Redwater River

Alternatives Assessment
to Provide Upstream Fish Passage at the
Nickwall and Redwater Road Crossings

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1. INTRODUCTION

Problem

A preliminary site assessment of two road crossings on the Redwater River was commissioned by Fish, Wildlife and Parks (FW&P) in the fall of 2006 to evaluate options for retrofitting the crossings to provide upstream fish passage. These crossings included the Nickwall Crossing (downstream) and the Redwater Crossing (upstream). A more thorough fish passage feasibility study was conducted in the fall of 2007 on behalf of the McCone County Conservation District. In the 2007 study, specific alternatives for the two sites were identified, evaluated and compared. However, McCone County was not able to select a preferred alternative for the sites, in part because the estimated implementation costs for the recommended alternatives appeared extremely high. It became apparent that a more involved Alternatives Analysis would be beneficial to further explore potential alternatives and associated costs.

Scope of This Report

The scope of this report consists of four general tasks. These tasks include:

Evaluate the 2007 Feasibility Study. Review and evaluate the study completed by Confluence Consulting. The hydrologic analysis and fish passage design criteria performed by Confluence were used as the basis for this Alternatives Assessment.

Existing Conditions Analysis. Create an AutoCAD drawing and digital terrain model of each of the project sites using survey data collected by the Natural Resources Conservation Service (NRCS). Develop cross-sections and incorporate data into a new HEC-RAS model.

Develop Alternatives. Identify several configurations for modifying the road crossings to provide fish passage. Narrow the alternatives to three to five representative choices for each crossing. Evaluate the hydraulics of the proposed solutions and produce schematic drawings of the proposed solutions. Estimate the construction costs of each of the alternatives.

*Alternatives Analysis Repor*t. Produce a report with a description of the alternatives and estimated construction costs, a comparative analysis of the alternatives, and recommendations for a preferred alternative.

2. EXISTING CONDITIONS

Introduction

The existing conditions have been described in a preliminary site assessment in 2006[1] and a feasibility study in 2007[2]. The existing conditions information regarding hydrology and fisheries provided in this report was extracted from these documents without modification. For this alternatives assessment, additional survey data were collected and hydraulic modeling of the existing conditions was undertaken.

Hydrology

Flow frequency of the Redwater River indicates that the river is subject to extremely high flows (Table 1). However, the purpose of this assessment is to consider fish passage, which occurs during low to moderate flows. Extreme flows, typically considered for flood conveyance or structural stability, were not considered as part of the alternatives analysis for two reasons. First, fish do not tend to migrate upstream during extreme events. Second, providing fish passage through road crossings at high flows is generally not feasible. As such, only low to moderate flows were considered for passage. Mean monthly flows (Table 2) were used to evaluate potential fish passage by season.

Table 1. Flow frequency (cfs) for the Redwater River at the Redwater and Nickwall Crossings, based on adjusted drainage basin size and the USGS gage at Vida, MT (06177825) (from Confluence 2007).

Location	Return Interval (years)						
	1.1	2	5	10	25	50	100
Redwater Crossing	51	854	4,120	8,650	17,800	27,500	39,800
Nickwall Crossing	52	874	4,220	8,850	18,200	28,100	40,600

Table 2. Mean monthly flow (cfs) for the Redwater River at the Redwater and Nickwall Crossings, based on adjusted drainage basin size and the USGS gage at Vida, MT (06177825) (from Confluence 2007).

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg Annual
Redwater Crossing	3.0	76.2	119	132	29.5	54.2	44.8	8.3	5.0	4.6	5.0	3.2	40.1
Nickwall Crossing	3.1	80.1	126	139	31.0	57.0	47.1	8.7	5.2	4.8	5.2	3.3	42.1

[1] Memorandum to Glenn Phillips of FW&P from Dale Miller of Mainstream Restoration dated September 30, 2007 (9 pages).

[2] Redwater River Crossings Fish Passage Feasibility Study, Confluence, dated August 31, 2007 (17 pages).

Fisheries

The feasibility study by Confluence (2007) addressed the fish found in the Redwater River; this information is not reiterated here. For the purposes of this alternatives analysis, the primary passage criterion was to create conditions where, during substantial periods of the year, water velocity would be less than 1 ft/sec through the two road crossings. A secondary criterion was to provide water depth of at least 0.4 feet.

In the feasibility study, Northern pike (*Esox lucius*) were identified as a surrogate for upstream passage. According to the study, Northern pike have burst and prolonged swim speeds of 2.5 and 0.5 ft/sec, respectively. However, many of the small Cyprinidae have burst speeds of 1.3 ft/sec, which is much lower than that for Northern pike.

Calculations of fish passage should evaluate fish swimming speed over a given distance for a period of time. Bell[3] suggests that burst speed can be maintained for 5 to 10 seconds. Thus, the length that fish can swim at burst speed is a function of the product of the time to fatigue and the difference between the fish speed and the water velocity:

LFS = (VF-VW)*TF

Where: LFS = length fish can swim

VF = fish burst speed

VW = water velocity

TF = time to fatigue (assumed to be 5 to 10 seconds)

For example, if water velocity is 1 ft/sec less than burst speed, then a fish can swim upstream at 1 fps (if water velocity is variable, then this equation should be solved accordingly). If the reach of high velocity is 30 feet long, then it will take a fish 30 seconds to pass through the reach. If a fish can only sustain a burst speed of 5 to 10 seconds, then such a reach would be impassible. Resting areas within the reach would need to be included where burst speed is insufficient for fish to pass through high velocities over some distance. Resting areas are typically provided by creating a rough channel bottom or small step-pools within a culvert, depending on the slope through a culvert.

For the two Redwater River crossings, even with a criterion of providing velocities less than 1 ft/sec through the crossings, resting areas will need to be incorporated to allow upstream fish passage under these conditions. Resting areas in low gradient culverts are typically provided by imbedding the culvert 20% of the height in order to backfill with streambed materials or allow the culverts to aggrade over time. For open span crossings, a natural stream bottom should provide resting areas (or resting areas can be incorporated into the bed of the span).

Topography

As part of the feasibility study, channel surveys were conducted using a centimeter grade GPS unit. Surveys included a longitudinal profile extending through the crossings, cross-sections upstream and downstream of the structures and along the road centerlines, and topographic survey points of the existing structures and culverts. To improve the level of

[3] Bell, M.C. 1990. Fisheries Handbook of Engineering Requirements and Biological Criteria, 3rd edition. Fish Passage Development and Evaluation Program, Corps of Engineers, North Pacific Division, Portland, OR.

analysis, new topography was surveyed by the NRCS in April 2008. Survey data from the feasibility study was not used for the alternatives study due to incompatible datum.

The 2008 survey involved surveying three to four representative channel cross-sections upstream and downstream of the crossings, including the crossings at the upstream and downstream faces, using a total station. All sections were tied to a local arbitrary datum. Cross-sections included the top and toe of the bank, the thalweg, a couple of intermediate channel bed points, and out-of-channel ground points that described the major breaks in slope. Sections extended above the average flood levels and were oriented so they were perpendicular to the high flow pathway. This survey data was used to determine the existing and proposed crossing configuration and to develop a hydraulic model of the crossings.

Hydraulic Conditions at Proposed Crossings

A HEC-RAS hydraulic model was developed for the two road crossings to determine the configuration of potential road crossing improvements and the associated hydraulic conditions at the mean monthly flows so as to consider the potential for upstream fish passage. Hydraulic conditions at peak flows were not considered, as fish passage is not possible at peak flows and structural stability was not considered at this stage in the project (structural design issues should be addressed under the design phase).

3. ALTERNATIVE DESCRIPTIONS

Three alternatives were developed for each of the two road crossings. These included maintaining the existing road crossings and installing new low to moderate conveyance openings as one or more spans, as several box culverts, and as several arched culverts. This section provides a description of each of these alternatives. A comparison of alternatives is presented in the next chapter.

Alternatives for Nickwall Crossing

At the Nickwall Crossing, the three alternatives consist of two 20-foot pre-cast concrete spans, four 12-foot wide pre-cast concrete or aluminum box culverts, and six 6.8 by 4.9-foot arched corrugated metal culverts, respectively (Table 3). These three alternatives are schematically depicted in Figures 1 through 3. Note that all of the crossings include a natural streambed, either by an open span or installing the culverts one foot below the channel grade and backfilling with streambed material (or allowing them to fill naturally to match the stream grade).

Table 3. Three alternatives for the Nickwall Crossing.

Site	Minimum Span or Culvert Length	Alternative 1: Spans	Alternative 2: Box Culverts	Alternative 3: Arch Culverts
Nickwall Crossing	36 ft	Two 20-ft by 4-ft high precast concrete spans	Four 12-ft by 5-ft pre-cast concrete or aluminum box culverts	Six 6.8-ft by 4.9-ft CMP arch culverts

Figure 1. Alternative 1 for the Nickwall Crossing consists of two 20-foot wide pre-cast concrete spans approximately 4 feet high. The bottom would be open and would consist of natural streambed materials.

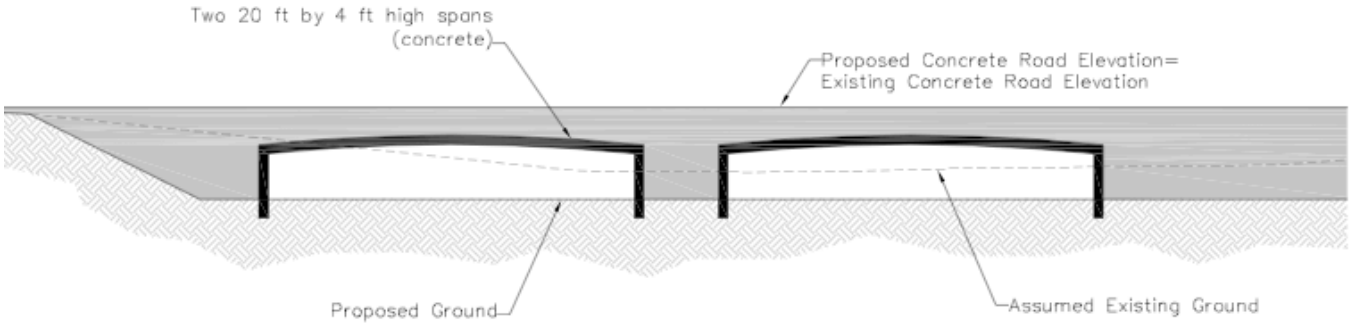


Figure 2. Alternative 2 for the Nickwall Crossing consists of four 12-foot wide by 5-foot high pre-cast concrete or aluminum box culverts. The box culverts would be embedded below grade by about one foot and backfilled with gravel to provide resting area for slow swimming fish within the culvert.

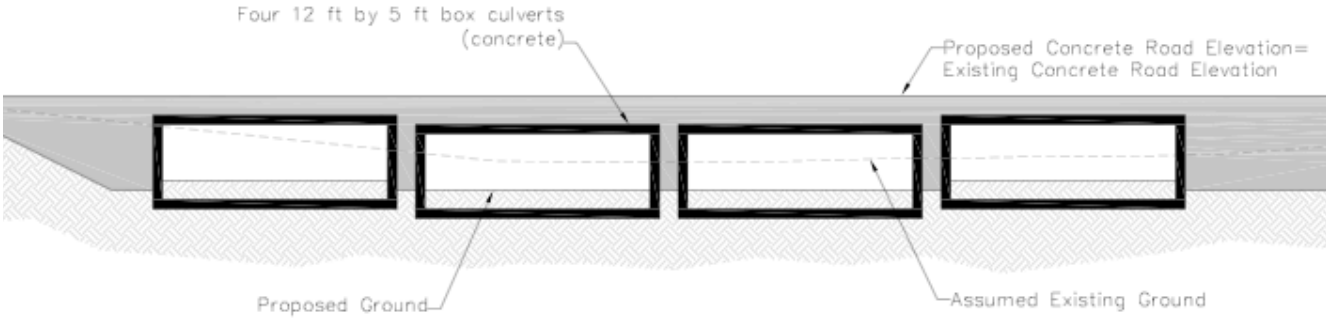
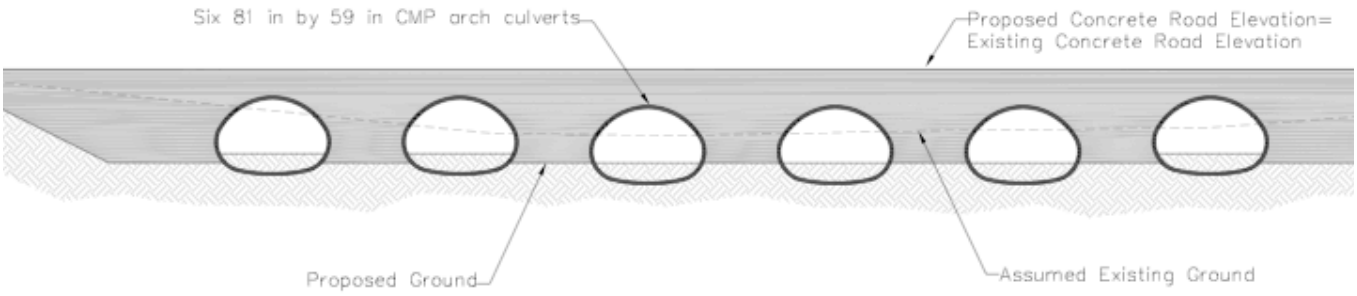


Figure 3. Alternative 3 for the Nickwall Crossing consists of six arched corrugated metal culverts. The arches would be approximately 6.8-feet wide by 4.9-feet high. The culverts would be embedded below grade by about one foot and either backfilled with gravel or allowed to aggrade with river sediment to provide resting area for slow swimming fish within the culvert.



Alternatives for Redwater Crossing

At the Redwater Crossing, the three alternatives consist of two 16-foot pre-cast concrete span, two 14-foot wide pre-cast concrete or aluminum box culverts, and five 5 by 3.8-foot arched corrugated metal culverts, respectively (Table 4). These three alternatives are schematically depicted in Figures 4 through 6. Like the Nickwall Crossings, these crossings also include a natural streambed, either by an open span or installing the culverts one foot below the channel grade and backfilling with streambed material (or allowing them to fill naturally to match the stream grade).

Table 4. Three alternatives for the Redwater Crossing.

Site	Minimum Span or Culvert Length	Alternative 1: Spans	Alternative 2: Box Culverts	Alternative 3: Arch Culverts
Redwater Crossing	36 ft	Two 16-ft by 4 ft pre-cast concrete span	Two 14-ft by 5-ft pre-cast concrete or aluminum box culverts plus raise the road 2 ft	Five 5-ft by 3.8-ft CMP arch culverts plus raise the road 0.5 ft

Figure 4. Alternative 1 for the Redwater Crossing consists of two 16-foot wide pre-cast concrete spans approximately 4-feet high. The bottom would be open and would consist of natural streambed materials.

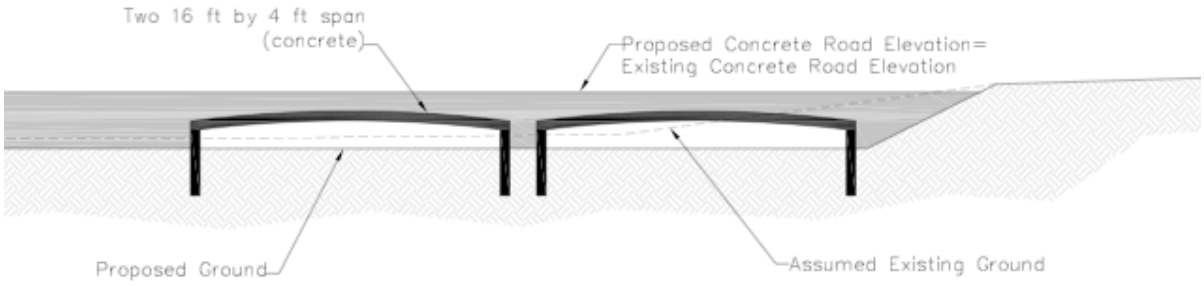


Figure 5. Alternative 2 for the Redwater Crossing consists of two 14-foot wide by 5-foot high pre-cast concrete or aluminum box culverts. The box culverts would be embedded below grade by about one foot and backfilled with gravel to provide resting area for slow swimming fish within the culvert.

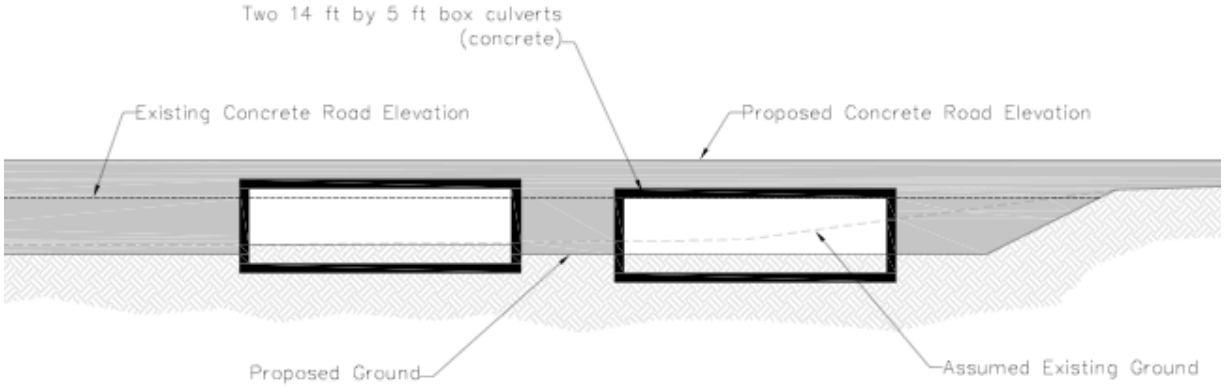
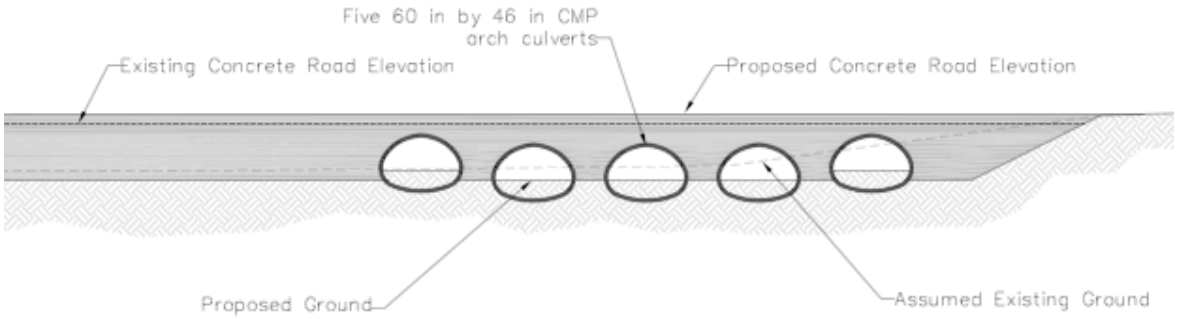


Figure 6. Alternative 3 for the Redwater Crossing consists of five arched corrugated metal culverts. The arches would be approximately 5 feet wide by 3.8 feet high. The culverts would be embedded below grade by about one foot and either backfilled with gravel or allowed to aggrade with river sediment to provide resting area for slow swimming fish within the culvert.



4. ALTERNATIVES ANALYSIS

The alternatives for the two crossings were evaluated based on two criteria: 1) upstream fish passage function at mean monthly flows and 2) the design and installation cost.

Upstream fish passage was evaluated using the hydraulic model by estimating the maximum water velocity and minimum water depth in each crossing at each mean monthly flow. Passage is reported for each crossing as whether the water velocity is greater or less than 1 foot per second for mean flows for each month. Water depth for all mean monthly flows was greater than 0.4 feet.

Cost was estimated by anticipated design and construction costs. Since costs are based on conceptual design configurations, the estimates include a 25% contingency.

The following subsections identify the results of this analysis.

Analysis of Nickwall Crossing

Fish Passage Conditions

Upstream fish passage was considered based on two criteria: water velocity of less than 1 ft/sec and water depth of at least 0.4 feet. Passage was evaluated based on hydraulic conditions at mean monthly flows. Both of these criteria are satisfied for several months for each the three Nickwall Crossing alternatives (Table 5). Alternatives 1 (Span) and 2 (Box Culverts) provide generally better passage conditions than Alternative 3 (Arch Culverts).

Cost

The cost to design and install each of the three Nickwall Crossing alternatives ranges from $191,000 to $511,000 (Table 6). The cost for Alternative 3 (Arch Culverts) is the lowest. The cost for Alternative 2 (Box Culverts) constructed of aluminum culvert, the next lowest in cost, is about 40% higher.

Discussion of Alternatives

Based on the aforementioned analysis, Alternative 1 (Span) and Alternative 2 (Box Culverts) provide somewhat better upstream fish passage at the Nickwall Crossing when compared to Alternative 3 (Arch Culverts). Passage criteria are satisfied during 8 months with the former alternatives and only 6 months with the latter alternative.

The cost estimates for the three Nickwall Crossing alternatives indicate that Alternative 3 (Arch Culverts) is the least expensive.

Alternative 3 (Arch Culverts) provides acceptable upstream fish passage function at the lowest cost.

Table 5. Summary of upstream fish passage conditions for the three Nickwall Crossing alternatives based on mean monthly flows. Figures in grey indicate that velocity and depth criteria are satisfied for a given month. Figures in pink indicate that velocity criteria are not satisfied for a given month. The number of months that velocity and depth criteria are satisfied is also shown.

Month	Mean Monthly Flow	Existing Conditions Velocity	Alternative 1: Span		Alternative 2: Box Culverts		Alternative 3: Arch Culverts	
			Max Velocity	Min Depth	Max Velocity	Min Depth	Max Velocity	Min Depth
	(cfs)	(ft/s)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
Jan	3.1	2.6	0.2	0.4	0.3	0.4	0.4	0.4
Feb	80.1	7.5	1.4	1.5	1.3	1.5	1.8	1.5
Mar	125.5	7.9	1.9	1.8	1.6	1.8	2.3	1.8
Apr	138.9	8.0	2.0	1.9	1.7	1.9	2.4	1.9
May	31.0	5.0	0.8	1.0	0.8	1.0	1.1	1.0
Jun	57.0	6.3	1.2	1.3	1.1	1.3	1.5	1.3
Jul	47.1	5.8	1.0	1.2	1.0	1.2	1.4	1.2
Aug	8.7	3.4	0.4	0.6	0.5	0.6	0.7	0.6
Sep	5.2	3.0	0.3	0.5	0.4	0.5	0.6	0.5
Oct	4.8	2.9	0.3	0.5	0.4	0.5	0.6	0.5
Nov	5.2	3.0	0.3	0.5	0.4	0.5	0.6	0.5
Dec	3.3	2.7	0.2	0.4	0.3	0.4	0.5	0.4
No. of Months Water Velocity and Depth Fish Passage Criteria are Satisfied (grey)			8		8		6	

Table 6. Estimated cost to design and install each alternative for the Nickwall Crossing alternatives.

Alternative	Cost
Nickwall Crossing Alternative 1: Two Spans	$347,000
Nickwall Crossing Alternative 2A: Four Concrete Box Culverts	$511,000
Nickwall Crossing Alternative 2B: Four Aluminum Box Culverts	$267,000
Nickwall Crossing Alternative 3: Six Arch Culverts	$191,000

Analysis of Redwater Crossing

Fish Passage Conditions

Upstream fish passage was considered based on two criteria: water velocity of less than 1 ft/sec and water depth of at least 0.4 feet. Passage was evaluated based on hydraulic conditions at mean monthly flows. Both of these criteria are satisfied for several months for each the three Redwater Crossing alternatives (Table 7). Alternatives 1 (Span) and 2 (Box Culverts) provide slightly better passage conditions than Alternative 3 (Arch Culverts).

Cost

The cost to design and install each of the three Redwater Crossing alternatives ranges from $125,000 to 302,000 (Table 8). The cost for Alternative 3 (Arch Culverts) is the lowest. The cost for Alternative 2 (Box Culverts) constructed of aluminum culvert, the next lowest in cost, is about 65% higher.

Discussion of Alternatives

Based on the aforementioned analysis, Alternative 1 (Span) and Alternative 2 (Box Culverts) provide slightly better upstream fish passage at the Redwater Crossing when compared to Alternative 3 (Arch Culverts). Passage criteria are satisfied during 7 months with the former alternatives and 6 months with the latter alternative.

The cost estimates for the three Redwater Crossing alternatives indicate that the cost for Alternative 3 (Arch Culverts) is the least expensive.

Alternative 3 (Arch Culverts) provides acceptable upstream fish passage function at the lowest cost.

Table 7. Summary of upstream fish passage conditions for the three Redwater Crossing alternatives based on mean monthly flows. Figures in grey indicate that velocity and depth criteria are satisfied for a given month. Figures in pink indicate that velocity criteria are not satisfied for a given month. The number of months that velocity and depth criteria are satisfied is also shown.

Month	Mean Monthly Flow	Existing Conditions Velocity	Alternative 1: Span		Alternative 2: Box Culverts		Alternative 3: Arch Culverts	
			Max Velocity	Min Depth	Max Velocity	Min Depth	Max Velocity	Min Depth
	(cfs)	(ft/s)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
Jan	3.0	1.11	0.3	0.4	0.5	0.4	0.6	0.4
Feb	76.2	5.69	2.4	1.5	1.8	1.8	3.0	1.8
Mar	119.4	5.42	3.8	1.5	2.3	2.1	4.8	2.1
Apr	132.1	5.37	4.2	1.5	2.5	2.2	5.1	road over-topped
May	29.5	4.47	1.0	1.3	1.0	1.3	1.6	1.2
Jun	54.2	5.79	1.7	1.5	1.5	1.6	2.4	1.6
Jul	44.8	5.82	1.4	1.5	1.3	1.5	2.1	1.5
Aug	8.3	2.02	0.5	0.7	0.7	0.7	0.9	0.7
Sep	5.0	1.52	0.4	0.5	0.7	0.5	0.8	0.5
Oct	4.6	1.45	0.3	0.5	0.7	0.5	0.7	0.5
Nov	5.0	1.52	0.4	0.5	0.7	0.5	0.8	0.5
Dec	3.2	1.16	0.3	0.4	0.6	0.4	0.6	0.4
No. of Months Water Velocity and Depth Fish Passage Criteria are Satisfied (grey)			7		7		6	

Table 8. Estimated cost to design and install each alternative for the Redwater Crossing alternatives.

Alternative	Cost
Redwater Crossing Alternative 1: Span	$302,000
Redwater Crossing Alternative 2A: Two Concrete Box Culverts	$296,000
Redwater Crossing Alternative 2B: Two Aluminum Box Culverts	$205,000
Redwater Crossing Alternative 3: Five Arch Culverts	$125,000

5. RECOMMENDATIONS

Based on the upstream fish passage criteria and analysis presented in this document, the most cost-effective alternatives for the two crossings that provide acceptable fish passage are Alternative 3 (Arch Culverts).

Appendix 1 Cost Estimates

Nickwall Crossing Alternative 1: Two Spans

Total Estimated Construction Cost With Contingency **$347,000**
Contingency Percent **25%**
Contingency Amount **$86,750**

No.	Activity	Quantity	Unit	Unit Price	Cost	Subtotal Cost	Assumptions and Comments
1.0	**Site Preparation**						
1.1	Mobilization and Demobilization	1	ls	$20,000	$20,000	**$37,500**	Adjusted to be about 8% of project construction cost.
1.2	Control of Water	1	ls	$15,000	$15,000		
1.3	Traffic Control	1	ls	$2,500	$2,500		
2.0	**Crossing Modifications**						
2.1	Stream Grading	1	ls	$10,000	$10,000	**$186,750**	Some degree of channel grade adjustment will be required
2.2	Excavation of Existing Concrete Road	225	cu yd	$10	$2,250		Multiplied cross-sectional area going 3 feet past structures on either side by the width of the road in direction of flow. Excavation includes excavation of concrete and soil.
2.3	Contech 20-ft x 4-ft Concrete Spans (2)	72	lf	$2,000	$144,000		Material price from Contech, including delivery, times 1.5 for installation. Interpolated cost upwards for 20x4 from 12x4 and 14x4.
2.4	Fill (Soil Core of Replaced Road)	80	cu yd	$100	$8,000		Total Excavation minus Concrete Replacement minus opening area
2.5	Concrete Road Replacement	45	cu yd	$500	$22,500		Multiplied distance from edge to edge of structures plus 6 feet by width of road in direction of flow by assumed 1 foot thickness of concrete
3.0	**Design and Construction Services**						
3.1	Engineering Design	1	ls	$35,000	$35,000	**$53,000**	Adjusted to be about 12% of project construction cost.
3.2	Permitting	1	ls	$6,000	$6,000		Adjusted to be about 2% of project construction cost.
3.3	Construction Assistance	1	ls	$12,000	$12,000		Adjusted to be about 4% of project construction cost.

Nickwall Crossing Alternative 2A: Four Concrete Box Culverts

Total Estimated Construction Cost With Contingency **$511,000**
Contingency Percent **25%**
Contingency Amount **$127,750**

No.	Activity	Quantity	Unit	Unit Price	Cost	Subtotal Cost	Assumptions and Comments
1.0	**Site Preparation**						
1.1	Mobilization and Demobilization	1	ls	$30,000	$30,000	**$47,500**	Adjusted to be about 8% of project construction cost.
1.2	Control of Water	1	ls	$15,000	$15,000		
1.3	Traffic Control	1	ls	$2,500	$2,500		
2.0	**Crossing Modifications**						
2.1	Stream Grading	1	ls	$10,000	$10,000	**$287,470**	Some degree of channel grade adjustment will be required
2.2	Excavation of Existing Concrete Road	265	cu yd	$10	$2,650		Multiplied cross-sectional area going 3 feet past structures on either side by the width of the road in direction of flow. Excavation includes excavation of concrete and soil.
2.3	12-ft x 5-ft Concrete Box Culverts (4)	144	lf	$1,655	$238,320		Material price from Cretex for 12x4, including delivery, times 1.5 for installation (adjusted 12x4 price by ratio of 12x5 weight to 12x4 weight)
2.4	Fill (Soil Core of Replaced Road)	90	cu yd	$100	$9,000		Total Excavation minus Concrete Replacement minus opening area
2.5	Concrete Road Replacement	55	cu yd	$500	$27,500		Multiplied distance from edge to edge of structures plus 6 feet by width of road in direction of flow by assumed 1 foot thickness of concrete
3.0	**Design and Construction Services**						
3.1	Engineering Design	1	ls	$50,000	$50,000	**$74,000**	Adjusted to be about 12% of project construction cost.
3.2	Permitting	1	ls	$8,000	$8,000		Adjusted to be about 2% of project construction cost.
3.3	Construction Assistance	1	ls	$16,000	$16,000		Adjusted to be about 4% of project construction cost.

Nickwall Crossing Alternative 2B: Four Aluminum Box Culverts

Total Estimated Construction Cost With Contingency **$267,000**
Contingency Percent **25%**
Contingency Amount **$66,750**

No.	Activity	Quantity	Unit	Unit Price	Cost	Subtotal Cost	Assumptions and Comments
1.0	**Site Preparation**						
1.1	Mobilization and Demobilization	1	ls	$16,000	$16,000	**$33,500**	Adjusted to be about 8% of project construction cost.
1.2	Control of Water	1	ls	$15,000	$15,000		
1.3	Traffic Control	1	ls	$2,500	$2,500		
2.0	**Crossing Modifications**						
2.1	Stream Grading	1	ls	$10,000	$10,000		Some degree of channel grade adjustment will be required
2.2	Excavation of Existing Concrete Road	265	cu yd	$10	$2,650		Multiplied cross-sectional area going 3 feet past structures on either side by the width of the road in direction of flow. Excavation includes excavation of concrete and soil.
2.3	14-ft 8-in x 4-ft 1-in Aluminum Box Culverts (3)	108	lf	$850	$91,800	**$140,950**	Material price from Contech for 14x4, including delivery, times 1.5 for installation
2.4	Fill (Soil Core of Replaced Road)	90	cu yd	$100	$9,000		Total Excavation minus Concrete Replacement minus opening area
2.5	Concrete Road Replacement	55	cu yd	$500	$27,500		Multiplied distance from edge to edge of structures plus 6 feet by width of road in direction of flow by assumed 1 foot thickness of concrete
3.0	**Design and Construction Services**						
3.1	Engineering Design	1	ls	$26,000	$26,000	**$39,000**	Adjusted to be about 12% of project construction cost.
3.2	Permitting	1	ls	$4,000	$4,000		Adjusted to be about 2% of project construction cost.
3.3	Construction Assistance	1	ls	$9,000	$9,000		Adjusted to be about 4% of project construction cost.

Nickwall Crossing Alternative 3: Six Arch Culverts

Total Estimated Construction Cost With Contingency **$191,000**
Contingency Percent **25%**
Contingency Amount **$47,750**

No.	Activity	Quantity	Unit	Unit Price	Cost	Subtotal Cost	Assumptions and Comments
1.0	**Site Preparation**						
1.1	Mobilization and Demobilization	1	ls	$12,000	$12,000	**$29,500**	Adjusted to be about 8% of project construction cost.
1.2	Control of Water	1	ls	$15,000	$15,000		
1.3	Traffic Control	1	ls	$2,500	$2,500		
2.0	**Crossing Modifications**						
2.1	Stream Grading	1	ls	$10,000	$10,000	**$100,560**	Some degree of channel grade adjustment will be required
2.2	Excavation of Existing Concrete Road	270	cu yd	$10	$2,700		Multiplied cross-sectional area going 3 feet past structures on either side by the width of the road in direction of flow. Excavation includes excavation of concrete and soil.
2.3	81-in x 59-in CMP Arch Culvert (6)	216	lf	$210	$45,360		Material price from Roscoe, including delivery, times 1.5 for installation
2.4	Fill (Soil Core of Replaced Road)	150	cu yd	$100	$15,000		Total Excavation minus Concrete Replacement minus opening area
2.5	Concrete Road Replacement	55	cu yd	$500	$27,500		Multiplied distance from edge to edge of structures plus 6 feet by width of road in direction of flow by assumed 1 foot thickness of concrete
3.0	**Design and Construction Services**						
3.1	Engineering Design	1	ls	$13,000	$13,000	**$23,000**	Adjusted to be about 12% of project construction cost.
3.2	Permitting	1	ls	$3,000	$3,000		Adjusted to be about 2% of project construction cost.
3.3	Construction Assistance	1	ls	$7,000	$7,000		Adjusted to be about 4% of project construction cost.

Redwater Crossing Alternative 1: Two Spans

Total Estimated Construction Cost With Contingency **$302,000**
Contingency Percent **25%**
Contingency Amount **$75,500**

No.	Activity	Quantity	Unit	Unit Price	Cost	Subtotal Cost	Assumptions and Comments
1.0	**Site Preparation**						
1.1	Mobilization and Demobilization	1	ls	$18,000	$18,000	**$35,500**	Adjusted to be about 8% of project construction cost.
1.2	Control of Water	1	ls	$15,000	$15,000		
1.3	Traffic Control	1	ls	$2,500	$2,500		
2.0	**Crossing Modifications**						
2.1	Stream Grading	1	ls	$10,000	$10,000	**$161,100**	Some degree of channel grade adjustment will be required
2.2	Excavation of Existing Concrete Road	100	cu yd	$10	$1,000		Multiplied cross-sectional area going 3 feet past structures on either side by the width of the road in direction of flow. Excavation includes excavation of concrete and soil.
2.3	Contech 16-ft x 4-ft Concrete Span (2)	72	lf	$1,800	$129,600		Material price from Contech, including delivery, times 1.5 for installation. Interpolated cost upwards for 16x4 from 12x4 and 14x4.
2.4	Fill (Soil Core of Replaced Road)	30	cu yd	$100	$3,000		Total Excavation minus Concrete Replacement minus opening area
2.5	Concrete Road Replacement	35	cu yd	$500	$17,500		Multiplied distance from edge to edge of structures plus 6 feet by width of road in direction of flow by assumed 1 foot thickness of concrete
3.0	**Design and Construction Services**						
3.1	Engineering Design	1	ls	$30,000	$30,000	**$45,000**	Adjusted to be about 12% of project construction cost.
3.2	Permitting	1	ls	$5,000	$5,000		Adjusted to be about 2% of project construction cost.
3.3	Construction Assistance	1	ls	$10,000	$10,000		Adjusted to be about 4% of project construction cost.

Redwater Crossing Alternative 2A: Two Concrete Box Culverts

Total Estimated Construction Cost With Contingency **$296,000**
Contingency Percent **25%**
Contingency Amount **$74,000**

No.	Activity	Quantity	Unit	Unit Price	Cost	Subtotal Cost	Assumptions and Comments
1.0	**Site Preparation**						
1.1	Mobilization and Demobilization	1	ls	$18,000	$18,000	**$35,500**	Adjusted to be about 8% of project construction cost.
1.2	Control of Water	1	ls	$15,000	$15,000		
1.3	Traffic Control	1	ls	$2,500	$2,500		
2.0	**Crossing Modifications**						
2.1	Stream Grading	1	ls	$10,000	$10,000	**$156,210**	Some degree of channel grade adjustment will be required
2.2	Excavation of Existing Concrete Road	105	cu yd	$10	$1,050		Multiplied cross-sectional area going 3 feet past structures on either side by the width of the road in direction of flow. Excavation includes excavation of concrete and soil.
2.3	14-ft x 5-ft Concrete Box Culverts (2)	72	lf	$1,655	$119,160		Material price from Cretex for 14x4, including delivery, times 1.5 for installation (adjusted 14x4 price by ratio of 14x5 weight to 14x4 weight)
2.4	Fill (Soil Core of Replaced Road)	60	cu yd	$100	$6,000		Since road is raised, new cross-sectional area of road x width of road in direction of flow minus concrete minus opening area
2.5	Concrete Road Replacement	40	cu yd	$500	$20,000		Multiplied distance from edge to edge of structures plus 6 feet by width of road in direction of flow by assumed 1 foot thickness of concrete
3.0	**Design and Construction Services**						
3.1	Engineering Design	1	ls	$30,000	$30,000	**$45,000**	Adjusted to be about 12% of project construction cost.
3.2	Permitting	1	ls	$5,000	$5,000		Adjusted to be about 2% of project construction cost.
3.3	Construction Assistance	1	ls	$10,000	$10,000		Adjusted to be about 4% of project construction cost.

Redwater Crossing Alternative 2B: Two Aluminum Box Culverts

Total Estimated Construction Cost With Contingency **$205,000**
Contingency Percent **25%**
Contingency Amount **$51,250**

No.	Activity	Quantity	Unit	Unit Price	Cost	Subtotal Cost	Assumptions and Comments
1.0	**Site Preparation**						
1.1	Mobilization and Demobilization	1	ls	$18,000	$18,000	**$35,500**	Adjusted to be about 8% of project construction cost.
1.2	Control of Water	1	ls	$15,000	$15,000		
1.3	Traffic Control	1	ls	$2,500	$2,500		
2.0	**Crossing Modifications**						
2.1	Stream Grading	1	ls	$10,000	$10,000		Some degree of channel grade adjustment will be required
2.2	Excavation of Existing Concrete Road	105	cu yd	$10	$1,050		Multiplied cross-sectional area going 3 feet past structures on either side by the width of the road in direction of flow. Excavation includes excavation of concrete and soil.
2.3	14-ft 8-in x 4-ft 1-in Aluminum Box Culverts (2)	72	lf	$850	$61,200	**$98,250**	Material price from Contech for 14x4, including delivery, times 1.5 for installation
2.4	Fill (Soil Core of Replaced Road)	60	cu yd	$100	$6,000		Since road is raised, new cross-sectional area of road x width of road in direction of flow minus concrete minus opening area
2.5	Concrete Road Replacement	40	cu yd	$500	$20,000		Multiplied distance from edge to edge of structures plus 6 feet by width of road in direction of flow by assumed 1 foot thickness of concrete
3.0	**Design and Construction Services**						
3.1	Engineering Design	1	ls	$20,000	$20,000	**$30,000**	Adjusted to be about 12% of project construction cost.
3.2	Permitting	1	ls	$3,000	$3,000		Adjusted to be about 2% of project construction cost.
3.3	Construction Assistance	1	ls	$7,000	$7,000		Adjusted to be about 4% of project construction cost.

Redwater Crossing Alternative 3: Five Arch Culverts

Total Estimated Construction Cost With Contingency **$125,000**
Contingency Percent **25%**
Contingency Amount **$31,250**

No.	Activity	Quantity	Unit	Unit Price	Cost	Subtotal Cost	Assumptions and Comments
1.0	**Site Preparation**						
1.1	Mobilization and Demobilization	1	ls	$8,000	$8,000	**$25,500**	Adjusted to be about 8% of project construction cost.
1.2	Control of Water	1	ls	$15,000	$15,000		
1.3	Traffic Control	1	ls	$2,500	$2,500		
2.0	**Crossing Modifications**						
2.1	Stream Grading	1	ls	$10,000	$10,000		Some degree of channel grade adjustment will be required
2.2	Excavation of Existing Concrete Road	90	cu yd	$10	$900		Multiplied cross-sectional area going 3 feet past structures on either side by the width of the road in direction of flow. Excavation includes excavation of concrete and soil.
2.3	60-in x 46-in CMP Arch Culvert (5)	180	lf	$140	$25,200	**$56,100**	Material price from Roscoe, including delivery, times 1.5 for installation
2.4	Fill (Soil Core of Replaced Road)	50	cu yd	$100	$5,000		Since road is raised, new cross-sectional area of road x width of road in direction of flow minus concrete minus opening area
2.5	Concrete Road Replacement	30	cu yd	$500	$15,000		Multiplied distance from edge to edge of structures plus 6 feet by width of road in direction of flow by assumed 1 foot thickness of concrete
3.0	**Design and Construction Services**						
3.1	Engineering Design	1	ls	$12,000	$12,000	**$18,000**	Adjusted to be about 12% of project construction cost.
3.2	Permitting	1	ls	$2,000	$2,000		Adjusted to be about 2% of project construction cost.
3.3	Construction Assistance	1	ls	$4,000	$4,000		Adjusted to be about 4% of project construction cost.