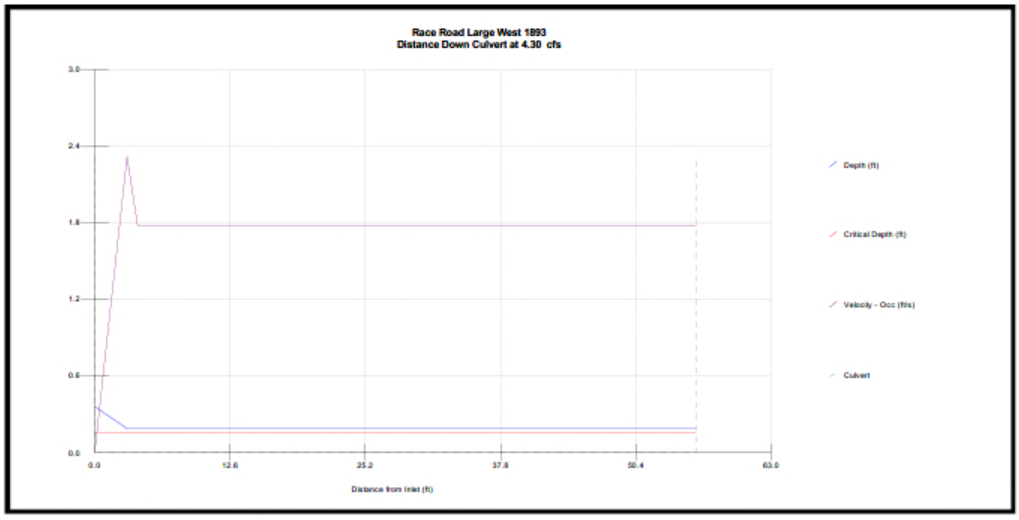


Figure 4. Culvert Profiles at 4.3 cfs

Table 7. Culvert Summary for 16.5 cfs.

Summary for Q = 16.50 cfs	
Normal Depth (ft)	0.42
Critical Depth (ft)	0.37
Headwater Depth (ft)	0.72
HW/D	0.15
Inlet Velocity (ft/s)	3.96
Tailwater Depth (ft)	0.42
Outlet Water Surface Drop (fl	0.00
Prolonged Swim Time (min)	0.45
Burst Swim Time (s)	0.00
Barrier Code	NONE

FishXing V3.0 2006

Table 8. Culvert Profiles for 16.5 cfs.

	Profiles for Q = 16.50 cfs				
Dist Down Culvert (ft)	Depth (ft)	Velocity Average (ft/s)	Velocity Occupied (ft/s)	Swim Mode	Barrier Type
0	0.72	0.00	0.00	Prolonged	NONE
3	0.42	3.96	3.95	Prolonged	
5	0.42	3.04	3.03	Prolonged	
8	0.42	3.04	3.03	Prolonged	
11	0.42	3.04	3.03	Prolonged	
14	0.42	3.04	3.03	Prolonged	
17	0.42	3.04	3.03	Prolonged	
20	0.42	3.04	3.03	Prolonged	
23	0.42	3.04	3.03	Prolonged	
26	0.42	3.04	3.03	Prolonged	
29	0.42	3.04	3.03	Prolonged	
32	0.42	3.04	3.03	Prolonged	
35	0.42	3.04	3.03	Prolonged	
38	0.42	3.04	3.03	Prolonged	
41	0.42	3.04	3.03	Prolonged	
44	0.42	3.04	3.03	Prolonged	
47	0.42	3.04	3.03	Prolonged	
50	0.42	3.04	3.03	Prolonged	
53	0.42	3.04	3.03	Prolonged	
56	0.42	3.00	2.99		

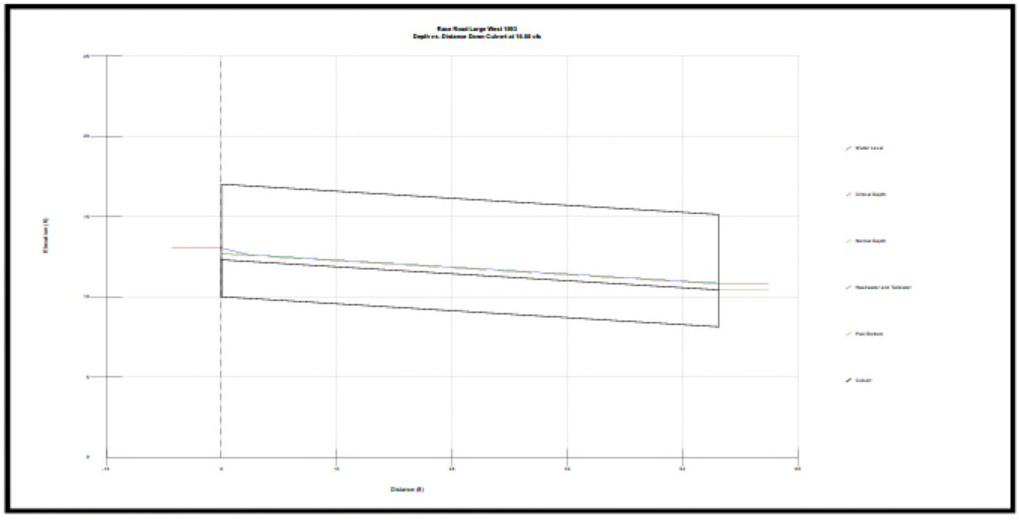


Figure 5. Water Surface Profile at 16.5 cfs

FishXing V3.0 2006

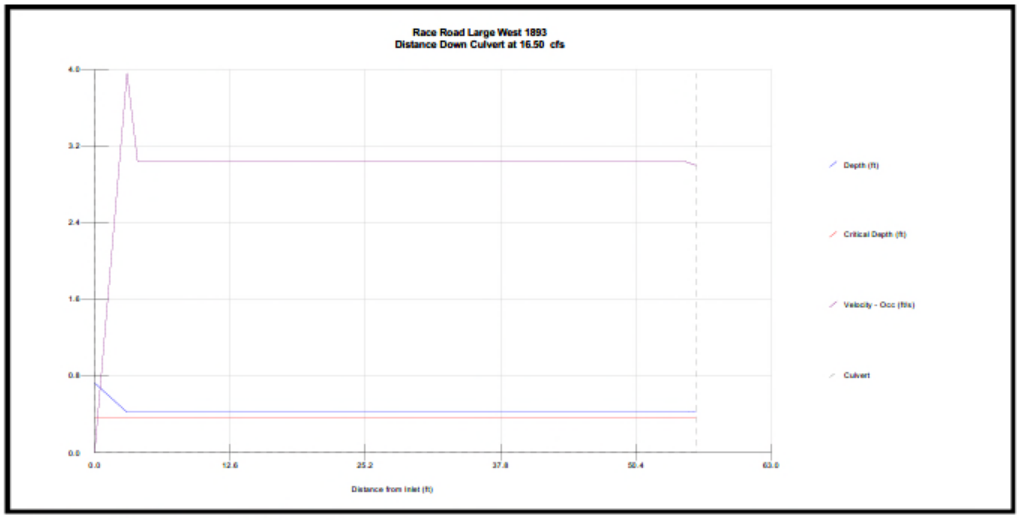


Figure 6. Culvert Profiles at 16.5 cfs

Table 9. Culvert Summary for 2 cfs.

Summary for Q = 2.00 cfs	
Normal Depth (ft)	0.12
Critical Depth (ft)	0.09
Headwater Depth (ft)	0.26
HW/D	0.05
Inlet Velocity (ft/s)	1.71
Tailwater Depth (ft)	0.11
Outlet Water Surface Drop (fl	0.00
Prolonged Swim Time (min)	0.25
Burst Swim Time (s)	0.00
Barrier Code	NONE

FishXing V3.0 2006

Table 10. Culvert Profiles for 2 cfs.

	Profiles for Q = 2.00 cfs				
Dist Down Culvert (ft)	Depth (ft)	Velocity Average (ft/s)	Velocity Occupied (ft/s)	Swim Mode	Barrier Type
0	0.26	0.00	0.00	Prolonged	NONE
3	0.12	1.71	1.70	Prolonged	
5	0.12	1.31	1.30	Prolonged	
8	0.12	1.31	1.30	Prolonged	
11	0.12	1.31	1.30	Prolonged	
14	0.12	1.31	1.30	Prolonged	
17	0.12	1.31	1.30	Prolonged	
20	0.12	1.31	1.30	Prolonged	
23	0.12	1.31	1.30	Prolonged	
26	0.12	1.31	1.30	Prolonged	
29	0.12	1.31	1.30	Prolonged	
32	0.12	1.31	1.30	Prolonged	
35	0.12	1.31	1.30	Prolonged	
38	0.12	1.31	1.30	Prolonged	
41	0.12	1.31	1.30	Prolonged	
44	0.12	1.31	1.30	Prolonged	
47	0.12	1.31	1.30	Prolonged	
50	0.12	1.31	1.30	Prolonged	
53	0.12	1.31	1.30	Prolonged	
56	0.11	1.37	1.37		

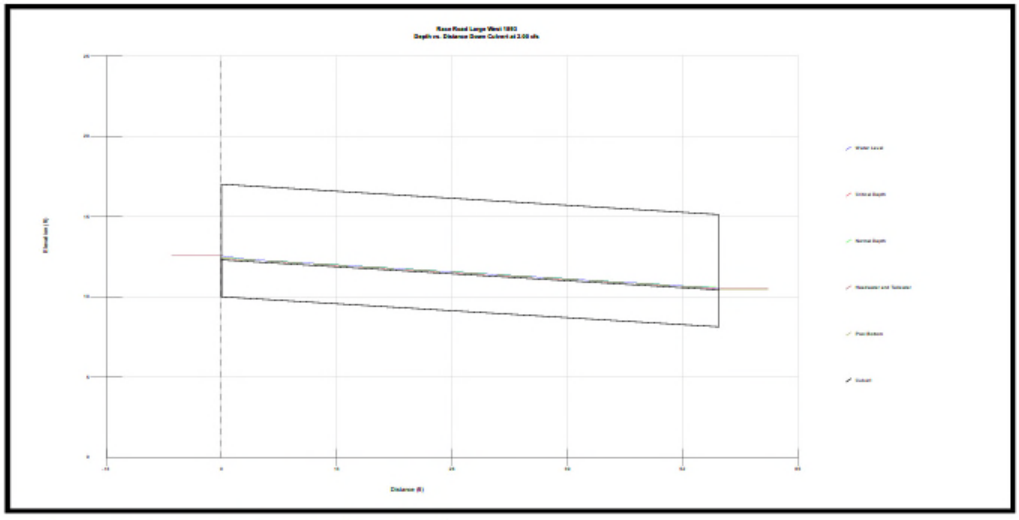


Figure 7. Water Surface Profile at 2 cfs

FishXing V3.0 2006

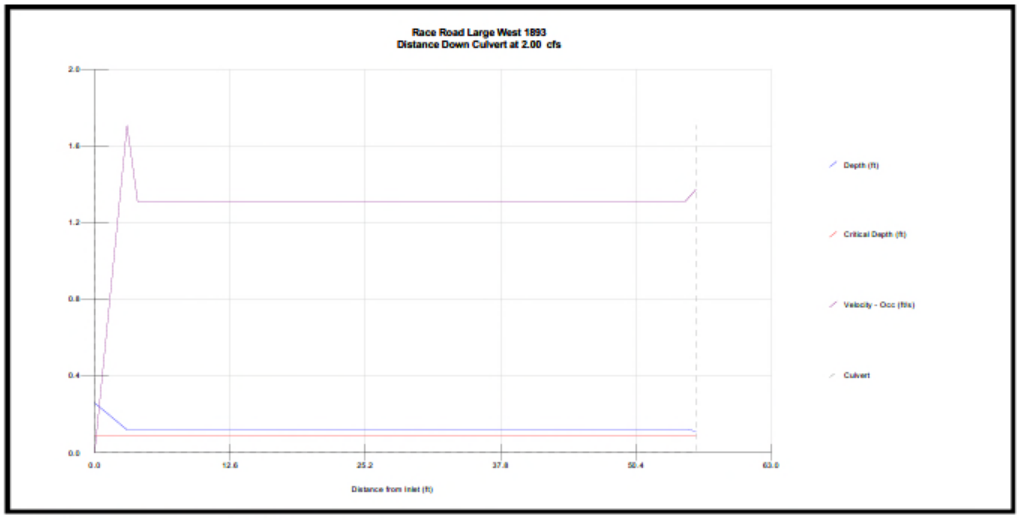


Figure 8. Culvert Profiles at 2 cfs

FishXing V3.0 2006

Table 11. Culvert Rating Table.

Q total (cfs)	Depth Min (ft)	V(occ) Max (ft/s)	Depth TW (ft)	Outlet WS Drop (ft)	Depth Pool (ft)	Barrier Type
0.0	0.00	0.00	-10.43	10.43	-10.43	Depth
0.8	0.07	1.20	0.07	0.00	0.07	Depth
1.6	0.10	1.65	0.10	0.00	0.10	Depth
2.5	0.13	1.85	0.13	0.00	0.13	NONE
3.3	0.16	2.08	0.16	0.00	0.16	NONE
4.30	0.19	2.32	0.19	0.00	0.19	NONE
5.1	0.21	2.48	0.21	0.00	0.21	NONE
5.9	0.23	2.64	0.23	0.00	0.23	NONE
6.8	0.24	2.77	0.25	0.00	0.25	NONE
7.6	0.26	2.90	0.27	0.00	0.27	NONE
8.4	0.28	3.03	0.28	0.00	0.28	NONE
9.2	0.29	3.14	0.30	0.00	0.30	NONE
10.0	0.31	3.25	0.31	0.00	0.31	NONE
10.9	0.32	3.35	0.33	0.00	0.33	NONE
11.7	0.34	3.45	0.34	0.00	0.34	NONE
12.5	0.35	3.54	0.36	0.00	0.36	NONE
13.3	0.37	3.64	0.37	0.00	0.37	NONE
14.1	0.38	3.72	0.39	0.00	0.39	NONE
15.0	0.39	3.81	0.40	0.00	0.40	NONE
15.8	0.41	3.89	0.41	0.00	0.41	NONE
16.50	0.42	3.96	0.42	0.00	0.42	NONE
17.3	0.43	4.04	0.44	0.00	0.44	NONE
18.1	0.44	4.11	0.45	0.00	0.45	NONE
19.0	0.45	4.18	0.46	0.00	0.46	NONE
19.8	0.47	4.26	0.47	0.00	0.47	NONE
20.6	0.48	4.32	0.49	0.00	0.49	NONE
21.4	0.49	4.39	0.50	0.00	0.50	NONE
22.2	0.50	4.46	0.51	0.00	0.51	NONE
23.1	0.51	4.52	0.52	0.00	0.52	NONE
23.9	0.52	4.59	0.53	0.00	0.53	NONE
24.8	0.53	4.65	0.54	0.00	0.54	NONE

FishXing V3.0 2006

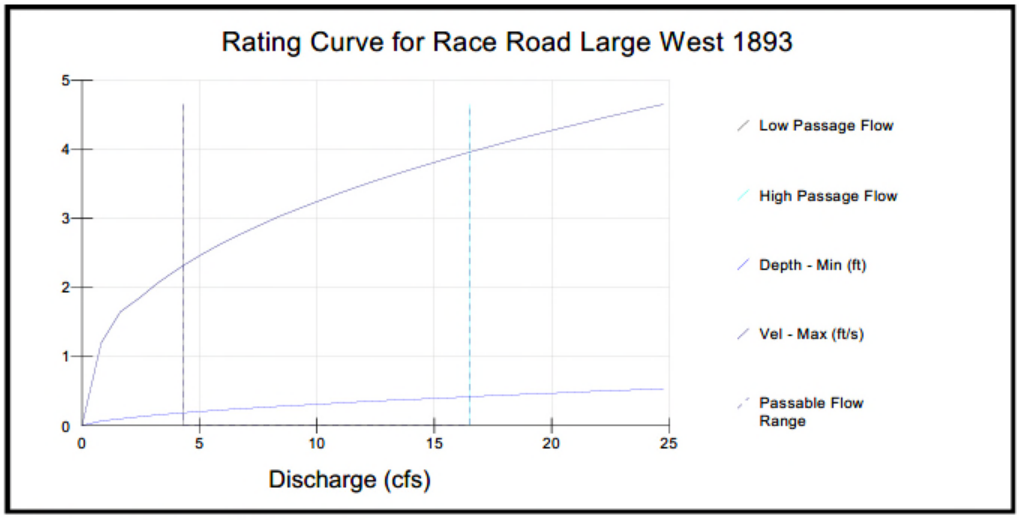


Figure 9. Culvert Rating Curve

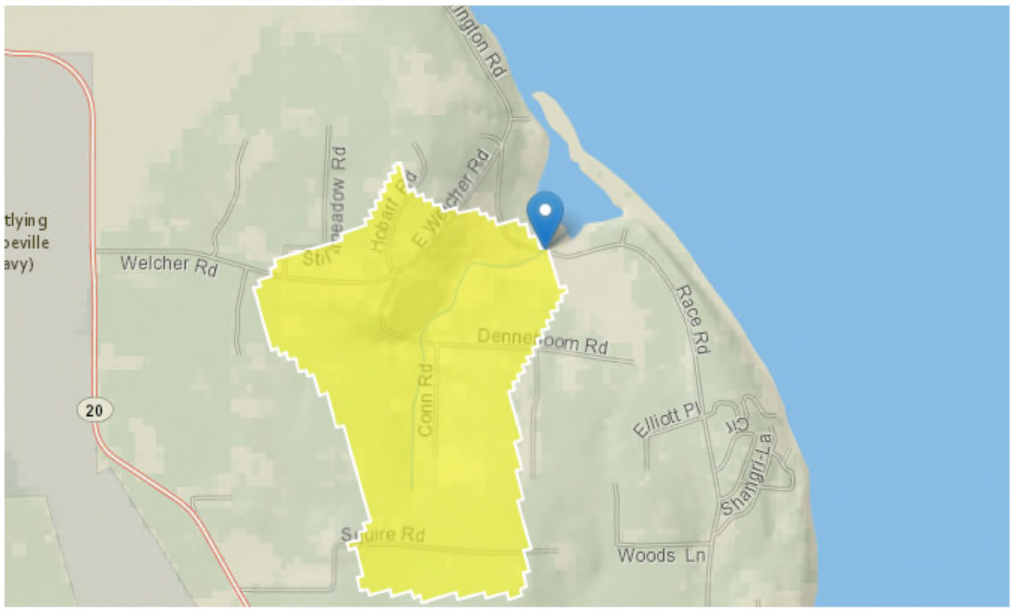
Barrier Codes

V = Strict Velocity Barrier
EB = Fish Exhausted at Burst Speed
Long = Fish Exhausted at Prolonged Speed
Leap = Excessive leap at outlet
Drop = Excessive drop at outlet
Depth = Too shallow for substantial distance
Pool = Leap Pool too shallow
NONE = Not a barrier

FishXing V3.0 2006

Stream Crossing Race Road at 1893

Region ID: WA
Workspace ID: WA20220310234322184000
Clicked Point (Latitude, Longitude): 48.19047, -122.60091
Time: 2022-03-10 15:43:49 -0800



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.56	square miles
PRECPRIS10	Basin average mean annual precipitation for 1981 to 2010 from PRISM	21.4	inches
PRECIP	Mean Annual Precipitation	20	inches
BSLDEM30M	Mean basin slope computed from 30 m DEM	6.26	percent
CANOPY_PCT	Percentage of drainage area covered by canopy as described in OK SIR 2009_5267	69.1	percent

Parameter Code	Parameter Description	Value	Unit
ELEV	Mean Basin Elevation	196	feet
ELEVMAX	Maximum basin elevation	347	feet
MINBELEV	Minimum basin elevation	21.2	feet
NFSL30	North-Facing Slopes Greater Than 30 Percent	0	percent
RELIEF	Maximum - minimum elevation	325	feet
SLOP30_30M	Percent area with slopes greater than 30 percent from 30-meter DEM.	0	percent

Peak-Flow Statistics Parameters [Peak Region 3 2016 5118]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.56	square miles	0.08	2610
PRECPRIS10	Mean Annual Precip PRISM 1981 2010	21.4	inches	33.2	168

Peak-Flow Statistics Disclaimers [Peak Region 3 2016 5118]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Peak-Flow Statistics Flow Report [Peak Region 3 2016 5118]

Statistic	Value	Unit
50-percent AEP flood	3.72	ft^3/s
20-percent AEP flood	6.14	ft^3/s
10-percent AEP flood	7.87	ft^3/s
4-percent AEP flood	10.2	ft^3/s
2-percent AEP flood	12	ft^3/s
1-percent AEP flood	14	ft^3/s
0.5-percent AEP flood	16	ft^3/s

Statistic	Value	Unit
0.2-percent AEP flood	18.8	ft^3/s

Peak-Flow Statistics Citations

Mastin, M.C., Konrad, C.P., Veilleux, A.G., and Tecca, A.E.,2016, Magnitude, frequency, and trends of floods at gaged and ungaged sites in Washington, based on data through water year 2014 (ver 1.1, October 2016): U.S. Geological Survey Scientific Investigations Report 2016–5118, 70 p. (http://dx.doi.org/10.3133/sir20165118)

Low-Flow Statistics Parameters [Low Flow Western 2 var 2012 5078]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.56	square miles	0.1	48.9
PRECIP	Mean Annual Precipitation	20	inches	25.1	143

Low-Flow Statistics Disclaimers [Low Flow Western 2 var 2012 5078]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Low-Flow Statistics Flow Report [Low Flow Western 2 var 2012 5078]

Statistic	Value	Unit
7 Day 10 Year Low Flow	0.0171	ft^3/s

Low-Flow Statistics Citations

Curran, C.A., Eng, Ken, and Konrad, C.P.,2012, Analysis of low flows and selected methods for estimating low-flow characteristics at partial-record and ungaged stream sites in western Washington: U.S. Geological Survey Scientific Investigations Report 2012-5078, 46 p. (http://pubs.usgs.gov/sir/2012/5078/)

Bankfull Statistics Parameters [99.2 Percent (0.553 square miles) Pacific Mountain System D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.56	square miles	6.1776	8079.9147

Bankfull Statistics Parameters [99.2 Percent (0.553 square miles) Pacific Border P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.56	square miles	6.169878	3938.976756

Bankfull Statistics Parameters [99.2 Percent (0.553 square miles) USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.56	square miles	0.07722	59927.7393

Bankfull Statistics Parameters [Pac Maritime Mtn CastroJackson 2001]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.56	square miles	54.8	3093

Bankfull Statistics Disclaimers [99.2 Percent (0.553 square miles) Pacific Mountain System D Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Bankfull Statistics Flow Report [99.2 Percent (0.553 square miles) Pacific Mountain System D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	10.5	ft
Bieger_D_channel_depth	0.842	ft
Bieger_D_channel_cross_sectional_area	11.9	ft^2

Bankfull Statistics Disclaimers [99.2 Percent (0.553 square miles) Pacific Border P Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Bankfull Statistics Flow Report [99.2 Percent (0.553 square miles) Pacific Border P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	8.5	ft
Bieger_P_channel_cross_sectional_area	9.95	ft^2
Bieger_P_channel_depth	0.779	ft

Bankfull Statistics Flow Report [99.2 Percent (0.553 square miles) USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	10.1	ft
Bieger_USA_channel_depth	1.07	ft
Bieger_USA_channel_cross_sectional_area	12.5	ft^2

Bankfull Statistics Disclaimers [Pac Maritime Mtn CastroJackson 2001]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Bankfull Statistics Flow Report [Pac Maritime Mtn CastroJackson 2001]

Statistic	Value	Unit
Bankfull Width	9.66	ft
Bankfull Depth	0.526	ft
Bankfull Area	9.29	ft^2
Bankfull Streamflow	61.7	ft^3/s

Bankfull Statistics Citations

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub /1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF& utm_campaign=PDFCoverPages)

Castro, J.M, and Jackson, P.L.Castro, J.M, and Jackson, P.L., 2001, Bankfull Discharge Recurrence Intervals and Regional Hydraulic Geometery Relationships: Patterns in the Pacific Northwest, USA, Journal of the American Water Resources Association, Volume 37, No. 5, 14 p. (https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1752-1688.2001.tb03636.x)

Future Projections for Climate-Adapted Culvert Design

Project Name: Race road fish passage cu

Stream Name: Unnamed West culvert 185

Street Name: Race road

Culvert coordinates: 48.1906, -122.6009

Grid ID 48.21875_-122.59375

Ecoregion Pacific Maritime Mountains

Projected mean percent change in bankfull flow:

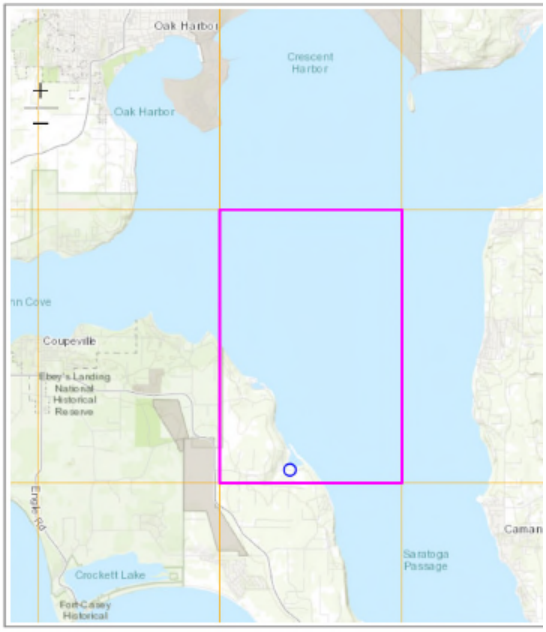
2040s: 9.9% **2080s:** 14.7%

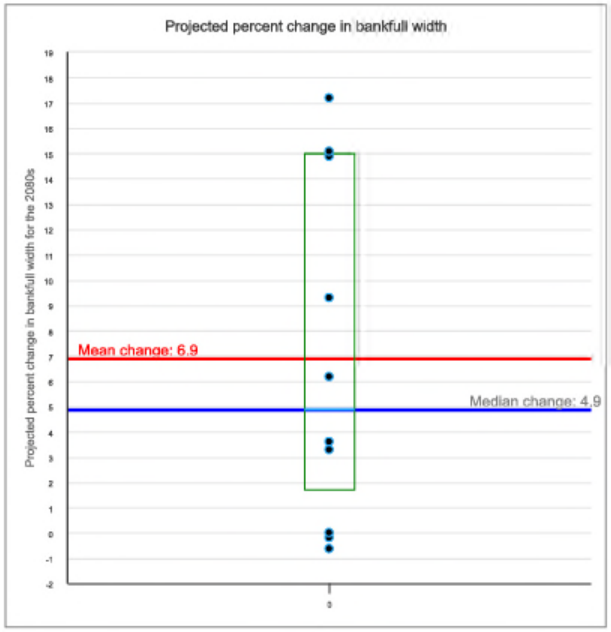
Projected mean percent change in bankfull width:

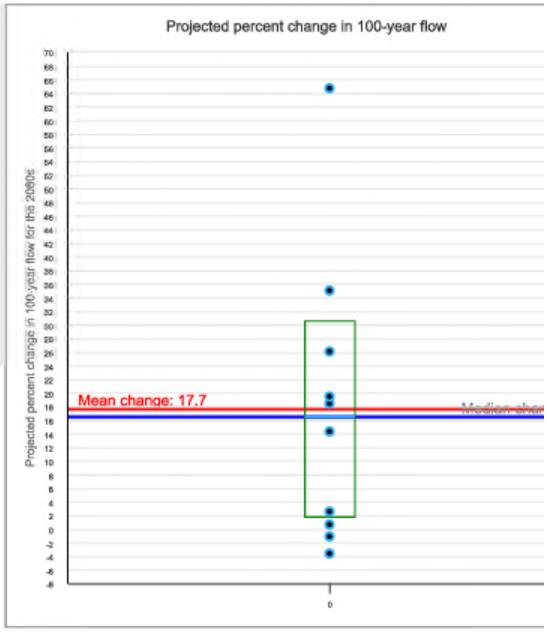
2040s: 4.7% **2080s:** 6.9%

Projected mean percent change in 100-year flood:

2040s: 8.8% **2080s:** 17.7%







Washington Department of
Fish and Wildlife

Fish Passage & Diversion Screening Inventory Database
Report Cover Sheet

The following report is extracted from the Washington Department of Fish and Wildlife's (WDFW) Fish Passage and Diversion Screening Inventory Database (FPDSI). WDFW makes every attempt to keep these reports in sync with FPDSI; however, the dynamic nature of the data and workflows associated with maintaining the database may result in short-term differences.

Users are encouraged to contact WDFW to discuss appropriate use of the data and how we can assist with fish passage barrier removal or inventory. Please visit the Fish Passage web site for contact information at: https://wdfw.wa.gov/species-habitats/habitat-recovery/fish-passage/about

Disclaimers:

- Data presented here represent a snapshot observation of conditions in a dynamic environment that is subject to change. Fish passage data are also collected from a variety of agencies and sources. Therefore, WDFW makes no guarantee concerning the data's content, accuracy, completeness, or the results obtained from use of the data. WDFW assumes no liability for the data represented here.
- These data are not an attempt to provide you with an official agency response as to the impacts of your project on fish and wildlife.
- Note that some fish passage features, habitats or species may occur in areas not currently known to the WDFW Fish Passage division, and may not be reflected in this database. A lack of data does not necessarily indicate that a feature, habitat, or species are not present.
- Unauthorized attempts to alter or modify these data are strictly prohibited.
- Bankfull width measurements included in these reports should not be used for fish passage crossing design. They are solely for assessment purposes.
- The barrier status reported in this document is based on the swimming abilities of adult salmonids. Passabilities are a qualitative value, and should not be interpreted as a quantitative calculation. Please see page 1-4 of the Fish Passage Inventory, Assessment and Prioritization Manual for further clarification: https://wdfw.wa.gov/publications/02061
- EXIF data presented with Image Reports may be erroneous due to camera battery failures and resetting of camera clock functions.

Abbreviations:

Most abbreviations in this report are defined in the Quick Reference Tables of the Fish Passage Inventory, Assessment, and Prioritization Manual. Additional commonly used abbreviations are defined as follows:

NFB = no potential salmonid use, **BB** = both banks, **LB** = left bank looking downstream, **RB** = right bank looking downstream, **US or U/S** = upstream, **DS or D/S** = downstream, **WSDrop** = water surface drop, **BFW** = bankfull width, **OHW** = ordinary high water, **SLW** = scour line width, **CMP** = corrugated metal pipe, Q_{fp} = fish passage flow, **V&D** = Velocity and Depth, **ROW** = Right of Way

The FPDSI database often uses default values such as '**-99.99**' or '**-999**' to represent null values.

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 609593 **Project** ☐ **Mitigated**

Geographic Coordinates

Latitude (WGS 84):	48.190567
Longitude (WGS 84):	-122.600867
East (NAD 83 HARN):	1,127,853.5
North (NAD 83 HARN)	1,048,934.0

Waterbody

Stream:	unnamed
Tributary To:	Race Lagoon
WRIA:	06
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Physical

General Location

Road Name:	Race Rd
Mile Post:	-999.99
County:	Island
WDFW Region:	4

Owner

Type:	County
Name:	Island County

PI Species

☐ Sockeye	☑ Chinook	☑ Sea Run Cutthroat
☐ Pink	☑ Coho	☑ Resident Trout
☑ Chum	☑ Steelhead	☐ Bull Trout

Associated Features

☑ Culvert	☐ Dam	☐ Natural Barrier	☐ Diversion
☐ Non-Culvert Xing	☐ Other	☐ Fishway	

Location/Directions

Site Comments

7/17/2023

These data represent a snapshot of the Washington Department of Fish and Wildlife's current records. Due to the ongoing nature of assessment and inventory of these features, these data may not accurately represent conditions on the ground, and are subject to change.

USGS Data Disclaimer: Unless otherwise stated, all data, metadata and related materials are considered to satisfy the quality standards relative to the purpose for which the data were collected. Although these data and associated metadata have been reviewed for accuracy and completeness and approved for release by the U.S. Geological Survey (USGS), no warranty expressed or implied is made regarding the display or utility of the data for other purposes, nor on all computer systems, nor shall the act of distribution constitute any such warranty.

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USGS Product Names Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Application Version: 4.7.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.2

Race Road Culvert and Bridge Calculator 1893

Values From Streamstats cfs

Return Yr	Value
2	3.72
5	6.14
10	7.87
25	10.2
50	12
100	14
200	16
500	18.8

Bieger BFW, feet 10.5 feet

Climate change Factors[1]

	Year factors		Increased Values	
	2040	*2080*	*2040*	*2080*
% increase in BFW Flow (2 year)	9.9	14.7	4.1	4.3 cfs
% increase in BFW Width	4.7	6.9	11.0	11.2 feet
% increase in 100 year Flood	8.8	17.7	15.2	16.5 cfs

[1] WDFW, web-based analysis. Culverts and Climate Change, changes in bank full width and flow rates in culverts in Washington state. Developed in conjunction with University of Washington 2021. https://geodataservices.wdfw.wa.gov/hp/culvert-app/#aboutTab

Where; Pll in the Prediction Interval limit lower, Plu is the Prediction Interval limit upper, and AESp is the Avergae Standard error of Prediction.

References;

Mastin, M.C., Konrad, C.P., Veilleux, A.G., and Tecca, A.E.,2016, Magnitude, frequency, and trends of floods at gaged and ungaged sites in Washington, based on data through water year 2014 (ver 1.1, October 2016): U.S. Geological Survey Scientific Investigations Report 2016–5118, 70 p.

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p.

Castro, J.M, and Jackson, P.L.Castro, J.M, and Jackson, P.L., 2001, Bankfull Discharge Recurrence Intervals and Regional Hydraulic Geometery Relationships: Patterns in the Pacific Northwest, USA, Journal of the American Water Resources Association, Volume 37, No. 5, 14 p.

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID:	**609593**				
Latitude:	**48.190567**	Stream:	**unnamed**	WRIA:	**06**
Longitude:	**-122.600867**	Tributary To:	**Race Lagoon**	Fish Use Potential:	**Yes**

Data Source: Skagit Fisheries Enhancement Group

Field Crew: George;Matthews;PM Review Date: 3/5/2020

Culvert Details — **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)	Sediment
1.1	RND	CST	0.85	0.85	18.60	0.05	NO	0.17	Inlet	No	No	3.08	

All dimensions in meters

Channel Description

Toe Width (m):	
Average Width (m):	1.17
Culvert/Stream Width Ratio:	0.73

Plunge Pool

Length (m):	2.10
Max Depth (m):	0.43
OHW Width (m):	2.40

Road

Fill Depth (m):	2.00

Assessment Results

		Tidal Influence:	Yes	Tidegate Present:	No
Barrier:	Unknown	Passability (%):	Unknown	Method:	Level A
Reason:	nsufficient Data	Fishway Present:	No	Recheck:	

Comments

Tidal influence, Level T required

Potential Habitat Gain

Survey Type:		Spawning (sq m):		Length (m):	
Significant Reach:	Unknown	Rearing (sq m):		**PI Total**	

7/17/2023

These data represent a snapshot of the Washington Department of Fish and Wildlife's current records. Due to the ongoing nature of assessment and inventory of these features, these data may not accurately represent conditions on the ground, and are subject to change.

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID:	**609593**				
Latitude:	**48.190567**	Stream:	**unnamed**	WRIA:	**06**
Longitude:	**-122.600867**	Tributary To:	**Race Lagoon**	Fish Use Potential:	**Yes**

Data Source: Skagit Fisheries Enhancement Group

Field Crew: George;Matthews;PM Review Date: 3/5/2020

Culvert Details / **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)	Sediment
1.1	RND	CST	0.85	0.85	18.60	0.05	NO	0.17	Inlet	No	No	3.08	

All dimensions in meters

Channel Description

Toe Width (m):	
Average Width (m):	1.17
Culvert/Stream Width Ratio:	0.73

Plunge Pool

Length (m):	2.10
Max Depth (m):	0.43
OHW Width (m):	2.40

Road

Fill Depth (m):	2.00

Assessment Results

		Tidal Influence:	Yes	Tidegate Present:	No
Barrier:	Unknown	Passability (%):	Unknown	Method:	Level A
Reason:	nsufficient Data	Fishway Present:	No	Recheck:	

Comments

Tidal influence, Level T required

Potential Habitat Gain

Survey Type:		Spawning (sq m):		Length (m):	
Significant Reach:	Unknown	Rearing (sq m):		**PI Total**	

7/17/2023

These data represent a snapshot of the Washington Department of Fish and Wildlife's current records. Due to the ongoing nature of assessment and inventory of these features, these data may not accurately represent conditions on the ground, and are subject to change.

WDFW Fish Passage and Diversion Screening Inventory Database

Image Report - Active

Site ID:	**609593**				
Latitude:	**48.190567**	Stream:	**unnamed**	WRIA:	**06**
Longitude:	**-122.600867**	Tributary To:	**Race Lagoon**	Fish Use Potential:	**Yes**

Associated Features

☑ Culvert	☐ Dam	☐ Natural Barrier	☐ Diversion
☐ Non-Culvert Xing	☐ Other	☐ Fishway	

Image Name: 609593_1.jpg, Date/Time: 03/05/2020 10:41

Image Name: 609593_2.jpg, Date/Time: 03/05/2020 10:49

7/17/2023

These data represent a snapshot of the Washington Department of Fish and Wildlife's current records. Due to the ongoing nature of assessment and inventory of these features, these data may not accurately represent conditions on the ground, and are subject to change.

Correction Analysis Form

Site Information (measurements in feet)

Project Name: Island Co. Culvert Prioritization – Area 2 Culvert #1893 | *SRFB Project #: 19-1343* | *Date: 9/24/21*

Bankfull Width (outside influence of culvert): 5.9' u.s., 8.8' d.s. | Utilities Crossing: ☒ Yes ☐ No ☐ Unknown

Road Fill at Culvert Invert: 8.9' outlet IE to road surface | Road Width: 31.5' shoulder to shoulder

Road Description/Condition (mainline, spur road, driveway/access): 2 lane county road

Evaluator Information

Evaluator Name: **Tom Slocum, PE** | Affiliation: **Whidbey Island Conservation District**

Mailing Address: **PO Box 490** | City: **Coupeville** | State: **WA** | Zip: **98239**

Telephone: | FAX: | Cell: 360 899-6041 | E-mail: tom@skagitcd.org

Upstream Habitat/Channel Description

Channel Slope (outside of culvert influence): 3.9% | Re-grade Potential (streambed US – streambed DS in feet): 2.30

Dominant Substrate: ☐ Sand (<1/5") ☒ Gravel (1/5"–3") ☐ Cobble (3"-12") ☐ Boulder (>12") ☐ Bedrock

Additional Upstream Information, Habitat Description, Other Site Conditions or Concerns, Including Potential Re-Grade Impacts Relative to Channel Stability And Habitat:

The channel u.s. of the culvert crossing is a straightened, excavated ditch thorugh dense blackberry thicket with no in-channel habitat features for at least 60 feet upstream of the crossing. The channel intersects the road ditch 5' u.s. of culvert.

Downstream Habitat/Channel Description

Channel Slope: 1.5% (outside of culvert influence)

Additional Downstream Information, Habitat Description, Other Site Conditions or Concerns:

The channel is a straightened ditch for 20 feet d.s. of the culvert crossing, then enters a less-impacted, more natural channel that runs through rose and hawthorne hedges to Race Lagoon. Tidal elevations were not measured. Tne stream is classified as Type F. See the profile drawing.

Correction Options and Preferred Alternative

Options to Consider – Provide up to Three Site-Appropriate Correction Alternatives.

Option 1: **60' x 14' diameter bottomless arch culvert, per Stream Simulation design.**

Option 2: **60' x 13' x 7' high 3-sided concrete box culvert, per Stream Simulation design**

Option 3: **25' x 26' prefabricated concrete bridge**

Preferred Alternative - Provide a 1- or 2-paragraph Recommendation for this Site. Include any Site-Specific Concerns that Will Need to be Addressed During Design and Construction:

Option 1 is simplest and cheapest to construct, but depending on tidal elevations, may be susceptible to salt-water corrosion. Tidal elevations need to be determined to verify this. The bridge option likely would be unfavorable to Island Count DPW due to maintenance requirements. All options may require some degree of relocating water and phone utility lines, depending on the locations (be be determined).

Cost Estimates

Rough Cost Estimate* - Attach Detailed Cost Breakdown Using the Appropriate Cost Estimate Template, Provided Separately.

Option 1: $368,200

Option 2: $566,500

Option 3: $484,000

*This is a rough approximation of project costs; actual costs may vary depending on specifications identified during final design.

Correction Analysis Form Instructions

This will be completed for projects determined to be of potential high benefit to fish resources based on the information provided in Barrier Evaluation Form and Expanded Barrier Evaluation Form. The completed forms will be used to develop a prioritized list of projects to be presented to SRFB for potential funding.

Site Information

Project Name–This is the landowner's last name followed by the creek name. If more than one site per landowner is evaluated on the same creek, designate each site with a letter, e.g. Franklin–Boulder Creek A.

RCO/SRFB Project Number–This will be provided by PRISM database.

Bankfull Width–The stream width measured perpendicular to flow at the stage at which water begins to overflow into the active flood plain. Bankfull width requires a floodplain or a bench not present in many channels. In those cases, use ordinary high water. O ordinary high water is where the regular stream flow makes a line on the bank marking soil or vegetation with a character distinct from that of the abutting upland. Also defined as the lowest point at which perennial vegetation grows on the stream bank. Enter the average of several bankfull width measurements taken up and/or downstream of the culvert, outside the influence of the culvert.

Utilities Crossing–Include any water, gas, phone or electrical utilities at the crossing to be affected by project construction.

Road Fill at Downstream End–Measure height of material from top of culvert to top of fill at downstream end.

Road Width–Measurement should include shoulders.

Road Description/Condition–Provide a brief description of the road surface, use, condition, etc.

Evaluator Information

Provide contact information for the people completing the Correction Analysis Form.

Upstream Habitat and Channel Description

Channel Slope–This is measured outside of the culvert influence.

Re-grade Potential–Subtract the downstream streambed elevation from the upstream streambed elevation at the site.

Dominant Substrate–Identify the size category most prominent in the substrate.

Additional Information–Provide any additional upstream information that may be important to the project.

Downstream Habitat and Channel Description

Channel Slope–This is measured outside of the culvert influence.

Additional Information–Provide any additional upstream information that may be important to the project.

Correction Options and Preferred Alternative

Options to Consider–The purpose of this section is to provide the sponsor some guidance on the intended fix. Most small forest landowner projects should be relatively straightforward; however each site is different.

Preferred Alternative–Describe the recommended correction and site-specific concerns to be addressed during design and construction.

Cost Estimates

Rough cost estimate–Provide estimated costs for correction options listed above. Costs should be based on cost estimate templates, provided separately, for culverts, bottomless arch culverts, and bridges. Attach the corresponding completed template for each estimate. These represent approximate costs; actual costs may vary depending on specifications identified during final project design.

CULVERT EVALUATION FIELD FORM (LEVEL A)

Site ID:[1]	1893	Culvert #:[2]	1.1	Date:[3]	3/5/20		Old ID:[4]	
SKCO ID:[5]		Org:[6]	SFEG	Crew:[7]	EM, JG PM		Stream.[8]	

PHOTOS TAKEN:[9] (US Culv) US Channel DS Culv DS Channel Road Right Road Left (Other)

ROAD DESCRIPTION

Road Surface Type:[10]	CS (A) GR Other	Road Width (including shoulders):[14]	8.87 meters
Temporary Access Needed?[11]	Yes (No) Unknown	Road Fill Depth:[15] (B-D)	1.95 meters
In-Road Utilities:[12]	(Yes) No Unknown	US Road Prism Depth:[16] (A-E)	2.145 meters
Overhead Utilities/Crossings:[13]	Yes (No) Unknown	DS Road Prism Depth:[17] (B-F)	2.88 meters

Road Notes:[18]

CULVERT DESCRIPTION

Culvert Shape:[19]	(RND) BOX ARCH SQSH ELL Other	Length of Culvert:[28]	18.63 meters
Culvert Material:[20]	PCC CPC (CST) SST SPA MRY CAL SPS PVC TMB Other	Culvert Span:[29]	0.95 meters
		Rise of Culvert:[30]	use SAME FOR RISE meters
Number of Baffles:[21] (If > 0, fill out fishway form)	NA	Culvert Slope:[31] $\left(\frac{\text{US Invert}^E - \text{DS Invert}^F}{\text{Length}^{28}}\right) \times 100$	%
Baffle Type:[22]	Concrete Metal Wood Plastic Rock Other	Water Depth:[32]	5"=5 cm meters
		Hydraulic Drop:[33]	17cm 19cm meters
Apron?[23]	US DS (No)	Drop Location:[34]	(Inlet) Outlet (Interior)
Gate?[24]	US DS (No)	**Plunge Pool Description (N/A if no Hydraulic Drop)**	
Fishway?[25] (If yes, fill out fishway form)	YES (No)	Plunge Pool Length:[35]	2.1 meters
Countersunk?[26]	YES (No)	Maximum Depth:[36]	0.43 meters
Backwatered?[27]	YES (No)	Scour Line Width:[37]	2.4 meters

Culvert Notes:[38] (If multiple culverts at site, indicate defining features of each)
SLIGHTLY CRUSHED AT UP STREAM END UPSTREAM DROP 17cm
TOTALLY RUSTED OUT AT BOTTOM, no inverts taken
MEASURED ELEVATION DROP FROM DS 19cm 1M IN CULVERT

CHANNEL DESCRIPTION

Channel Width:[39] 1.17m	Culvert Span ÷ Channel Width:[40] (29÷39)

Channel Notes:[41]

BARRIER STATUS[42] (Circle one below)

Passable[43]	Barrier Reason[44]		Level B Analysis Required[45]		
	Drop > .24 M	(Slope >= 1%)	Backwatered	Slope < 1%	Culvert Width < 75%

Barrier Notes:[46]

CULVERT EVALUATION FIELD FORM (LEVEL A): CALCULATIONS

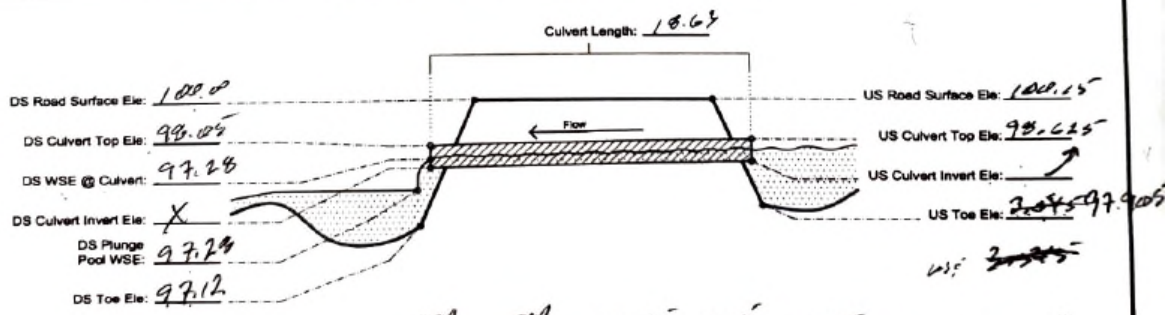
Site ID: 1893 Culvert #: 1.1 Date: 3-5-2020

FS	IH	BS	EL	NOTE
	101.45	1.45	100.000	BENCH MARK
~~3.325~~	"		~~98.125 3.46 3.325~~	~~US WSE 30cm~~
4.46	"		96.99 3.46	INLET WSE
4.17	"		97.28	DS WSE
4.33	"		97.12	DS TOE
~~1.45~~	"	1.45	100.000	BS
3.545			97.905	US TOE

ENTER FINAL MEASUREMENTS HERE

US Road Shoulder:[A]	1.320 / 100.17	DS Road Shoulder:[B]	1.45 / 100	22-1000 (BM)
US Culvert Top:[C]	2.825 / 98.625	DS Culvert Top:[D]	3.40 / 98.05	
US Culvert Invert:[E]	RUSTED OUT	DS Culvert Invert:[F]	RUSTED OUT	

SCHEMATIC OF CULVERT MEASUREMENTS



Slope = (US Invert — DS Invert) / Culvert Length = (98.625 − 98.05) / 18.63 = 0.03 3.08%

Note: *If culvert is countersunk, use bed elevations to calculate slope*

Hydraulic Drop = DS WSE @ Culvert — DS Plunge Pool WSE = ~~97.28 − 98.05~~ = ____

*Simpler to use invert in place of toe if this is representative of road prism. If toe of prism elevation is greatly different than invert elevation, use toe.

DS Prism Depth = DS Road Surface — DS Toe 100.17 − 97.12 = 2.88

US Prism Depth = US Road Surface — US Toe = 100.17 − 97.905 = 2.345

19mm - 1mm in SWE Drop

17

Crossing Report for Race Road Small Culvert to East 1894

Project: Hydraulics and FishXing

Table 1. Project Summary for Hydraulics and FishXing

File Name	Crossing Name	Stream Name	Culvert Length	QLP	QHP	% Passable
small Race Road.xng	Race Road	unnamed	74 ft	2 cfs	8.55 cfs	100.0%

Crossing Location Information

Crossing Name: Race Road Small Culvert to East 1894
Stream Name: unnamed
Road: Race Road

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Design Flows
Low Passage Flow: 2.3 cfs
High Passage Flow: 8.9 cfs

Tailwater Information
Tailwater Option: Tailwater Channel Cross-Section
Channel Bottom Slope: 3%
Outlet-Pool Bottom Elevation: 13.67 ft

Table 2. Tailwater Cross Section Data.

Station (ft)	Elevation (ft)	Roughness Coefficient
0.00	16.00	0.055
1.00	14.00	
8.50	14.00	
9.50	16.00	

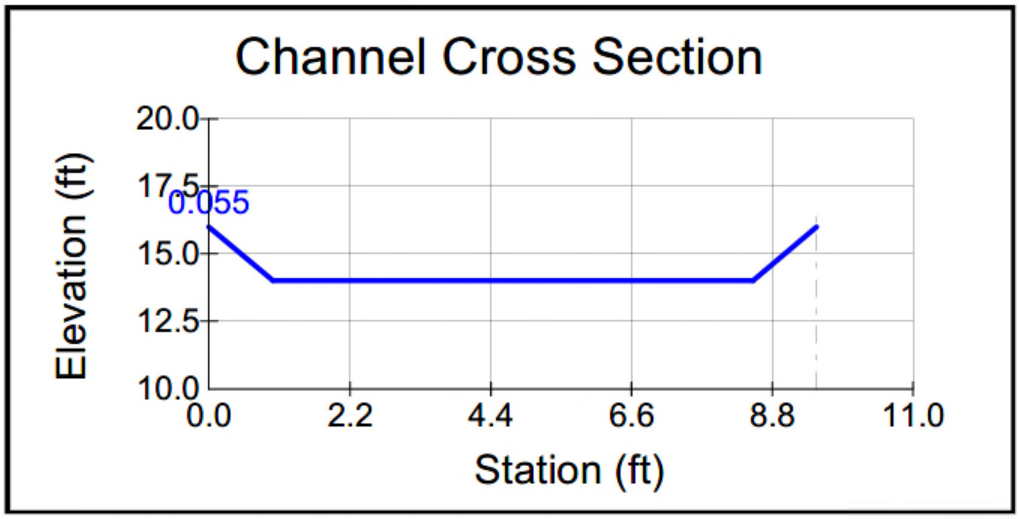

Figure 1. Channel Cross Section at Tailwater Crest.

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Table 3. Tailwater Rating Table Information.

Discharge (cfs)	Tailwater Elevation (ft)	Wetted Perimeter (ft)	Cross-Sect. Area (sq. ft)	Composite Roughness Coefficient
0.0	14.0	0.00	0.00	0.000
0.7	14.1	7.72	0.75	0.055
2.4	14.2	7.95	1.52	0.055
4.6	14.3	8.17	2.29	0.055
7.4	14.4	8.39	3.08	0.055
10.6	14.5	8.62	3.87	0.055
14.3	14.6	8.84	4.68	0.055
18.4	14.7	9.07	5.49	0.055
22.9	14.8	9.29	6.32	0.055
27.7	14.9	9.51	7.15	0.055
32.8	15.0	9.74	8.00	0.055
38.3	15.1	9.96	8.85	0.055
44.1	15.2	10.18	9.72	0.055
50.2	15.3	10.41	10.59	0.055
56.5	15.4	10.63	11.48	0.055
63.2	15.5	10.85	12.37	0.055
70.1	15.6	11.08	13.28	0.055
77.3	15.7	11.30	14.19	0.055
84.8	15.8	11.52	15.12	0.055
92.5	15.9	11.75	16.06	0.055
100.5	16.0	11.97	17.00	0.055

FishXing V3.0 2006

Table 8. Culvert Profiles for 8.9 cfs.

	Profiles for Q = 8.90 cfs				
Dist Down Culvert (ft)	Depth (ft)	Velocity Average (ft/s)	Velocity Occupied (ft/s)	Swim Mode	Barrier Type
0	0.74	0.00	0.00	Prolonged	NONE
3	0.63	2.64	2.64	Prolonged	
6	0.63	2.03	2.02	Prolonged	
10	0.63	2.03	2.02	Prolonged	
14	0.63	2.03	2.02	Prolonged	
18	0.63	2.03	2.02	Prolonged	
22	0.63	2.03	2.02	Prolonged	
26	0.63	2.03	2.02	Prolonged	
30	0.64	1.99	1.98	Prolonged	
34	0.64	1.97	1.97	Prolonged	
38	0.65	1.96	1.95	Prolonged	
42	0.66	1.94	1.94	Prolonged	
46	0.66	1.92	1.91	Prolonged	
50	0.67	1.89	1.89	Prolonged	
54	0.68	1.86	1.85	Prolonged	
58	0.70	1.82	1.82	Prolonged	
62	0.71	1.78	1.78	Prolonged	
66	0.73	1.74	1.73	Prolonged	
70	0.75	1.69	1.68	Prolonged	
74	0.78	1.64	1.63		

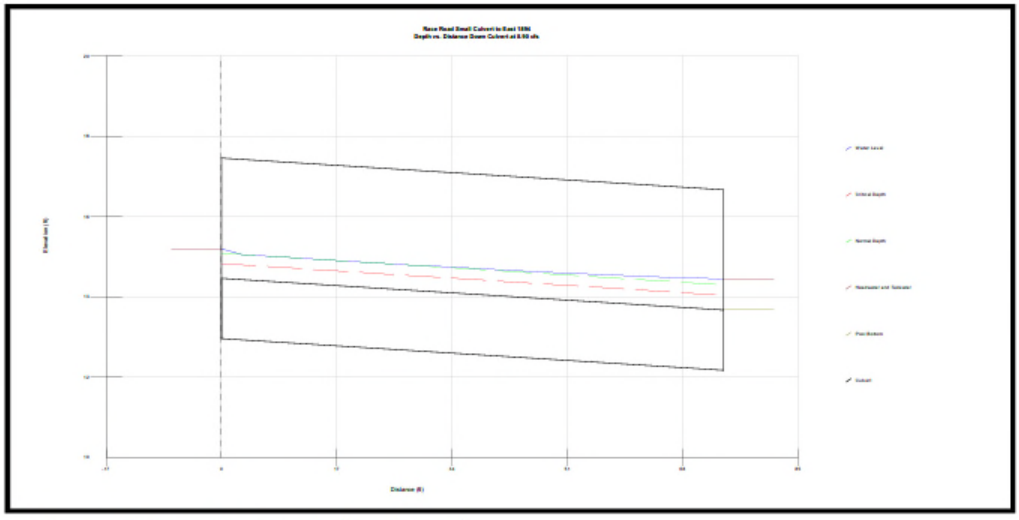

Figure 5. Water Surface Profile at 8.9 cfs

FishXing V3.0 2006

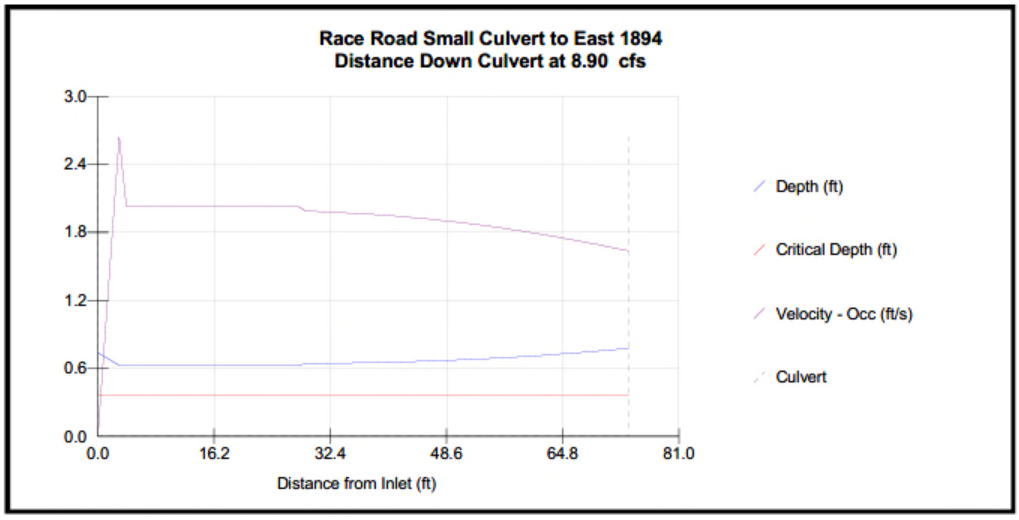

Figure 6. Culvert Profiles at 8.9 cfs

Table 9. Culvert Summary for 1 cfs.

Summary for Q = 1.00 cfs	
Normal Depth (ft)	0.17
Critical Depth (ft)	0.09
Headwater Depth (ft)	0.19
HW/D	0.06
Inlet Velocity (ft/s)	1.11
Tailwater Depth (ft)	0.45
Outlet Water Surface Drop (fl	0.00
Prolonged Swim Time (min)	0.28
Burst Swim Time (s)	0.00
Barrier Code	Depth

FishXing V3.0 2006

Table 10. Culvert Profiles for 1 cfs.

	Profiles for Q = 1.00 cfs				
Dist Down Culvert (ft)	Depth (ft)	Velocity Average (ft/s)	Velocity Occupied (ft/s)	Swim Mode	Barrier Type
0	0.19	0.00	0.00	Prolonged	Depth
3	0.17	1.11	1.10	Prolonged	Depth
6	0.17	0.85	0.84	Prolonged	Depth
10	0.17	0.85	0.84	Prolonged	Depth
14	0.17	0.85	0.84	Prolonged	Depth
18	0.17	0.85	0.84	Prolonged	Depth
22	0.17	0.85	0.84	Prolonged	Depth
26	0.17	0.85	0.84	Prolonged	Depth
30	0.17	0.85	0.84	Prolonged	Depth
34	0.17	0.85	0.84	Prolonged	Depth
38	0.17	0.82	0.82	Prolonged	Depth
42	0.18	0.78	0.78	Prolonged	Depth
46	0.20	0.72	0.72	Prolonged	Depth
50	0.22	0.64	0.64	Prolonged	
54	0.25	0.57	0.56	Prolonged	
58	0.29	0.50	0.49	Prolonged	
62	0.32	0.44	0.44	Prolonged	
66	0.36	0.39	0.39	Prolonged	
70	0.40	0.35	0.35	Prolonged	
74	0.45	0.32	0.32		

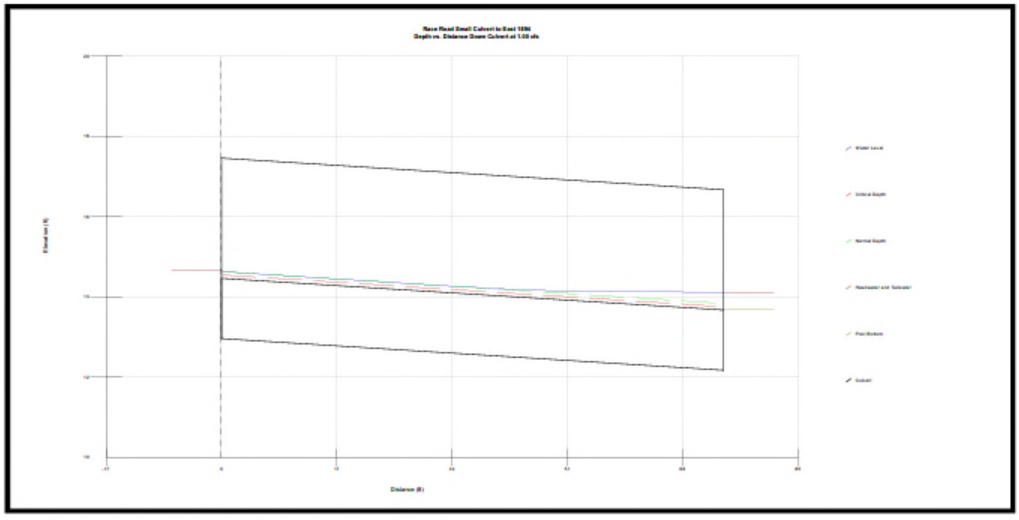

Figure 7. Water Surface Profile at 1 cfs

FishXing V3.0 2006

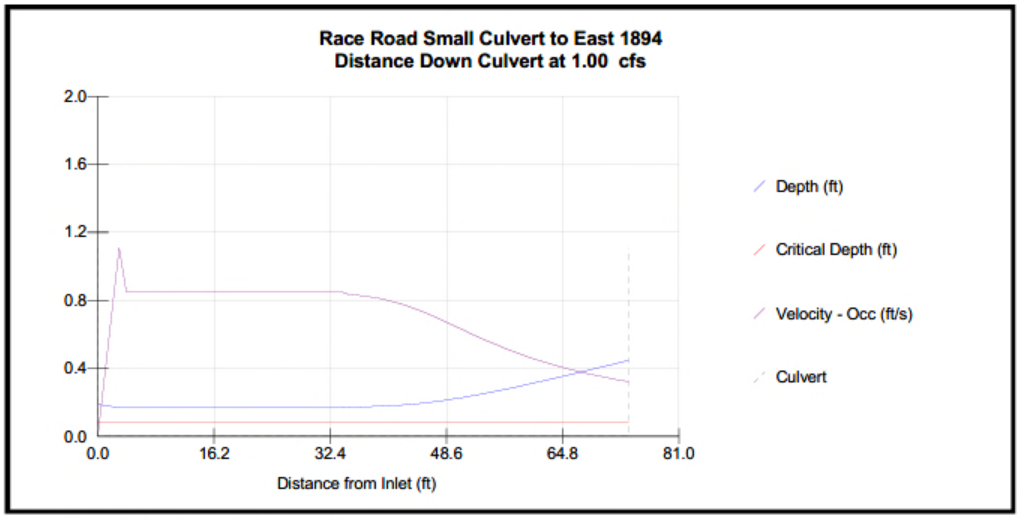

Figure 8. Culvert Profiles at 1 cfs

FishXing V3.0 2006

Table 11. Culvert Rating Table.

Q total (cfs)	Depth Min (ft)	V(occ) Max (ft/s)	Depth TW (ft)	Outlet WS Drop (ft)	Depth Pool (ft)	Barrier Type
0.00	0.00	0.00	-13.67	13.67	-13.67	Drop; Depth; P
0.44	0.10	0.80	0.39	0.00	0.39	Depth
0.88	0.16	1.05	0.44	0.00	0.44	Depth
1.32	0.20	1.24	0.47	0.00	0.47	Depth
1.76	0.24	1.39	0.49	0.00	0.49	NONE
2.30	0.28	1.54	0.53	0.00	0.53	NONE
2.74	0.31	1.66	0.55	0.00	0.55	NONE
3.18	0.34	1.76	0.57	0.00	0.57	NONE
3.62	0.36	1.85	0.59	0.00	0.59	NONE
4.06	0.39	1.94	0.61	0.00	0.61	NONE
4.50	0.42	2.02	0.63	0.00	0.63	NONE
4.94	0.44	2.09	0.64	0.00	0.64	NONE
5.38	0.46	2.16	0.66	0.00	0.66	NONE
5.82	0.49	2.23	0.67	0.00	0.67	NONE
6.26	0.51	2.30	0.69	0.00	0.69	NONE
6.70	0.53	2.36	0.71	0.00	0.71	NONE
7.14	0.55	2.42	0.72	0.00	0.72	NONE
7.58	0.57	2.48	0.74	0.00	0.74	NONE
8.02	0.59	2.54	0.75	0.00	0.75	NONE
8.46	0.61	2.59	0.76	0.00	0.76	NONE
8.90	0.63	2.64	0.78	0.00	0.78	NONE
9.34	0.65	2.69	0.79	0.00	0.79	NONE
9.78	0.66	2.74	0.80	0.00	0.80	NONE
10.22	0.68	2.79	0.82	0.00	0.82	NONE
10.66	0.70	2.84	0.83	0.00	0.83	NONE
11.10	0.72	2.88	0.84	0.00	0.84	NONE
11.54	0.73	2.93	0.85	0.00	0.85	NONE
11.98	0.75	2.97	0.87	0.00	0.87	NONE
12.42	0.77	3.01	0.88	0.00	0.88	NONE
12.86	0.78	3.05	0.89	0.00	0.89	NONE
13.35	0.80	3.10	0.90	0.00	0.90	NONE

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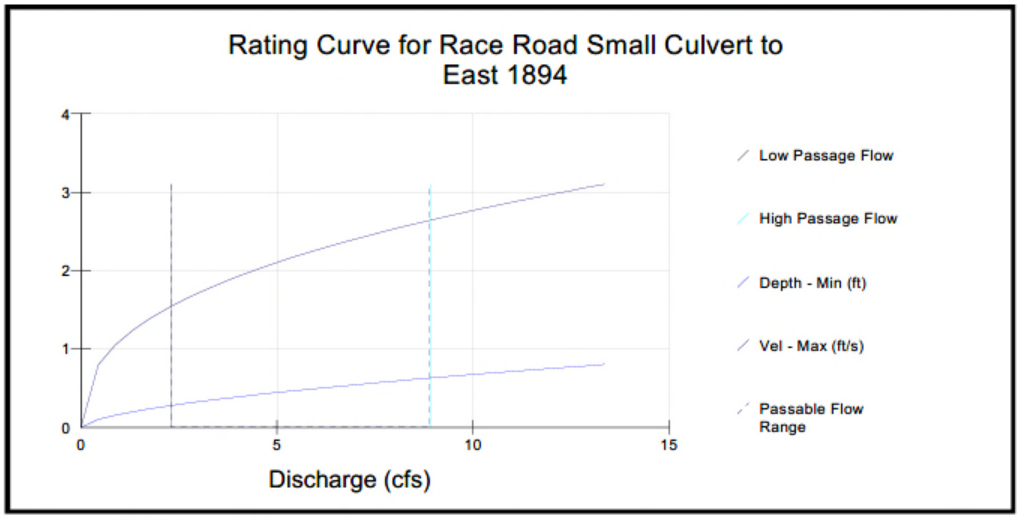


Figure 9. Culvert Rating Curve

Barrier Codes

V = Strict Velocity Barrier
EB = Fish Exhausted at Burst Speed
Long = Fish Exhausted at Prolonged Speed
Leap = Excessive leap at outlet
Drop = Excessive drop at outlet
Depth = Too shallow for substantial distance
Pool = Leap Pool too shallow
NONE = Not a barrier

FishXing V3.0 2006

Table 3. Tailwater Rating Table Information.

Discharge (cfs)	Tailwater Elevation (ft)	Wetted Perimeter (ft)	Cross-Sect. Area (sq. ft)	Composite Roughness Coefficient
0.0	14.0	0.00	0.00	0.000
0.7	14.1	7.72	0.75	0.055
2.4	14.2	7.95	1.52	0.055
4.6	14.3	8.17	2.29	0.055
7.4	14.4	8.39	3.08	0.055
10.6	14.5	8.62	3.87	0.055
14.3	14.6	8.84	4.68	0.055
18.4	14.7	9.07	5.49	0.055
22.9	14.8	9.29	6.32	0.055
27.7	14.9	9.51	7.15	0.055
32.8	15.0	9.74	8.00	0.055
38.3	15.1	9.96	8.85	0.055
44.1	15.2	10.18	9.72	0.055
50.2	15.3	10.41	10.59	0.055
56.5	15.4	10.63	11.48	0.055
63.2	15.5	10.85	12.37	0.055
70.1	15.6	11.08	13.28	0.055
77.3	15.7	11.30	14.19	0.055
84.8	15.8	11.52	15.12	0.055
92.5	15.9	11.75	16.06	0.055
100.5	16.0	11.97	17.00	0.055

FishXing V3.0 2006

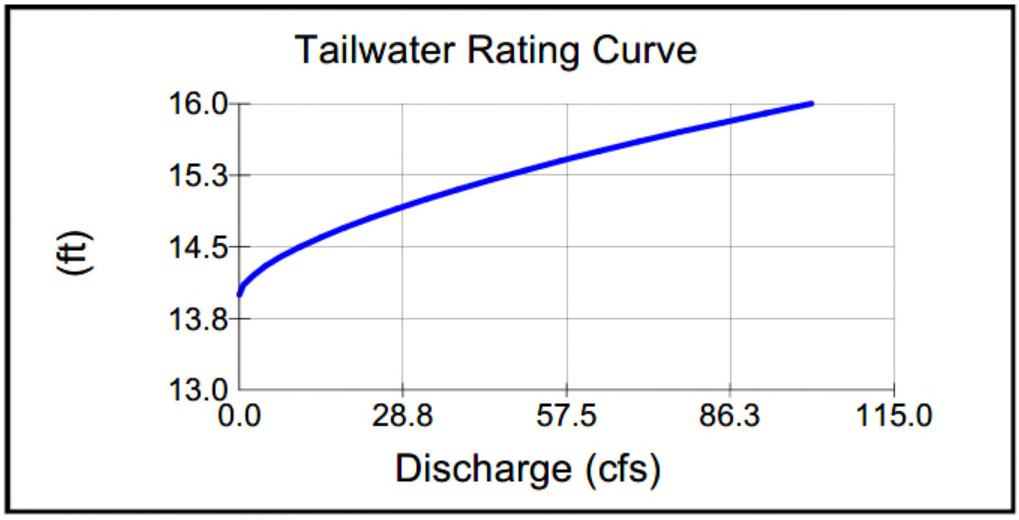


Figure 2. Tailwater Rating Curve

Table 4. Fish Passage Summary.

Fish Passage Summary	
Low Passage Design Flow	2.30 cfs
High Passage Design Flow	8.90 cfs
Percent of Flows Passable	100.0 %
Passable Flow Range	2.30 to 8.90 cfs
Depth Barrier	None
Outlet Drop Barriers	None
Velocity Barrier	None
Pool Depth Barrier	None

Table 5. Culvert Summary for 2.30 cfs.

Summary for Q = 2.30 cfs	
Normal Depth (ft)	0.28
Critical Depth (ft)	0.15
Headwater Depth (ft)	0.31
HW/D	0.10
Inlet Velocity (ft/s)	1.54
Tailwater Depth (ft)	0.53
Outlet Water Surface Drop (fl	0.00
Prolonged Swim Time (min)	0.30
Burst Swim Time (s)	0.00
Barrier Code	NONE

FishXing V3.0 2006

Table 6. Culvert Profiles for 2.30 cfs.

	Profiles for Q = 2.30 cfs				
Dist Down Culvert (ft)	Depth (ft)	Velocity Average (ft/s)	Velocity Occupied (ft/s)	Swim Mode	Barrier Type
0	0.31	0.00	0.00	Prolonged	NONE
3	0.28	1.54	1.54	Prolonged	
6	0.28	1.18	1.16	Prolonged	
10	0.28	1.18	1.16	Prolonged	
14	0.28	1.18	1.16	Prolonged	
18	0.28	1.18	1.16	Prolonged	
22	0.28	1.18	1.16	Prolonged	
26	0.28	1.18	1.16	Prolonged	
30	0.28	1.18	1.16	Prolonged	
34	0.29	1.15	1.15	Prolonged	
38	0.29	1.13	1.12	Prolonged	
42	0.30	1.09	1.09	Prolonged	
46	0.31	1.05	1.04	Prolonged	
50	0.33	0.99	0.98	Prolonged	
54	0.36	0.92	0.92	Prolonged	
58	0.39	0.85	0.85	Prolonged	
62	0.42	0.79	0.78	Prolonged	
66	0.45	0.73	0.72	Prolonged	
70	0.49	0.67	0.67	Prolonged	
74	0.53	0.62	0.62		

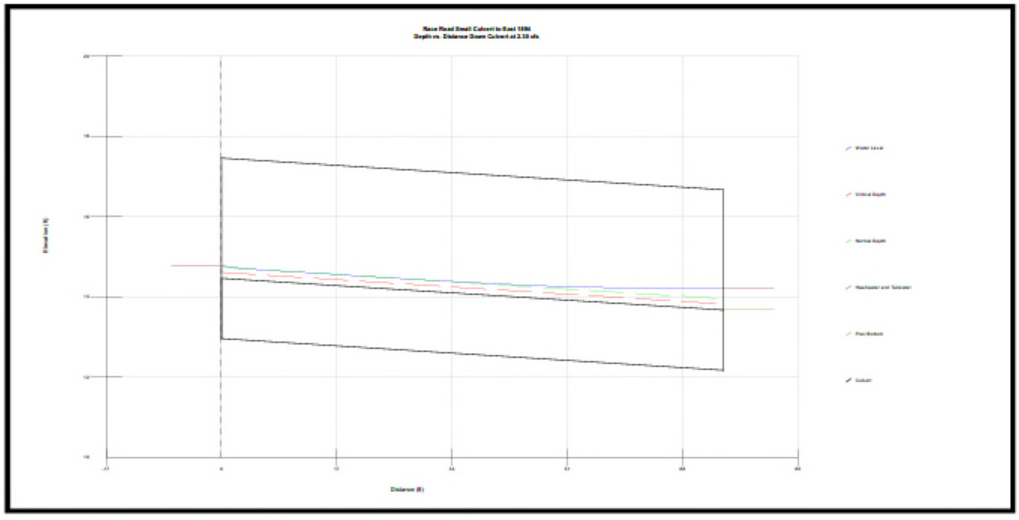


Figure 3. Water Surface Profile at 2.3 cfs

FishXing V3.0 2006

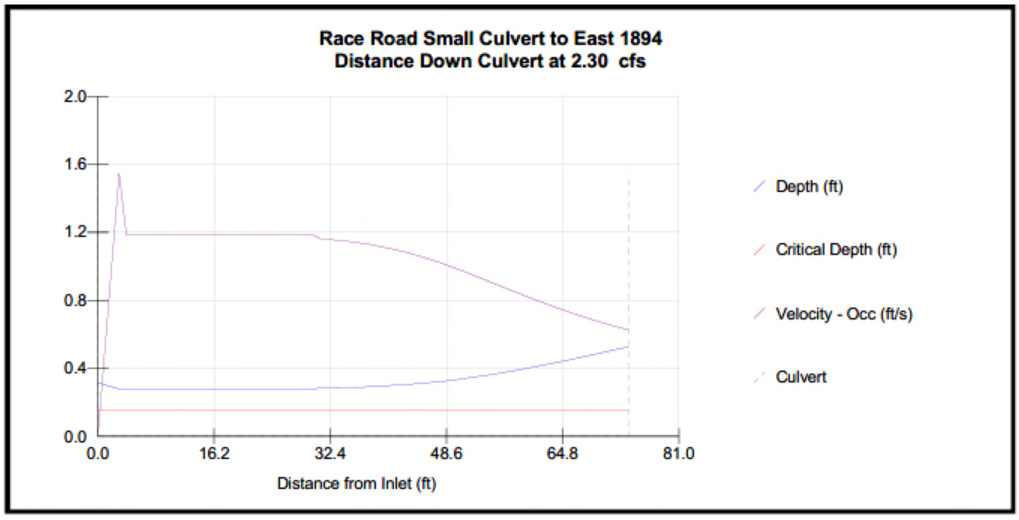


Figure 4. Culvert Profiles at 2.3 cfs

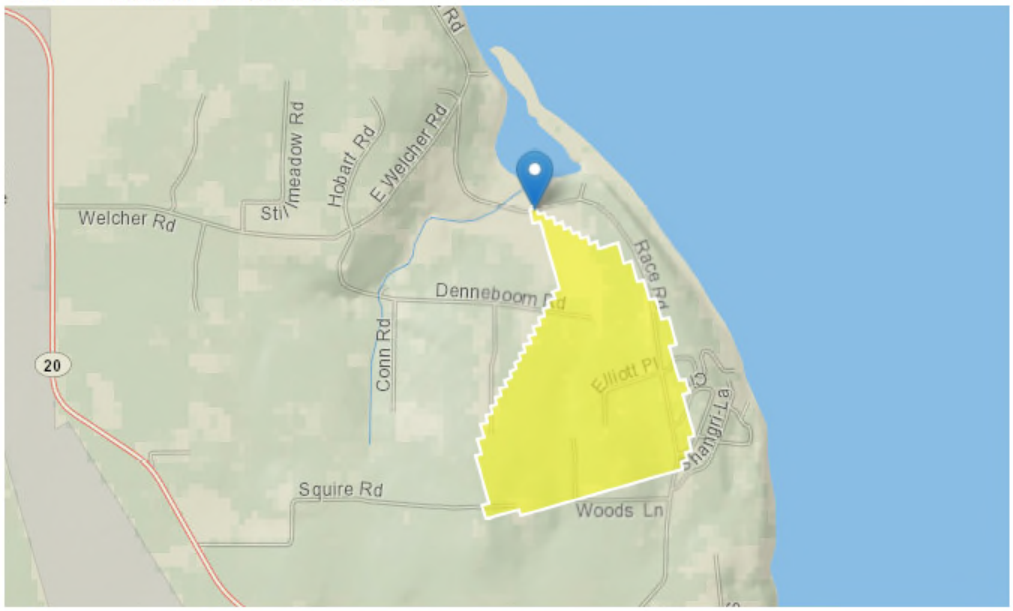
Table 7. Culvert Summary for 8.9 cfs.

Summary for Q = 8.90 cfs	
Normal Depth (ft)	0.63
Critical Depth (ft)	0.37
Headwater Depth (ft)	0.74
HW/D	0.25
Inlet Velocity (ft/s)	2.64
Tailwater Depth (ft)	0.78
Outlet Water Surface Drop (fl	0.00
Prolonged Swim Time (min)	0.39
Burst Swim Time (s)	0.00
Barrier Code	NONE

FishXing V3.0 2006

Race Road Culvert Stream Stats at 1894 SE Culvert

Region ID: WA
Workspace ID: WA20220311000053870000
Clicked Point (Latitude, Longitude): 48.19019, -122.59897
Time: 2022-03-10 16:01:20 -0800



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.28	square miles
PRECPRIS10	Basin average mean annual precipitation for 1981 to 2010 from PRISM	21.4	inches
PRECIP	Mean Annual Precipitation	20.1	inches
BSLDEM30M	Mean basin slope computed from 30 m DEM	7.95	percent
CANOPY_PCT	Percentage of drainage area covered by canopy as described in OK SIR 2009_5267	75.5	percent

Parameter Code	Parameter Description	Value	Unit
ELEV	Mean Basin Elevation	179	feet
ELEVMAX	Maximum basin elevation	344	feet
MINBELEV	Minimum basin elevation	26.2	feet
NFSL30	North-Facing Slopes Greater Than 30 Percent	0	percent
RELIEF	Maximum - minimum elevation	317	feet
SLOP30_30M	Percent area with slopes greater than 30 percent from 30-meter DEM.	0	percent

Peak-Flow Statistics Parameters [Peak Region 3 2016 5118]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	0.08	2610
PRECPRIS10	Mean Annual Precip PRISM 1981 2010	21.4	inches	33.2	168

Peak-Flow Statistics Disclaimers [Peak Region 3 2016 5118]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Peak-Flow Statistics Flow Report [Peak Region 3 2016 5118]

Statistic	Value	Unit
50-percent AEP flood	1.99	ft^3/s
20-percent AEP flood	3.3	ft^3/s
10-percent AEP flood	4.23	ft^3/s
4-percent AEP flood	5.49	ft^3/s
2-percent AEP flood	6.44	ft^3/s
1-percent AEP flood	7.5	ft^3/s
0.5-percent AEP flood	8.55	ft^3/s

Statistic	Value	Unit
0.2-percent AEP flood	10.1	ft^3/s

Peak-Flow Statistics Citations

Mastin, M.C., Konrad, C.P., Veilleux, A.G., and Tecca, A.E.,2016, Magnitude, frequency, and trends of floods at gaged and ungaged sites in Washington, based on data through water year 2014 (ver 1.1, October 2016): U.S. Geological Survey Scientific Investigations Report 2016–5118, 70 p. (http://dx.doi.org/10.3133/sir20165118)

Low-Flow Statistics Parameters [Low Flow Western 2 var 2012 5078]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	0.1	48.9
PRECIP	Mean Annual Precipitation	20.1	inches	25.1	143

Low-Flow Statistics Disclaimers [Low Flow Western 2 var 2012 5078]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Low-Flow Statistics Flow Report [Low Flow Western 2 var 2012 5078]

Statistic	Value	Unit
7 Day 10 Year Low Flow	0.00766	ft^3/s

Low-Flow Statistics Citations

Curran, C.A., Eng, Ken, and Konrad, C.P.,2012, Analysis of low flows and selected methods for estimating low-flow characteristics at partial-record and ungaged stream sites in western Washington: U.S. Geological Survey Scientific Investigations Report 2012-5078, 46 p. (http://pubs.usgs.gov/sir/2012/5078/)

Bankfull Statistics Parameters [37.0 Percent (0.103 square miles) Pacific Mountain System D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	6.1776	8079.9147

Bankfull Statistics Parameters [37.0 Percent (0.103 square miles) Pacific Border P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	6.169878	3938.976756

Bankfull Statistics Parameters [37.0 Percent (0.103 square miles) USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	0.07722	59927.7393

Bankfull Statistics Parameters [58.0 Percent (0.162 square miles) Pac Maritime Mtn CastroJackson 2001]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.28	square miles	54.8	3093

Bankfull Statistics Disclaimers [37.0 Percent (0.103 square miles) Pacific Mountain System D Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Bankfull Statistics Flow Report [37.0 Percent (0.103 square miles) Pacific Mountain System D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	7.97	ft
Bieger_D_channel_depth	0.687	ft
Bieger_D_channel_cross_sectional_area	7.59	ft^2

Bankfull Statistics Disclaimers [37.0 Percent (0.103 square miles) Pacific Border P Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Bankfull Statistics Flow Report [37.0 Percent (0.103 square miles) Pacific Border P

Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	6.27	ft
Bieger_P_channel_cross_sectional_area	6.08	ft^2
Bieger_P_channel_depth	0.62	ft

Bankfull Statistics Flow Report [37.0 Percent (0.103 square miles) USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	7.91	ft
Bieger_USA_channel_depth	0.919	ft
Bieger_USA_channel_cross_sectional_area	8.59	ft^2

Bankfull Statistics Disclaimers [58.0 Percent (0.162 square miles) Pac Maritime Mtn CastroJackson 2001]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Bankfull Statistics Flow Report [58.0 Percent (0.162 square miles) Pac Maritime Mtn CastroJackson 2001]

Statistic	Value	Unit
Bankfull Width	7.17	ft
Bankfull Depth	0.402	ft
Bankfull Area	5.57	ft^2
Bankfull Streamflow	38.8	ft^3/s

Bankfull Statistics Citations

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub /1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF& utm_campaign=PDFCoverPages)

Castro, J.M, and Jackson, P.L.Castro, J.M, and Jackson, P.L., 2001, Bankfull Discharge Recurrence Intervals and Regional Hydraulic Geometery Relationships: Patterns in the

Pacific Northwest, USA, Journal of the American Water Resources Association, Volume 37, No. 5, 14 p. (https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1752-1688.2001.tb03636.x)

Application Version: 4.7.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.2

Flows for design small 1894 east

Values From Streamstats

cfs

Return Year	Value
2	1.99
5	3.3
10	4.23
25	5.49
50	6.44
100	7.55
200	8.55
500	10.1

Bieger BFW, feet 7.97 feet

Climate change Factors[1]

	Year factors		Increased Values		
	2040	*2080*	*2040*	*2080*	
% increase in BFW Flow (2 year)	9.9	14.7	2.2	2.3	cfs
% increase in BFW Width	4.7	6.9	8.3	8.5	feet
% increase in 100 year Flood	8.8	17.7	8.2	8.9	cfs

[1] WDFW, web-based analysis. Culverts and Climate Change, changes in bank full width and flow rates in culverts in Washington state. Developed in conjunction with University of Washington 2021. https://geodataservices.wdfw.wa.gov/hp/culvert-app/#aboutTab

Where; Pll in the Prediction Interval limit lower, Plu is the Prediction Interval limit upper, and AESp is the Avergae Standard error of Prediction.

References;

Mastin, M.C., Konrad, C.P., Veilleux, A.G., and Tecca, A.E.,2016, Magnitude, frequency, and trends of floods at gaged and ungaged sites in Washington, based on data through water year 2014 (ver 1.1, October 2016): U.S. Geological Survey Scientific Investigations Report 2016–5118, 70 p.

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p.

Castro, J.M, and Jackson, P.L.Castro, J.M, and Jackson, P.L., 2001, Bankfull Discharge Recurrence Intervals and Regional Hydraulic Geometery Relationships: Patterns in the Pacific Northwest, USA, Journal of the American Water Resources Association, Volume 37, No. 5, 14 p.

Future Projections for Climate-Adapted Culvert Design

Project Name: Race Road Fish Passage (

Stream Name: unnamed Tributary to Race

Street Name: Race Road

Culvert coordinates: 48.1904, -122.5995

Grid ID 48.21875_-122.59375

Ecoregion Pacific Maritime Mountains

Projected mean percent change in bankfull flow:

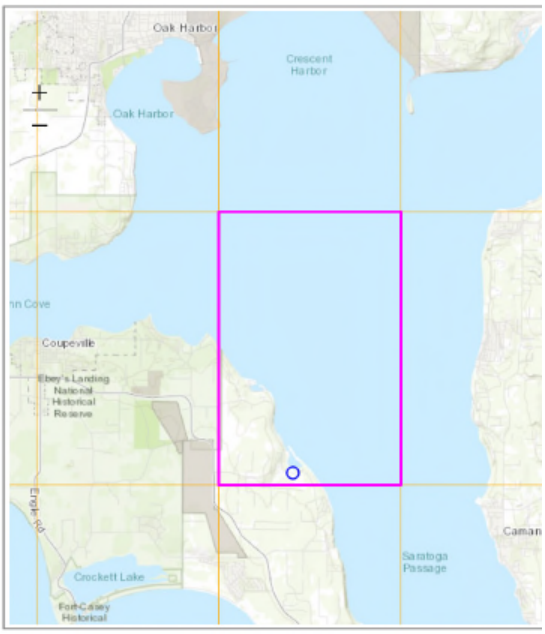
2040s: 9.9% **2080s:** 14.7%

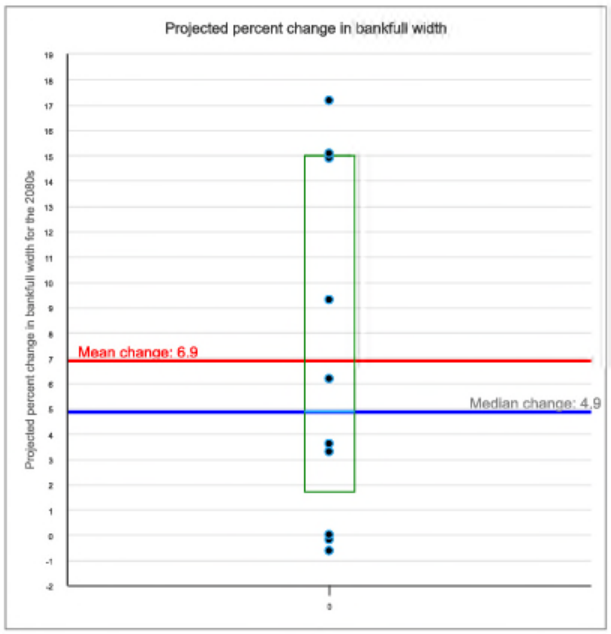
Projected mean percent change in bankfull width:

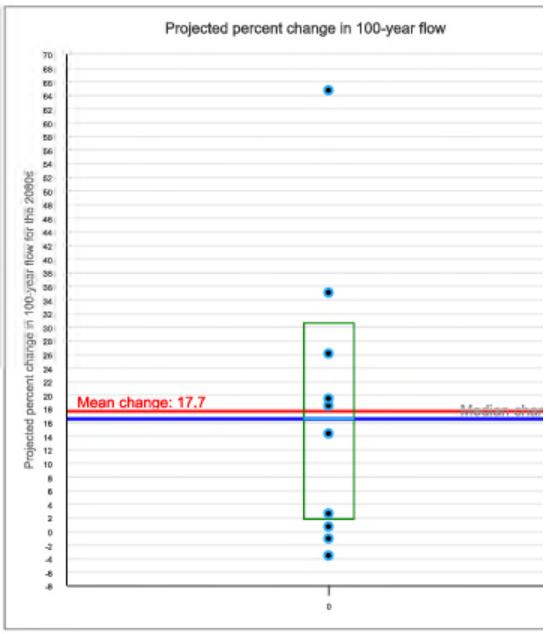
2040s: 4.7% **2080s:** 6.9%

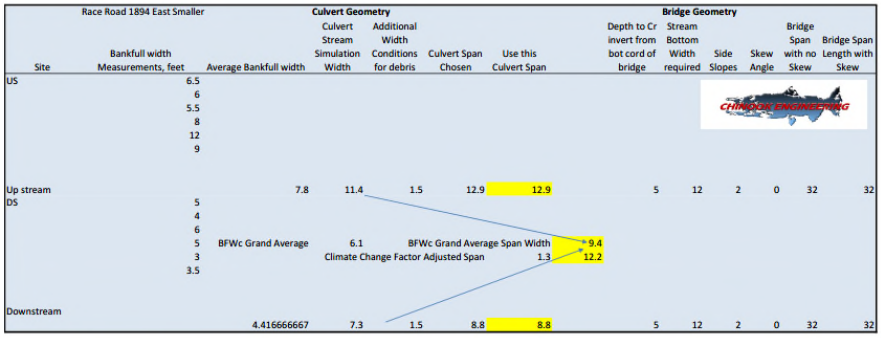
Projected mean percent change in 100-year flood:

2040s: 8.8% **2080s:** 17.7%









Race Road 1894 East Smaller			Culvert Geometry					Bridge Geometry					
Site	Bankfull width Measurements, feet	Average Bankfull width	Culvert Stream Simulation Width	Additional Width Conditions for debris	Culvert Span Chosen	Use this Culvert Span		Depth to Cr invert from bot cord of bridge	Stream Bottom Width required	Side Slopes	Skew Angle	Bridge Span with no Skew	Bridge Span Length with Skew
US	6.5												
	6												
	5.5												
	8												
	12												
	9												
Up stream		7.8	11.4	1.5	12.9	12.9		5	12	2	0	32	32
DS	5												
	4												
	6												
	5	BFWc Grand Average	6.1		BFWc Grand Average Span Width		9.4						
	3		Climate Change Factor Adjusted Span			1.3	12.2						
	3.5												
Downstream													
		4.416666667	7.3	1.5	8.8	8.8		5	12	2	0	32	32

Race Road 1893 West Larger			Culvert Geometry					Bridge					
Site	Bankfull width Measurements, feet	Average Bankfull width	Culvert Stream Simulation Width	Additional Width Conditions for debris	Culvert Span Chosen	Use this Culvert Span		Depth to Cr invert from bot cord of bridge	Stream Width required	Side Slopes	Skew Angle	Bridge Span with no Skew	Bridge Span Length with Skew
Up stream	6												
	7.5												
	10.5												
Up stream		8.0	11.6	1.5	13.1	13.1		3	7.5	2.5	0	22.5	23
	5												
	6												
	5.5												
	7	BFWc Grand Average	7.4		BFWc Grand Average		10.9						
	10.5		Climate Change Factor Adjusted Span			1.3	14.1						
Downstream													
		6.8	10.2	1.5	11.7	11.7		3	7.5	2.5	0	22.5	23

Washington Department of
Fish and Wildlife

Fish Passage & Diversion Screening Inventory Database
Report Cover Sheet

The following report is extracted from the Washington Department of Fish and Wildlife's (WDFW) Fish Passage and Diversion Screening Inventory Database (FPDSI). WDFW makes every attempt to keep these reports in sync with FPDSI; however, the dynamic nature of the data and workflows associated with maintaining the database may result in short-term differences.

Users are encouraged to contact WDFW to discuss appropriate use of the data and how we can assist with fish passage barrier removal or inventory. Please visit the Fish Passage web site for contact information at: https://wdfw.wa.gov/species-habitats/habitat-recovery/fish-passage/about

Disclaimers:

- Data presented here represent a snapshot observation of conditions in a dynamic environment that is subject to change. Fish passage data are also collected from a variety of agencies and sources. Therefore, WDFW makes no guarantee concerning the data's content, accuracy, completeness, or the results obtained from use of the data. WDFW assumes no liability for the data represented here.
- These data are not an attempt to provide you with an official agency response as to the impacts of your project on fish and wildlife.
- Note that some fish passage features, habitats or species may occur in areas not currently known to the WDFW Fish Passage division, and may not be reflected in this database. A lack of data does not necessarily indicate that a feature, habitat, or species are not present.
- Unauthorized attempts to alter or modify these data are strictly prohibited.
- Bankfull width measurements included in these reports should not be used for fish passage crossing design. They are solely for assessment purposes.
- The barrier status reported in this document is based on the swimming abilities of adult salmonids. Passabilities are a qualitative value, and should not be interpreted as a quantitative calculation. Please see page 1-4 of the Fish Passage Inventory, Assessment and Prioritization Manual for further clarification: https://wdfw.wa.gov/publications/02061
- EXIF data presented with Image Reports may be erroneous due to camera battery failures and resetting of camera clock functions.

Abbreviations:

Most abbreviations in this report are defined in the Quick Reference Tables of the Fish Passage Inventory, Assessment, and Prioritization Manual. Additional commonly used abbreviations are defined as follows:

NFB = no potential salmonid use, **BB** = both banks, **LB** = left bank looking downstream, **RB** = right bank looking downstream, **US or U/S** = upstream, **DS or D/S** = downstream, **WSDrop** = water surface drop, **BFW** = bankfull width, **OHW** = ordinary high water, **SLW** = scour line width, **CMP** = corrugated metal pipe, Q_{fp} = fish passage flow, **V&D** = Velocity and Depth, **ROW** = Right of Way

The FPDSI database often uses default values such as '**-99.99**' or '**-999**' to represent null values.

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 609594 **Project** ☐ **Mitigated**

Geographic Coordinates

Latitude (WGS 84):	48.1903825
Longitude (WGS 84):	-122.5995231
East (NAD 83 HARN):	1,128,179.5
North (NAD 83 HARN)	1,048,858.0

Waterbody

Stream:	unnamed
Tributary To:	Race Lagoon
WRIA:	06
River Mile:	-999.99
Fish Use Potential:	Unknown
FUP Criteria:	

General Location

Road Name:	Race Rd
Mile Post:	-999.99
County:	Island
WDFW Region:	4

Owner

Type:	County
Name:	Island County

PI Species

☐ Sockeye	☐ Chinook	☐ Sea Run Cutthroat
☐ Pink	☐ Coho	☐ Resident Trout
☐ Chum	☐ Steelhead	☐ Bull Trout

Associated Features

☑ Culvert	☐ Dam	☐ Natural Barrier	☐ Diversion
☐ Non-Culvert Xing	☐ Other	☐ Fishway	

Location/Directions

Site Comments

7/17/2023

These data represent a snapshot of the Washington Department of Fish and Wildlife's current records. Due to the ongoing nature of assessment and inventory of these features, these data may not accurately represent conditions on the ground, and are subject to change.

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID:	**609594**				
Latitude:	**48.1903825**	Stream:	**unnamed**	WRIA:	**06**
Longitude:	**-122.5995231**	Tributary To:	**Race Lagoon**	Fish Use Potential:	**Unknown**

Data Source: Skagit Fisheries Enhancement Group

Field Crew: Matthews;JJ;PM Review Date: 2/27/2020

Culvert Details / **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)	Sediment
1.1	RND	CST	0.50	0.55	23.10	0.10	NO	0.00		No	No	0.97	

All dimensions in meters

Channel Description

Toe Width (m):	
Average Width (m):	1.80
Culvert/Stream Width Ratio:	0.28

Plunge Pool

Length (m):	0.00
Max Depth (m):	-99.99
OHW Width (m):	-999.99

Road

Fill Depth (m):	1.10

Assessment Results

		Tidal Influence:	No	Tidegate Present:	No
Barrier:	Unknown	Passability (%):	Unknown	Method:	Level A
Reason:	evel B Require	Fishway Present:	No	Recheck:	LB

Comments

Potential Habitat Gain

Survey Type:		Spawning (sq m):		Length (m):	
Significant Reach:	Unknown	Rearing (sq m):		**PI Total**	

7/17/2023

These data represent a snapshot of the Washington Department of Fish and Wildlife's current records. Due to the ongoing nature of assessment and inventory of these features, these data may not accurately represent conditions on the ground, and are subject to change.

WDFW Fish Passage and Diversion Screening Inventory Database

Image Report - Active

Site ID:	**609594**				
Latitude:	**48.1903825**	Stream:	**unnamed**	WRIA:	**06**
Longitude:	**-122.5995231**	Tributary To:	**Race Lagoon**	Fish Use Potential:	**Unknown**

Associated Features

☑ Culvert	☐ Dam	☐ Natural Barrier	☐ Diversion
☐ Non-Culvert Xing	☐ Other	☐ Fishway	

Image Name: 609594_1.jpg, Date/Time: 02/27/2020 12:45

Image Name: 609594_2.jpg, Date/Time: 02/27/2020 12:41

7/17/2023

These data represent a snapshot of the Washington Department of Fish and Wildlife's current records. Due to the ongoing nature of assessment and inventory of these features, these data may not accurately represent conditions on the ground, and are subject to change.

Correction Analysis Form

Site Information (measurements in feet)

Project Name: Island Co. Culvert Prioritization – Area 2 Culvert #1894 | *SRFB Project #: 19-1343* | *Date: 9/24/21*

Bankfull Width (outside influence of culvert): 3.3' u.s., 4.6' d.s. | Utilities Crossing: ☒ Yes ☐ No ☐ Unknown

Road Fill at Culvert Invert: 5.2' outlet IE to road surface | Road Width: 27' shoulder to shoulder

Road Description/Condition (mainline, spur road, driveway/access): 2 lane county road

Evaluator Information

Evaluator Name: **Tom Slocum, PE** | Affiliation: **Whidbey Island Conservation District**

Mailing Address: **PO Box 490** | City: **Coupeville** | State: **WA** | Zip: **98239**

Telephone: | FAX: | Cell: 360 899-6041 | E-mail: tom@skagitcd.org

Upstream Habitat/Channel Description

Channel Slope (outside of culvert influence): 0.8% | Re-grade Potential (streambed US – streambed DS in feet): 0.9

Dominant Substrate: ☐ Sand (<1/5") ☒ Gravel (1/5"–3") ☐ Cobble (3"-12") ☐ Boulder (>12") ☐ Bedrock

Additional Upstream Information, Habitat Description, Other Site Conditions or Concerns, Including Potential Re-Grade Impacts Relative to Channel Stability And Habitat:

Straightened, excavated channel thorugh dense rose bush and hawthorne thickets with no in-channel habitat features. Intersects road ditch 5' u.s. of culvert.

Downstream Habitat/Channel Description

Channel Slope: 3.7% (outside of culvert influence)

Additional Downstream Information, Habitat Description, Other Site Conditions or Concerns:

Excavated channel for 28 feet d.s. of culvert, where two, 12" diam. CPP culverts across a private access lane create a passage barrier. Tidal elevation was not measured. Stream is classified improbably as Type F. See the profile drawing.

Correction Options and Preferred Alternative

Options to Consider – Provide up to Three Site-Appropriate Correction Alternatives.

Option 1: **60 LF x 7-ft diameter pipe arch culvert per No Slope design**

Option 2: **60 LF x 7.5-ft diameter bottomless arch culvert per No Slope design**

Option 3: **60 LF x 7-ft wide x 4-ft high concrete box culvert, per No Slope design**

Preferred Alternative - Provide a 1- or 2-paragraph Recommendation for this Site. Include any Site-Specific Concerns that Will Need to be Addressed During Design and Construction:

Option 1 is simplest to construct, but depending on tidal elevations, may be susceptible to salt-water corrosion. Tidal elevations need to be determined to verify this. If salt water corrosion will be excssive, then Option 3 (concrete box culvert) would be the preferred alternative. All options may require some degree of relocating water and phone utility lines, depending on the locations (be be determined).

Cost Estimates

Rough Cost Estimate* - Attach Detailed Cost Breakdown Using the Appropriate Cost Estimate Template, Provided Separately.

Option 1: $271,900

Option 2: $279,500

Option 3: $340,000

*This is a rough approximation of project costs; actual costs may vary depending on specifications identified during final design.

CULVERT EVALUATION FIELD FORM (LEVEL A)

Site ID:[1]	1894	Culvert #:[2]	1.1	Date:[3]	2/27/20	Old ID:[4]		
SKCO ID:[5]		Org:[6]	SFEG	Crew:[7]	RM, EM, JJ	Stream.[8]		

PHOTOS TAKEN:[9] (US Culv) (US Channel) (DS Culv) (DS Channel) (Road Right) (Road Left) Other

ROAD DESCRIPTION

Road Surface Type:[10]	CS	(A)	GR	Other	Road Width (including shoulders):[14] ~~22.25~~ 8-10	meters
Temporary Access Needed?[11]	Yes	No	(Unknown)		Road Fill Depth:[15] (B-D) 1.078	meters
In-Road Utilities:[12]	(Yes)	No	Unknown		US Road Prism Depth:[16] (A-E) 1.485	meters
Overhead Utilities/Crossings:[13]	Yes	(No)	Unknown		DS Road Prism Depth:[17] (B-F) 1.538	meters

Road Notes:[18] power box near road

CULVERT DESCRIPTION

Culvert Shape:[19]	(RND)	BOX	ARCH	SQSH	ELL	Other	Length of Culvert:[28] ~~22.25~~ 23.14	meters
Culvert Material:[20]	PCC	CPC	(CST)	SST	SPA	MRY	Culvert Span:[29] ~~0.46~~ 0.50	meters
	CAL	SPS	PVC	TMB	Other		Rise of Culvert:[30] 0.55	meters
Number of Baffles:[21] (If > 0, fill out fishway form)	NA						Culvert Slope:[31] $\left(\frac{\text{US Invert}^2 - \text{DS Invert}^1}{\text{Length}^{28}}\right) \times 100$ 0.97	%
Baffle Type:[22]	Concrete		Metal		Wood		Water Depth:[32] 0.105	meters
	Plastic		Rock		Other		Hydraulic Drop:[33] 0.0	meters
Apron?[23]	US		DS		(No)		Drop Location:[34] NA Inlet Outlet Interior	
Gate?[24]	US		DS		(No)		**Plunge Pool Description** (N/A if no Hydraulic Drop)	
Fishway?[25] (If yes, fill out fishway form)			YES		(No)		Plunge Pool Length:[35]	meters
Countersunk?[26]			YES		(No)		Maximum Depth:[36]	meters
Backwatered?[27]			YES		(No)		Scour Line Width:[37]	meters

Culvert Notes:[38] (If multiple culverts at site, indicate defining features of each) Land owner says sewer crossing ~30 meters North of road
private culvert DS
•GNSS location: 48.19024460, -122.59939764
•US neighbor is Engineer @ Penn Cove Shellfish
DS neighbor
Rod Scherencel (360)804-7669 RodScherencel@gmail.com

CHANNEL DESCRIPTION

Channel Width:[39] Span 1.1m BFW 1.8m	Culvert Span ÷ Channel Width:[40] (29÷39)
Channel Notes:[41]	

BARRIER STATUS[42] (Circle one below)

Passable[43]	Barrier Reason[44]		Level B Analysis Required[45]		
	Drop > .24 M	Slope >= 1%	Backwatered	Slope < 1%	Culvert Width < 75%

Barrier Notes:[46] Slope is close to Level A barrier Criteria

CULVERT EVALUATION FIELD FORM (LEVEL A): CALCULATIONS

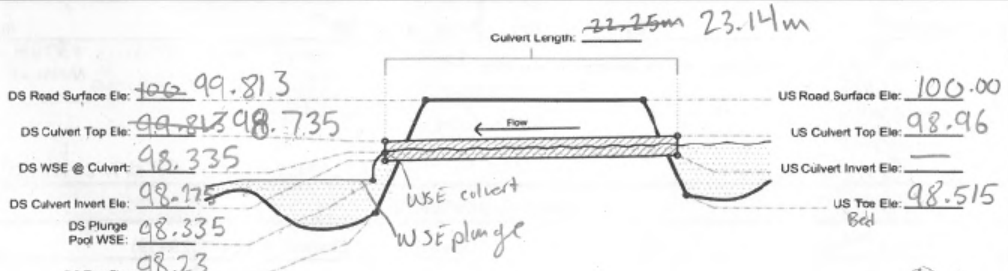
Site ID: 1894 Culvert #: 1.1 Date: 2/27/20

FS	IH	BS	EL	NOTE
	101.38	1.38	100.00	Benchmark (US Road on white mark)
2.865			98.515	US bed
3.045			98.335	DS WSE
3.15			98.23	DS bed
	101.38	1.38	100.00	Close to benchmark

ENTER FINAL MEASUREMENTS HERE

US Road Shoulder:[A]	1.38	100.00	DS Road Shoulder:[B]	~~1.38~~ 1.567	~~100.00~~ 99.813
US Culvert Top:[C]	2.42	98.96	DS Culvert Top:[D]	2.645	98.735
US Culvert Invert:[E]	— See notes		DS Culvert Invert:[F]	3.105	98.275

SCHEMATIC OF CULVERT MEASUREMENTS



Slope = $\frac{\text{US Invert} - \text{DS Invert}}{\text{Culvert Length}}$ = $\frac{98.96 - 98.735}{23.14}$ ~~0.0101~~ = ~~1.01%~~ 0.00972 = 0.97%

Note: *If culvert is countersunk, use bed elevations to calculate slope*

Hydraulic Drop = DS WSE @ Culvert — DS Plunge Pool WSE = 98.335 − 98.335 = 0.0

*Simpler to use invert in place of toe if this is representative of road prism. If toe of prism elevation is greatly different than invert elevation, use toe.

DS Prism Depth = DS Road Surface — DS Toe (bed) = 99.813 − 98.23 = 1.485

US Prism Depth = US Road Surface — US Toe (bed) = 100.00 − 98.515 = 1.538

LEVEL B HYDRAULIC ANALYSIS FIELD FORM (3/18/2019)

[1]Site ID 1894
[2]Culvert Number 1.1
[5]Datum Elevation 100.00
[6]Datum Location US road (on white mark)

[3]Crew EM, PM, JJ
[4]Date 2/27/20

[7]CULVERT MEASUREMENTS

	IH	RH	VD -/+	ELEV
Upstream Invert	101.38	(see notes)		
Upstream Culvert Bed		2.865		98.515
Downstream Invert		3.105		98.275
Downstream Culvert Bed		3.15		98.23

IH = Instrument Height; RH = Rod Height; VD = Vertical Distance (for equipment that measures incline); ELEV = Elevation (relative to Datum Elevation). Formulas on reverse side.

[8]Culvert Roughness ☐ concrete ☐ smooth ☐ paved invert
corrugation: ☒ 0.5" x 2.67" ☐ 1" x 3" ☐ 2" x 6" ☐ other _____

[9]Sediment Through Length of Pipe? ☐ yes ☒ no ☐ unknown

[10]DOWNSTREAM CONTROL CROSS-SECTION

	STA (0.20 meters)	IH	RH	VD -/+	ELEV	DEP	WSE	SUB
Top LB	~~0.00~~	101.38	2.59		98.79			F
Toe LB	0.68		3.045		98.285	0.04	98.325	
Bed 1	0.88		3.155		98.225	~~0.10~~ 0.09	98.315	
Bed 2	1.08		3.160		98.220	0.10	98.32	
Bed 3	1.28		3.11		98.265	0.06	98.325	
Toe RB	1.47		3.085		98.290	0.04	98.33	
Top RB	2.05		2.87		98.51			

[10]Avg. WSE 0.323m

STA = Station; DEP = Water Depth; WSE = Water Surface Elevation; SUB = Dominant Substrate (F = Fines, C = Gravels/Cobbles/Bedrock, B = Boulders, W = Wood)

	IH	RH	VD -/+	WSE
[12]Water Surface Downstream of X-Section:	101.38	3.265		98.115

[13]Distance from X-section 7.7 m
⇒ cant go 15m down because there is another culvert

Correction Analysis Form Instructions

This will be completed for projects determined to be of potential high benefit to fish resources based on the information provided in Barrier Evaluation Form and Expanded Barrier Evaluation Form. The completed forms will be used to develop a prioritized list of projects to be presented to SRFB for potential funding.

Site Information

Project Name–This is the landowner's last name followed by the creek name. If more than one site per landowner is evaluated on the same creek, designate each site with a letter, e.g. Franklin–Boulder Creek A.

RCO/SRFB Project Number–This will be provided by PRISM database.

Bankfull Width–The stream width measured perpendicular to flow at the stage at which water begins to overflow into the active flood plain. Bankfull width requires a floodplain or a bench not present in many channels. In those cases, use ordinary high water. O ordinary high water is where the regular stream flow makes a line on the bank marking soil or vegetation with a character distinct from that of the abutting upland. Also defined as the lowest point at which perennial vegetation grows on the stream bank. Enter the average of several bankfull width measurements taken up and/or downstream of the culvert, outside the influence of the culvert.

Utilities Crossing–Include any water, gas, phone or electrical utilities at the crossing to be affected by project construction.

Road Fill at Downstream End–Measure height of material from top of culvert to top of fill at downstream end.

Road Width–Measurement should include shoulders.

Road Description/Condition–Provide a brief description of the road surface, use, condition, etc.

Evaluator Information

Provide contact information for the people completing the Correction Analysis Form.

Upstream Habitat and Channel Description

Channel Slope–This is measured outside of the culvert influence.

Re-grade Potential–Subtract the downstream streambed elevation from the upstream streambed elevation at the site.

Dominant Substrate–Identify the size category most prominent in the substrate.

Additional Information–Provide any additional upstream information that may be important to the project.

Downstream Habitat and Channel Description

Channel Slope–This is measured outside of the culvert influence.

Additional Information–Provide any additional upstream information that may be important to the project.

Correction Options and Preferred Alternative

Options to Consider–The purpose of this section is to provide the sponsor some guidance on the intended fix. Most small forest landowner projects should be relatively straightforward; however each site is different.

Preferred Alternative–Describe the recommended correction and site-specific concerns to be addressed during design and construction.

Cost Estimates

Rough cost estimate–Provide estimated costs for correction options listed above. Costs should be based on cost estimate templates, provided separately, for culverts, bottomless arch culverts, and bridges. Attach the corresponding completed template for each estimate. These represent approximate costs; actual costs may vary depending on specifications identified during final project design.

SITE IDENTIFICATION FIELD FORM (1/15/09)

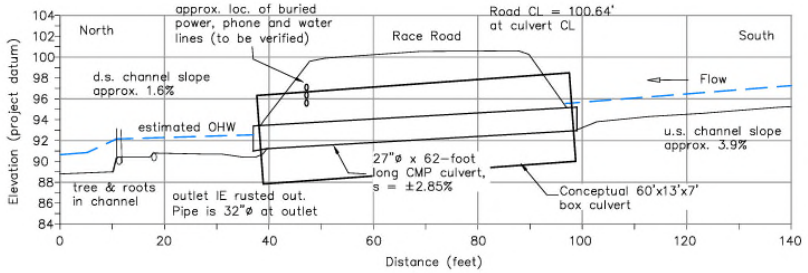
[1]Site ID: 1894 GPS Position Taken: ☒Yes ☐No
[2]Latitude: 48.19024960 [3]Longitude: -122.59939769
[4]Identifying Group: SFEG [5]Road Name: Race Rd
[6]Milepost: [7]County: Island County
[8]Location/Directions: Take Hwy 20 south, Turn Left on W Welcher Rd. Turn Right on ~~Race~~ Rd. 0.3 miles
[9]Stream Name: WDFW reach code 171100 19-002374 [10]WRIA #: 6
[11]Tributary To: Race Lagoon [12]River Mile: —
[13]Fish Use Potential: ☐Yes ☐No ☐Unknown
[14]Fish Use Criteria: ☐Mapped ☐Physical ☐Biological ☐Other
[15]Species: ☐Chinook ☐Chum ☐Sockeye ☐Coho ☐Pink ☐Steelhead ☐Resident Cutthroat/Rainbow Trout ☐Searun Cutthroat ☐Bull/Dolly Varden Trout
[16]Feature Type: ☒Culvert ☐Fishway ☐Dam ☐Gravity Diversion ☐Pump Diversion ☐Other ☐Non Culvert Crossing ☐Natural Barrier
[17]Site Comments:

[18]OWNER INFORMATION

Type: ☐Federal ☐State ☒County ☐City ☐Tribal ☐Private ☐Other
Name: Island County
Street Address:
Mailing Address:
City: State: Zip:
Phone #:
Contact Name & Phone#:

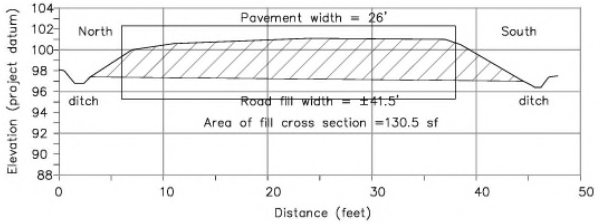
Appendix B Conceptual Alternative Designs from Correctional Analysis Forms

Culvert #1893 Existing Profile View – 2H:1V Distortion

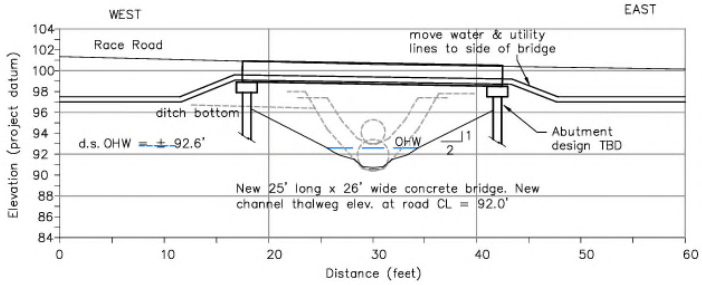


Culvert #1893 Road Prism Cross Section – 1H:1V

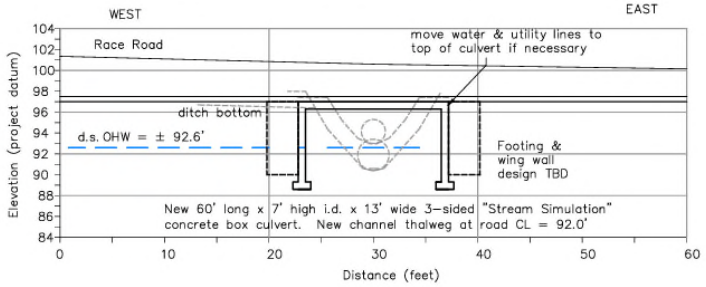
(10' West of Culvert Crossing)



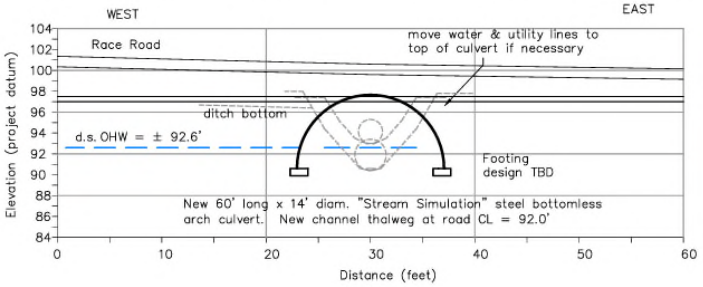
Culvert #1893 Bridge Alternative – 1H:1V



Culvert #1893 Box Culvert Alternative – 1H:1V



Culvert #1893 Bottomless Arch Culvert Alternative – 1H:1V



Revisions

Island County Area 2 Fish Passage Barrier Project Development
Culvert 1893 Conceptual Alternatives

Prepared for:
Skagit Fisheries Enhancement Group

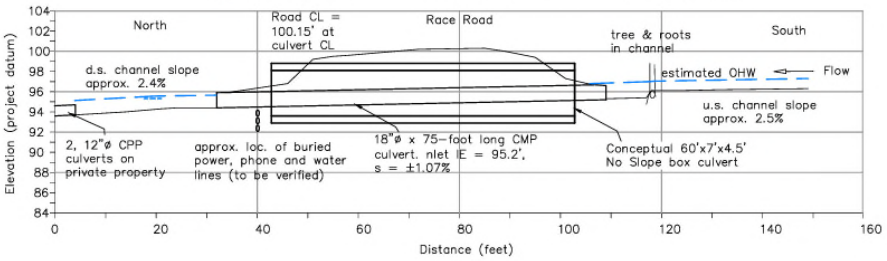
Prepared by:
Northwest Indian Fisheries Commission
PO Box 490
Coupeville, WA 98239
(360) 678-4708

9-24-21

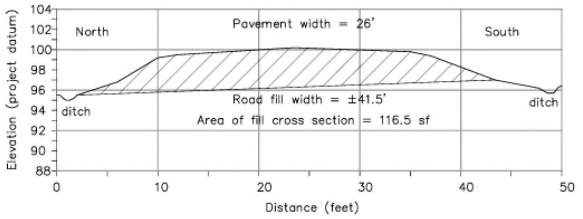
as noted

Sheet # 2 of 3

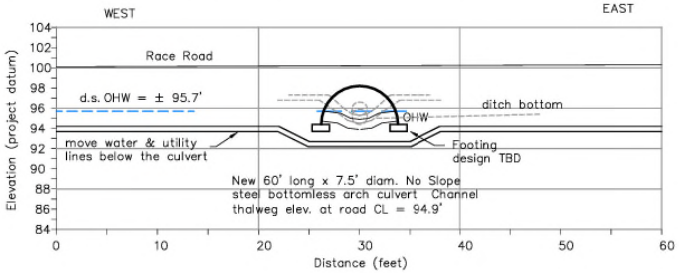
Culvert #1894 Profile View – 2H:1V Distortion



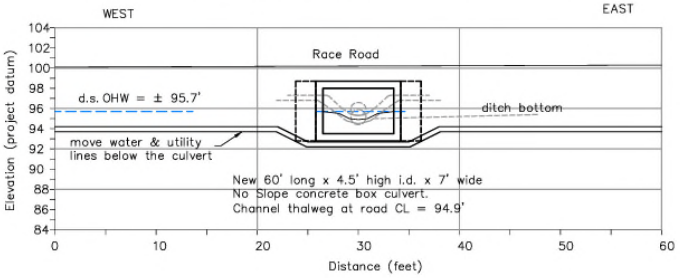
Culvert #1894 Road Prism Cross Section – 1H:1V
(10' East of Culvert Crossing)



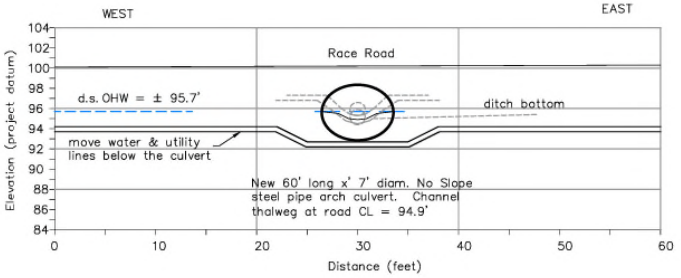
Culvert #1894 Bottomless Arch Culvert Alternative – 1H:1V



Culvert #1894 Box Culvert Alternative – 1H:1V



Culvert #1894 Pipe Arch Culvert Alternative – 1H:1V



Revisions

Island County Area 2 Fish Passage
Barrier Project Development
Culvert 1894 Conceptual Alternatives

Prepared for:
Skagit Fisheries Enhancement Group

Prepared by:
PO Box 490
Coupeville, WA 9823973
(360) 678-4708

9-24-21

as noted

3 of 3

Appendix C Preliminary Design Comments from Island County Public Works

The attached comments are intended to record tasks for revising the final designs and are included for the record. These Comments are from the Matthew Lander, PE, Engineering Manager, Island County Public Works.

Concrete structure:

Buried Structure Slit Box Standard Plan:

https://wsdot.wa.gov/publications/fulltext/Standards/english/PDF/e20.10-00.pdf

The concrete structures will be in the splash zone related to corrosion:

The structure protection against corrosion needs to be designed for a 75-year+ design life.

"The splash zone is defined as the region from the Mean Lower Low Water (MLLW) elevation to 20 feet above the Mean Higher High Water (MHHW) elevation and/or a horizontal distance of 20 ft. from the edge of the water at the MHHW elevation."

Cover for culverts: Permit reviewers would like to see that the culverts have 2 feet of clearance above the 100-year surface water elevation to the crown of the culvert. If clearance is less than two feet, we will need a memo with a rationale that large debris is not expected in the stream cross memo and clearance is adequate. We would prefer to have the two feet to appease stakeholders. On top of the culvert, we would like a min. of 1 foot of (road). (0.2 feet HMA +0.2 feet HMA + min. .6 feet of CSBC). If you do not have 12" plus of cover over the culvert where pavement is proposed, please call to discuss.

Delete Sheet SPC: specifications should not be within plan set. Specification should be within specifications section of contract bid.

Add Excavation limits on the plan set.

All sheets that have a green background need to be revised.

Add saw cut locations two on each side of the excavation trench.

Specify second (outer) asphalt cuts will per perpendicular to the center line of the road and the cut will be made after the trench is backfilled.

Show anticipated Temporary Construction Easement Limits for areas with excavation and a place to disperse dewater water.

Gravel under Culvert: The more robust of 1.5' CSBC over Geotextile for Soil Stabilization 9-33.2(1) Table 3 or the geotechnical engineer's recommendations.

Remove sheet C-15

Remove Sheet C-17. Place the bore locations on an another existing sheet, if engineer wants to have locations on plans.

Remove Bore Logs from Plans: Sheets C-18 and C-19.