TECHNICAL MEMORANDUM

Harvey Creek Fish Barrier and Culvert

Prepared by:

Great West engineering

Prepared for:
Trout Unlimited

TROUT UNLIMITED

December 2014

HARVEY CREEK FISH BARRIER AND CULVERT

TECHINICAL MEMORANDUM

Prepared for:

Trout Unlimited

DECEMBER 2014

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TECHNICAL MEMORANDUM

Harvey Creek Fish Barrier and Culvert
Mullan Trail

Trout Unlimited
Granite County, Montana

Table Of Contents

SECTION 1 INTRODUCTION

Description and History of Project

The Harvey Creek watershed located near Bearmouth, Montana is a priority stream for genetically pure native bull trout and Westslope cutthroat trout populations. The project is located approximately 1200' upstream of the confluence with the Clark Fork River. The focus of the project is an existing timber fish barrier structure and a roadway crossing culvert located just upstream of the fish barrier. The fish barrier consists of treated timber railroad ties and measures approximately 9' tall and 10'-12' wide. The timber structure was originally built to modify the Harvey Creek stream gradient to enable construction of the railroad line downstream of the structure. The culvert at the Mullan Trail road crossing consists of a 7' span by 5' rise corrugated steel culvert. According to the local landowner, the previous road crossing was a bridge structure and was replaced with the current culvert by County crews. Additionally, he stated that there was a timber flume structure present at one time downstream of the existing fish barrier structure that conveyed Harvey Creek. It is important to note that the existing fish barrier is a component of the road crossing structure and is currently serving as a weir, stabilizing the stream channel upstream and downstream.

The purpose of this project is to evaluate the condition of the fish barrier and the culvert crossing, consider risk of failure and propose replacement alternatives (if necessary). The intent is to preserve the integrity of the fish barrier to prevent nonnative fishes and other aquatic organisms from invading this high priority stream. Additionally, based on discussion with project stakeholders, future incorporation of selective fish passage modifications may be introduced depending on the status of Bull Trout recovery in Harvey Creek.

Project Location

The project is located on both public (County Owned) and private property, and is approximately 12 miles west of Drummond, Montana (Figure 1). The site lies in the southeast quarter of Section 16, Township 11 North and Range 14 West, in Granite County, at latitude 46.70341°N, longitude 113.3723°W and elevation of 3800 feet. The culvert crossing is located on Mullan Trail, a Granite County maintained public roadway.

Site Description

The site consists of an assortment of deciduous trees, shrubs and riparian vegetation. Willows, grasses, and sedges are present in many areas. An irrigation ditch return enters Harvey Creek approximately 100' downstream of the existing fish barrier. A stream gage and concrete structure are present in the stream approximately 120' downstream of the fish barrier. A private residence is located approximately 300' to the southeast of the site. The existing land use is primarily agricultural, with occasional grazing throughout the project site. No signs of overgrazing are present and land use appears to be well managed. Utilities appear to be present, though identifying and marking utilities is outside the scope of this contract.

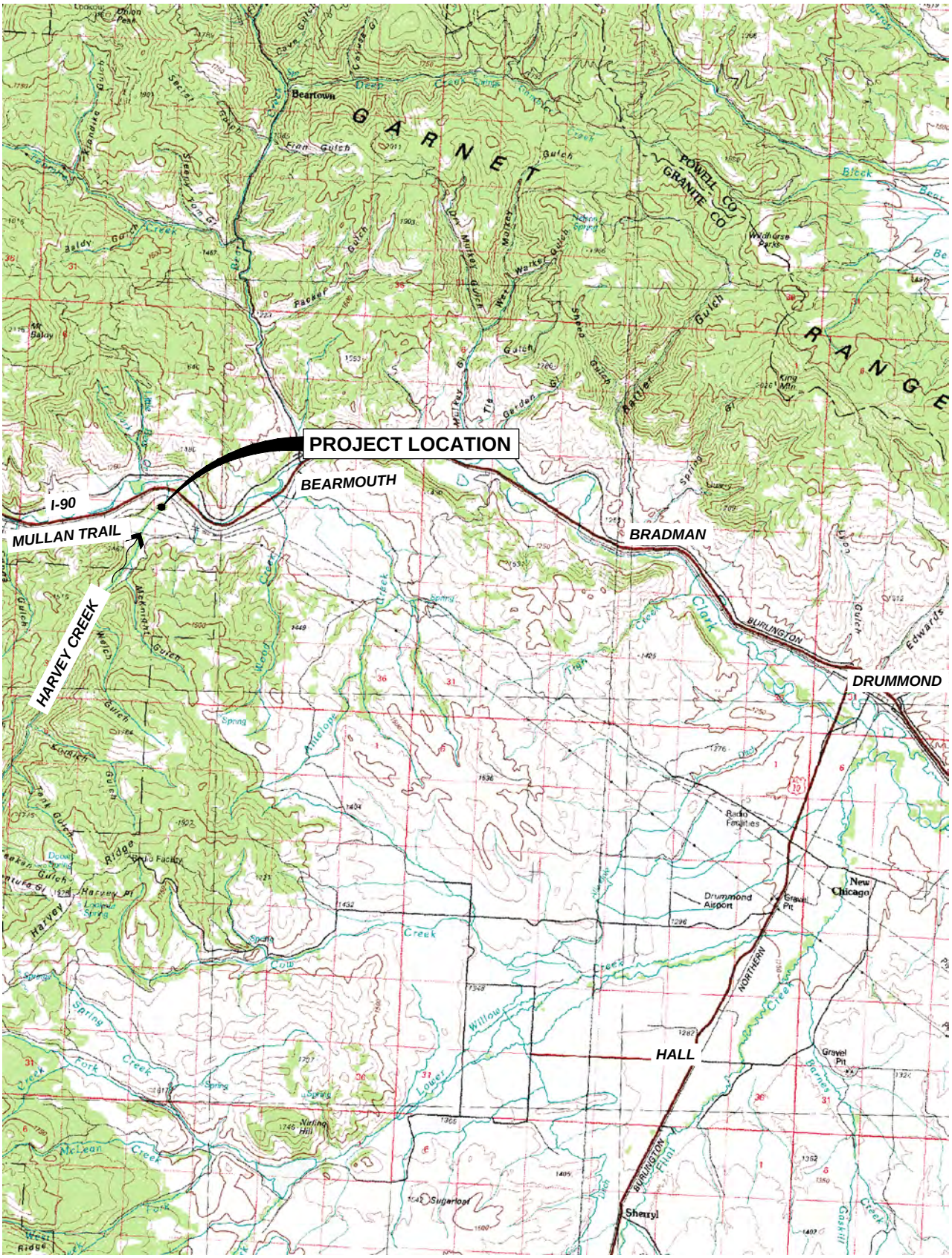

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Figure #1
Location Map

SECTION 2 EXISTING CONDITIONS

Fish Barrier Structure

The existing fish barrier structure consists of 8” x 12” treated timber railroad ties. The barrier is constructed in a stepped and battered crib wall configuration. The structure is approximately 9’ tall, 10’ to 12’ wide and 8’ deep (along stream horizontal alignment). As noted previously, the structure was originally constructed to modify the downstream stream gradient to facilitate railway construction and was not constructed for the purpose of being a fish barrier. The exact age of the structure is unknown, but based on materials, estimated between 40 and 50 years. See the following figures below for a plan and profile view of the existing structure:

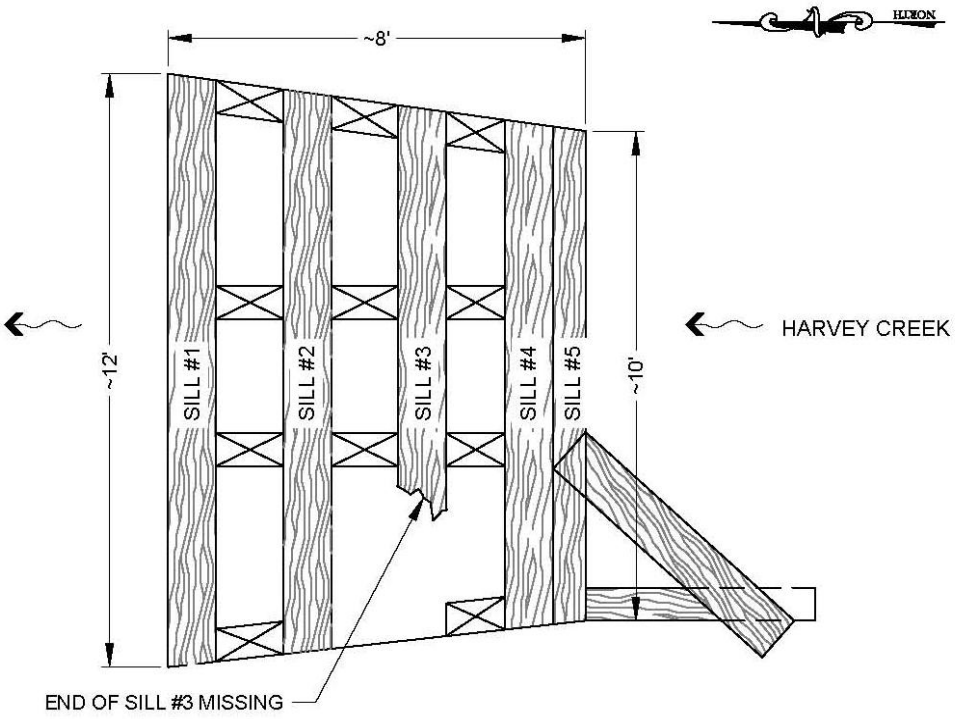

Figure 2: Fish Barrier Plan

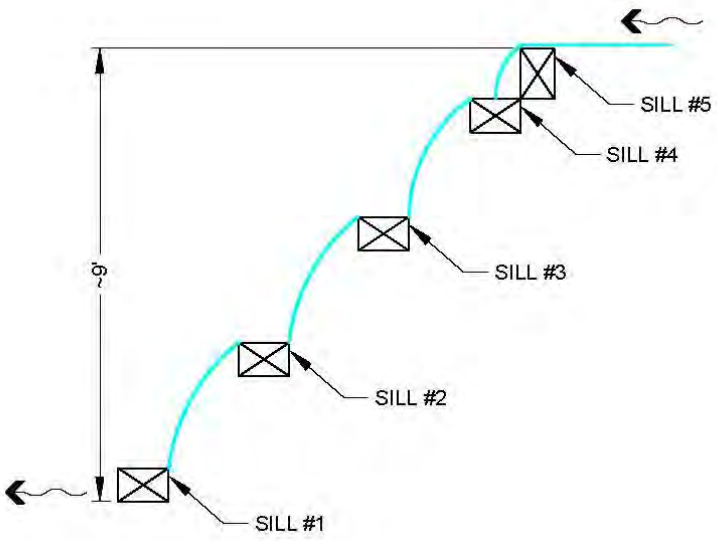

Figure 3: Fish Barrier Profile

Overall, the structure is in poor condition. Sill #3 has experienced failure on the west side of the structure, with a significant portion of the member gone. The remainder of Sill #3 is tipping and structurally unsound. There are numerous areas of undermining throughout the structure, with the worst being under Sill #4 on the west face, with up to 4' of horizontal undermining. Additionally, Sills #1 and #2 are experiencing undermining (up to 2'-6" horizontal). The overall condition of the timber is poor-to-fair, with numerous areas of section loss, crushing, splitting and areas of decay. In general, ½" to 1" of surface decay is present with other areas of moderate to full decay. Timber borings were done in four locations throughout the structure. See the timber boring logs in Section 10. Vegetation and moss growth are present in numerous locations throughout the structure.

Figure 4: Existing Fish Barrier

Figure 5: 4' horizontal undermining under Sill #2

Repairs have been previously attempted on the existing structure and consisted of installing rebar into crib wall members to provide additional lateral and vertical support. The date of the repair is unknown. The repairs appear to be mostly cosmetic and likely do little to prevent the current stability issues of the wall.

Figure 6: Previously attempted repair has failed

Culvert Structure

The culvert structure consists of a 7' span x 5' rise x 33' long corrugated steel pipe arch culvert of unknown age. The culvert has 3" x 1" corrugations. The structure has approximately 1'-1.5' of cover over the top of the pipe. The culvert is skewed approximately 20 degrees to the roadway. Some existing riprap (12"-24" diameter) is present on the downstream end of the culvert.

The culvert is in very poor condition and is currently in a stage of failure. The culvert invert is has completely failed for a length of 10' near the culvert inlet. The invert has complete section

loss and the bottom has ruptured. Because of the invert failure, some piping under the culvert is present. The bottom of the pipe has visible undulations, possibly a result of piping and differential settlement.

Figure 7: Culvert failure near inlet

Additionally, minor to moderate deformation is present throughout the culvert on the walls and the top of the pipe. Moderate corrosion is present elsewhere in the culvert invert and sides extending 18" vertically from the invert. Both culvert ends exhibit moderate damage. The upstream end of the culvert is not aligned properly to the stream and should be moved to the west approximately 3' to 4' to promote better hydraulic efficiency. The existing length of the culvert appears sufficient, though downstream could be lengthened 4' to 5' to better retain road fill.

Figure 8: View of existing culvert inlet

Harvey Creek

Harvey Creek in the vicinity of the project has been impaired and impacted by the significant vertical change in channel gradient caused by the installation of the existing fish barrier structure. Significant channel incision is present throughout the upstream reach. In the vicinity of the culvert, stream aggradation (material deposition) is present on the upstream right bank above the culvert. Some areas of channel overwidening are present, likely due to past human activities in the stream. The stream banks appear well vegetated and relatively stable.

Mullan Trail

The roadway through the site is in good condition, with a 14’ useable road width and 18’ top width. Some gravel surfacing is present, though mostly fines exist in the roadway prism. The structure is located on a tangent section of roadway. A horizontal curve starts 80’ to the east of the structure. The vertical profile of the roadway is relatively flat, with a vertical crest curve approximately 100’ west of the structure.

SECTION 3 POTENTIAL RISKS OF FAILURE

Culvert Structure

As stated previously, the existing culvert structure is currently in state of failure. The culvert invert has completely failed for a length of 10' near the upstream inlet. Additionally, there are areas of deformation throughout the pipe and corrosion in the lower 18" of the pipe. The culvert invert provides significant structural support, and a culvert invert with full section loss results in areas of significant point loading, which can result in deformation. It appears the failure is located under the upstream roadway lane and due to the minimal cover over the culvert, will likely result in slow deformation (until complete failure). Estimating time to failure is challenging and especially so with a lightly used roadway with occasional high loads (log trucks, concrete trucks, etc.).

Additional methods for potential failure include high flow events. The existing culvert cannot handle the County standard 25-year design event without overtopping. Potential high flow events could remove road bed material and result in the potential loss of the structure.

Other areas of failure include potential failure due to loss of the fish barrier. If the fish barrier were to fail, it is likely that stream headcutting would result in roadway loss and culvert loss.

Fish Barrier Structure

The fish barrier structure is in poor condition. The primary structural concerns are timber structural member loss, significant undermining and condition of the timber materials. Currently, the undermining would likely yield failure more quickly than any other method. If undermining continues of the timber sills, members could fail, resulting in material loss, eventually leading to significant headcutting and potential roadway loss upstream. It is estimated that due to the undermining concerns and the timber structural concerns, this structure has approximately 5-10 years of useful life left before replacement.

Other potential failure mechanisms include failure due to loss of the culvert. The loss of the culvert could create grade stabilization issues, flow concentrations or other problems that could overwhelm the existing structure, causing it to fail.

SECTION 4 PRELIMINARY FISH BARRIER DESIGN ALTERNATIVES

Numerous design alternatives were evaluated as potential structures for fish barriers. Consideration was given to constructability, economics, visual impacts, future selective fish passage modifications and environmental impacts. Generally, if site constraints allow, barriers located in “pinch” points of the channel with native rock are ideal locations. However, the project site is limited in placement locations and locating the structure near its current location was identified as being the location with the least impacts. Having a vertical fish barrier structure located adjacent to the roadway presents some safety concerns to the traveling public. There is currently no roadside barrier in place adjacent to the roadway.

Several different structures, consisting of vertical drop structures and velocity barriers, were analyzed as possible replacements for the current structure. Additionally, due to the existing drop (approximately 9’), it may be possible to do two stepped structures. For simplicity, analysis of structures was completed utilizing a single drop structure, so each structure could be evaluated equally. The fish barrier structures were all evaluated at anticipated heights of 9’, with variable widths, depending on structure type. The fish barrier structures will be sized for the Q50 flood event, the same design event as the culvert structure, in accordance with Granite County Road Standards.

Fish Barrier Alternatives – Vertical Drop Structures

Alternative 1: Three-Sided Concrete Box Structure

This alternative would consist of a precast concrete fish barrier. The configuration would be a three-sided concrete box culvert flipped over to allow the sides of the culvert to serve as fill retainage. The base of the three sided concrete box culvert would serve as the splash pad. The sides of the culvert could be tapered to match existing ground. Downstream of the splash pad, a riprap apron would be installed to further reduce erosion and dissipate velocities.

Figure 9: Three-Side concrete box (in combination with four-sided concrete box road structure)

Pros

- Fits site well, minimal cover required
- Debris passage
- Allowance for future selective fish passage modifications

Cons

- Cost effectiveness
- Height of three sided sections may required lateral bracing

Alternative 2: Perched Culvert with Retaining Wall

This structure would consist of extending the culvert replacement structure to the top of the retaining wall creating a perched culvert with a retaining wall serving as support and the barrier structure. The retaining wall could be constructed from a variety of materials; including gabions, precast concrete blocks, cast-in-place concrete or sheet pile.

Due to the height required, gabions would likely require a tie back system. Gabions would also likely be the most cost effective retaining wall type. However, due to the poor condition of the existing culvert, some corrosion issues appear to be present (possible pH related) from either the surrounding water or soil. Further analysis should be completed on the soil and water prior to structure selection to analyze chemical properties and determine suitability of material types. No structure coatings were analyzed or included in the cost estimates. This may impact both the gabion wall and sheet pile wall alternatives.

The precast concrete block wall would be a fully engineered wall consisting either of large gravity block or a smaller block wall with horizontal tie backs. This may be the most aesthetic solution for a retaining wall option.

The cast-in-place wall would be a fully engineered full height retaining wall with a footing and stem system. No tie backs would likely be necessary for this wall, assuming a full width footing can be installed.

All wall options stated above would need a full splash pad. Splash pads are typically constructed of concrete, grouted riprap or riprap. Due to anticipated high velocities and long term stability concerns, concrete will be assumed for use as splash pad. A downstream apron will be installed below the splash pad to provide addition energy dissipation.

Figure 10: Perched culvert w/gabion retaining wall (Photo courtesy of George Long, Region 3 USDA Forest Service)

Pros

- Versatility to fit site well
- Potential cost effectiveness

Cons

- High velocities due to limited flow spread
- Some concern with wall height (tie backs may be necessary on numerous)
- Potential icing issues in winter
- Challenging to provide future selective fish passage modifications
- Concern with material erodibility (if gabions are utilized)
- Geotechnical evaluations may be required (for sheet pile)
- Specialized equipment may be required (for sheet pile)

Vertical Fish Barrier Summary

The previously discussed vertical fish barrier alternatives each have their own distinct advantages and disadvantages. The perched culvert with sheet pile alternative will not be investigated further due to cost concerns and unknown geotechnical conditions at the site. The perched culvert with cast-in-place wall will likely be more expensive than the precast block wall and require more on-site challenges (formwork) and will not be investigated further. The three-sided concrete box (Alternative 1), perched culvert with concrete block (Alternative 2a) and perched culvert with gabions (Alternative 2b) will be evaluated further. Refer to preliminary opinions of probable cost in Section 1.8.

Fish Barrier Alternatives – Velocity Barriers

Alternative 3: Cast-in-place Concrete Velocity Barrier

This alternative would consist of creating a concrete apron at a steep slope. This concrete apron will have cutoff walls on the top and bottom ends to prevent any potential undermining. The apron will have a defined trapezoidal section to prevent sidecutting of the structure and promote effective, efficient flow passage for the design event. Energy dissipation features, such as concrete baffles, may be placed on the slope to aid in velocity/energy reduction.

Figure 11: Cast-in-place concrete velocity barrier with dissipation

Pros

- Customization to fit site well
- Reduction in potential scour potential (due to lower velocities)
- Potential allowance for future selective fish passage modifications

Cons

- Potential icing issues in winter
- Constructability

Alternative 4: Culvert Extension

This alternative would consist of extending the new culvert to the stream grade. This would only work cost effectively with the corrugated steel pipe arch option and may require a transitional section to a different pipe section. This is commonly referred to as a ‘broken back’ configuration.

Pros

- May offer safer roadway due to non vertical configuration

Cons

- Costly
- Potential icing issues in winter
- Challenging to provide future selective fish passage modifications
- Constructability
- Long term life

Alternative 5: Rock Chute

This alternative would consist of installing a riprap chute from the new culvert outlet to the streambed.

Pros

- Customization to fit site well
- Affordable

Cons

- Long term stability issues
- Challenging to provide future selective fish passage modifications
- Potential for fish movement

Velocity Fish Barrier Summary

The previously discussed velocity fish barrier alternatives each have their own distinct advantages and disadvantages. The culvert extension alternative will not be evaluated further due to long term structure concerns and cost concerns. The rock chute alternative will not be evaluated further due to long term stability concerns and potential for fish movement through the structure. The cast-in-place concrete velocity barrier (Alternative 3) will be evaluated further. Refer to preliminary opinions of probable cost in Section 1.8.

SECTION 5 PRELIMINARY CULVERT DESIGN ALTERNATIVES

Culvert Structure Alternatives

Aquatic organism passage (AOP) was not identified on-site by the project owner representative as being necessary for potential replacement, due to the close proximity to the fish barrier structure. Though the Granite County Bridge Standards recommend open bottom structures to be considered, they are a more expensive solution and not required at the site. Therefore, only closed bottom structures were identified as potential replacement structures. These structures are typically constructed of reinforced concrete, aluminum or steel. Due to the corrosion and section loss on the existing steel pipe, some corrosivity issues appear to be present (possible pH related) in either the surrounding water or soil. Further analysis should be completed on the soil and water prior to structure selection to analyze chemical properties to determine suitability of material types. No structure coatings were analyzed or included in the cost estimates.

The Granite County Bridge Standards require structures to pass the 25-year flood event or if possible the 50-year event, if costs aren't sufficiently increased. Preliminary hydraulic calculations showed that there is a relatively minimal difference in structure sizes between the Q25 and Q50 events, therefore, a Q50 design event will be utilized. Additionally, the current side slopes of the structure (approx. 1.5:1) are too steep for County standard; therefore, all structures will be evaluated at a 40' length, which should be sufficient to accommodate the roadway and side slopes. See specific hydraulic requirements in Section 1.7.

Alternative A: Corrugated Steel Pipe Arch Culvert

This design alternative would replace the existing structure with a similar pipe arch culvert structure. Preliminary hydraulic calculations have determined that replacement as a 103" (8'-7") span x 71" (5'-11") rise structure will handle the 50-year flood event and meet County headwater requirements. This would require raising the road approximately 12"-18".

Pros

- Fits stream channel well
- Potential extension into fish barrier alternatives

Cons

- May require coating depending on water and soil chemical composition

Alternative B: Circular Steel Culvert

This design alternative would replace the existing structure with a round corrugated steel culvert. Preliminary hydraulic calculations have determined that a 7' diameter round pipe will handle the 50-year flood event and meet County headwater requirements. This would require raising the roadway approximately 24"-30".

Pros
- Most cost effective

Cons
- Does not fit stream channel well
- Would require substantial raising of roadway
- May require coating depending on water and soil chemical composition

Alternative C: Concrete Box Culvert (Four – Sided)

This design alternative would replace the existing structure with a precast four-sided concrete box culvert. Preliminary calculations have determined that an 8' span x 5' rise concrete box culvert will handle the 50-year flood event and still meet County headwater requirements. This would require raising roadway approximately 6".

Pros
- Allows minimal cover
- Potential extension into fish barrier alternative
- Fits stream channel well
- Provides natural corrosion resistance

Cons
- Cost effectiveness

Alternative D: Aluminum Box Culvert

This design alternative would replace the existing structure with an aluminum box culvert with an aluminum bottom. Preliminary calculations have identified replacement as a 10' span x 4'-10" rise aluminum box culvert will handle the Q50 event. This would require raising the roadway approximately 6".

Pros
- Hydraulically efficient section
- Fits stream channel well
- Provides natural corrosion resistance

Cons
- Cost effectiveness

Culvert Structure Alternative Summary

The circular corrugated steel pipe culvert alternative does not fit the road profile and would require raising the roadway 2' to 3', which is not practical. Therefore, it will not be investigated further. The aluminum box culvert offers similar advantages as the pipe arch, but costs substantially more; therefore, it will not be investigated further. The pipe arch (Alternative A) and four-sided concrete box culvert (Alternative C) will be investigated further. Refer to preliminary opinions of probable cost in Section 8.

SECTION 6 HYDROLOGY

The Harvey Creek drainage is approximately 39.5 square miles at the Mullan Trail road crossing and is located in the USGS West Drainage Basin. Average precipitation for the drainage basin is estimated at 20 inches and approximately 80% of the basin is forested. No USGS stream gages are present on Harvey Creek or any nearby drainage basins. Therefore, USGS rural regression equations were utilized to determine peak flow rates on Harvey Creek for use on this project. The regression equations used a combination of basin characteristics, active channel width and estimated bankfull width to determine flood frequency. Bankfull channel characteristics were evaluated based on field measurements. The results of the hydrologic calculations are shown in the tables below and the hydrologic basin delineation and USGS regression results are included in subsequent pages.

Table 1: Harvey Creek Site Data

Harvey Creek Stream Channel Data	
Stream Name:	Harvey Creek
Drainage Area:	39.5 Square Miles
Bankfull Width:	11’-0”
Bankfull Depth:	1’-3”
Width to Depth Ratio:	8.8:1

Table 2: Harvey Creek Hydrology

FLOW EVENT	DISCHARGE (CFS)
Q_2	61
Q_{25}	225
Q_{50}	283
Q_{100}	343

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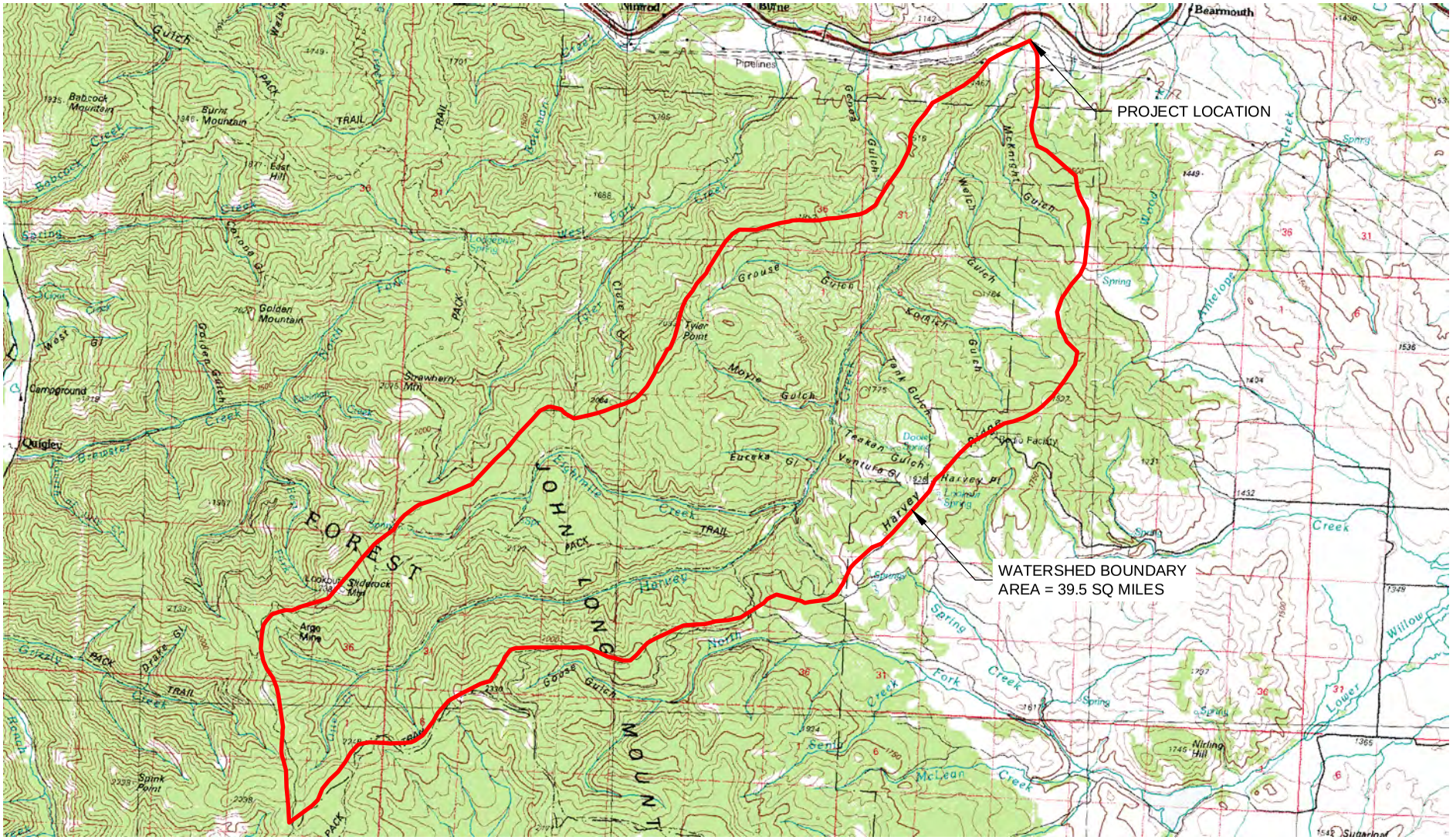

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HYDROLOGIC DELINEATION

TROUT UNLIMITED
HARVEY CREEK FISH BARRIER EVALUATION

USGS

Montana Flood-Frequency and Basin-Characteristic Data

Estimate Flood Discharges at Ungaged Sites in Montana -- (continued)

Summary of Estimation Parameters Selected:

Name for this estimation:	**Harvey Creek Fish Barrier**
Region:	**West**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**39.5**
Mean annual precipitation in inches:	**20**
Percent basin forested:	**80**
Width of active channel in feet:	**7**
Width of bank full channel in feet:	**11**

Flood Discharge Estimation:

(In the Flood Discharge table, RI is the Recurrence Interval, in years; STD ERR is the Standard Error; and 90% PRED. INTERVAL is the 90% Prediction Interval, in cubic feet per second)

```
METHOD: Regression on basin characteristics
Flood frequency estimates for
Harvey Creek Fish Barrier
West Region : A =     39.50: P =  20.00: F =  80.00
RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
           (cfs)      PREDICTION(%)
    2        105.        60.2              41.6              264.
    5        188.        55.2              79.8              442.
   10        252.        54.1             108.7              585.
   25        341.        54.4             146.4              794.
   50        411.        55.8             173.3              976.
  100        483.        58.3             196.8             1180.
  200        558.        62.0             216.5             1440.
  500        662.        67.6             239.0             1830.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Harvey Creek Fish Barrier
West Region: WAC = 7.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	33.	63.6	12.5	87.
5	59.	61.2	23.2	151.
10	80.	61.6	31.4	206.
25	111.	63.6	42.1	292.
50	136.	66.5	49.8	371.
100	162.	69.9	57.0	462.
200	191.	74.1	63.7	573.
500	232.	80.2	71.9	746.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Harvey Creek Fish Barrier
West Region: WBF = 11.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	32.	72.4	11.0	95.
5	58.	67.6	21.1	162.
10	79.	66.8	28.9	217.
25	109.	67.7	39.4	303.
50	134.	69.7	47.1	380.
100	160.	72.6	54.2	470.
200	188.	76.4	60.9	579.
500	227.	82.0	69.0	747.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Harvey Creek Fish Barrier
Region 1

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	61.	49.9	28.1	134.
5	115.	46.9	54.8	240.
10	159.	47.0	75.7	334.
25	225.	49.0	104.2	486.
50	283.	51.0	127.3	627.
100	343.	54.3	147.8	798.
200	408.	58.9	165.1	1010.
500	500.	65.2	185.9	1340.

Q25: DESIGN EVENT 225 CFS

Montana Flood-Frequency and Basin-Characteristic Data

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SECTION 7 HYDRAULICS

Hydraulic Requirements

This project is located on Mullan Trail, a Granite County maintained roadway. As such, all replacement structures must be designed to meet County standards as stated in the 2011 Granite County Bridge Standards. These standards state that all culvert replacements shall be designed for the 25-year recurrence interval, and if possible, the 50-year event. Because all replacement structures identified are culverts, culverts will be designed to meet headwater requirements. Headwater for large diameter culverts must be less than 1.5 times the diameter of the rise of the pipe. Due to minimal cover over the pipe, the headwater will likely be controlled by the road surface elevation.

Hydraulic Analysis

The hydraulic characteristics of Harvey Creek were analyzed to estimate flood elevations and velocities at various recurrence intervals. FHWA HY-8 software was utilized to approximate the water surface elevations passing through the existing and proposed structures for the preliminary hydraulic analysis.

Data for Harvey Creek was obtained from on-site longitudinal profile measurements using a level and other on-site field measurements. The existing channel slope in the vicinity of the culvert is between 1.6% and 4.9%, with the existing culvert slope at 1.8%.

Manning's "n" values used in the hydraulic computations were determined based on engineering judgment using photos and site observations and then calibrated to match anticipated channel velocities and bankfull flow capacity. Channel roughness values for the site utilized n = 0.042 for the channel. The mannings "n" for the existing culvert and replacement culverts was identified based on their material types.

The existing culvert was modeled to determine capacity. Each proposed replacement structure was also modeled. The proposed conditions model the proposed conditions after removal of the existing culvert and replacement with the proposed structure.

Existing Culvert

The following is a table of the results of the existing culvert:

Table 3: Existing Culvert Hydraulics – 7' Span x 5' Rise Corrugated Steel Pipe Arch

Flood Event	Flow (cfs)	Headwater Depth (ft)	Outlet Velocity (ft/s)	Freeboard (ft)
2-Year	61	2.54	5.67	2.48
25-Year	225	5.97	7.17	-0.2 (Overtops Road)
50-Year	283	6.19	8.66	-0.4 (Overtops Road)

The existing culvert does not meet Granite County Bridge Standards and overtops the roadway at the Q25 year event.

Proposed Culverts

The following tables are results of the hydraulics for the proposed replacement culverts. For simplicity, all culverts were modeled utilizing the gradient of the existing culvert:

Table 4: Proposed Culvert Hydraulics – 103" Span x 71" Rise Corrugated Steel Pipe Arch

Flood Event	Flow (cfs)	Headwater Depth (ft)	Outlet Velocity (ft/s)	Freeboard (ft)
2-Year	61	2.29	5.67	3.62
25-Year	225	5.18	10.38	0.73
50-Year	283	6.16	11.04	0.24 (Headwater)

Table 5: Proposed Culvert Hydraulics – 8' Span x 5' Rise Concrete Box Culvert

Flood Event	Flow (cfs)	Headwater Depth (ft)	Outlet Velocity (ft/s)	Freeboard (ft)
2-Year	61	1.84	6.0	3.16
25-Year	225	4.46	8.95	0.44
50-Year	283	5.28	9.56	0.28 (Headwater)

SECTION 8 PRELIMINARY OPINION OF PROBABLE COSTS

Trout Unlimited - Harvey Creek Fish Barrier and Culvert

PRELIMINARY DESIGN ALTERNATIVES SUMMARY

Alternatives		Proposed Structure	Total Cost*
Fish Barrier Alternatives			
Alternative 1	Precast 3-Sided Concrete Box Culvert	Varies	**$78,432.00**
Alternative 2a	Precast Concrete Block Wall	Varies	**$60,049.50**
Alternative 2b	Gabion Rock Wall	Varies	**$58,669.20**
Alternative 3	Cast-in-place Concrete Velocity Barrier	Varies	**$73,852.50**
Culvert Alternatives			
Alternative A	Pipe Arch Culvert	8'-7" Span x 5'-11" Rise	**$33,540.00**
Alternative C	Four-Sided Concrete Box Culvert	8' Span x 5' Rise	**$70,756.50**

Possible Alternative Combinations (Most Cost Effective) Include:

Alternative Combination	Total Cost*
Alternative 1 - C	$149,188.50
Alternative 2a-A	$93,589.50
Alterantive 2b-A	$92,209.20
Alternative 3-A	$107,392.50

Total costs include contingency and engineering

PRELIMINARY OPINION OF PROBABLE COST

PROJECT	CLIENT	DATE
Harvey Creek Fish Barrier and Culvert	***Trout Unlimited***	***11/3/2014***

	COUNTY	ROAD NO.	ALTERNATIVE
	Granite	***Mullan Trail***	***Fish Barrier Replacement - Alternative 1 - Three Sided Concrete Box Culvert***

ITEM NO.	*DESCRIPTION*	*UNIT*	*QUANTITY*	*PRICE*	*AMOUNT*
1	Mobilization	10%	1	$6,100.00	$6,100.00
2	Temporary Soil Erosion and Pollution Control	Lump Sum	1	$5,000.00	$5,000.00
3	Construction Staking	Lump Sum	1	$1,000.00	$1,000.00
4	Structure Excavation	Lump Sum	1	$6,000.00	$6,000.00
5	Removal of Existing Structure	Lump Sum	1	$4,500.00	$4,500.00
6	Precast Concrete Cutoff Walls	Each	2	$1,500.00	$3,000.00
7	Precast Concrete 3-Sided Box Culvert	Lump Sum	1	$30,000.00	$30,000.00
8	Placed Riprap (Riprap Apron)	Cubic Yards	25	$100.00	$2,500.00
9	Bedding Material	Cubic Yards	10	$55.00	$550.00
10	Hydraulic Excavator with Thumb	Hour	6	$150.00	$900.00
11	Lateral Support Bars for End Sections	Lump Sum	1	$1,250.00	$1,250.00
		SUBTOTAL			$60,800.00
		Contingency		**15%**	**$9,120.00**
		Engineering Design		**14%**	**$8,512.00**
		TOTAL			**$78,432.00**

PRELIMINARY OPINION OF PROBABLE COST

PROJECT	CLIENT	DATE
Harvey Creek Fish Barrier and Culvert	***Trout Unlimited***	***11/3/2014***

	COUNTY	ROAD NO.	TASK
	Granite	***Mullan Trail***	***Fish Barrier Replacement - Alternative 2a - Perched Culvert w/Precast Block Wall***

ITEM NO.	*DESCRIPTION*	*UNIT*	*QUANTITY*	*PRICE*	*AMOUNT*
1	Mobilization	10%	1	$4,700.00	$4,700.00
2	Temporary Soil Erosion and Pollution Control	Lump Sum	1	$5,000.00	$5,000.00
3	Construction Staking	Lump Sum	1	$1,000.00	$1,000.00
4	Structure Excavation	Lump Sum	1	$6,000.00	$6,000.00
5	Removal of Existing Structure	Lump Sum	1	$4,000.00	$4,000.00
6	Concrete Block Wall	Square Foot	350	$42.00	$14,700.00
7	Bedding Material/Structural Backfill	Cubic Yards	35	$50.00	$1,750.00
8	Concrete Splash Pad	Cubic Yards	8	$1,000.00	$8,000.00
9	Placed Riprap (Riprap Apron)	Cubic Yards	25	$20.00	$500.00
10	Hydraulic Excavator with Thumb	Hour	6	$150.00	$900.00
		SUBTOTAL			$46,550.00
		Contingency		**15%**	**$6,982.50**
		Engineering Design		**14%**	**$6,517.00**
		TOTAL			**$60,049.50**

PRELIMINARY OPINION OF PROBABLE COST

PROJECT	CLIENT	DATE
Harvey Creek Fish Barrier and Culvert	***Trout Unlimited***	***11/3/2014***

	COUNTY	ROAD NO.	TASK
	Granite	***Mullan Trail***	***Fish Barrier Replacement - Alternative 2b - Perched Culvert with Gabion Baskets***

ITEM NO.	*DESCRIPTION*	*UNIT*	*QUANTITY*	*PRICE*	*AMOUNT*
1	Mobilization	10%	1	$4,600.00	$4,600.00
2	Temporary Soil Erosion and Pollution Control	Lump Sum	1	$5,000.00	$5,000.00
3	Construction Staking	Lump Sum	1	$1,000.00	$1,000.00
4	Structure Excavation	Lump Sum	1	$6,000.00	$6,000.00
5	Removal of Existing Structure	Lump Sum	1	$4,000.00	$4,000.00
6	Gabions, Galvanized (Includes Rock Fill)	Cubic Yards	55	$215.00	$11,825.00
7	Non-Woven Separation Fabric	Square Yard	45	$9.00	$405.00
8	Bedding Material/Structural Backfill	Cubic Yards	25	$50.00	$1,250.00
9	Concrete Splash Pad	Cubic Yard	8	$1,000.00	$8,000.00
10	Placed Riprap (Riprap Apron)	Cubic Yard	25	$100.00	$2,500.00
11	Hydraulic Excavator with Thumb	Hour	6	$150.00	$900.00
		SUBTOTAL			$45,480.00
		Contingency		**15%**	**$6,822.00**
		Engineering Design		**14%**	**$6,367.20**
		TOTAL			**$58,669.20**

PRELIMINARY OPINION OF PROBABLE COST

PROJECT	CLIENT	DATE
Harvey Creek Fish Barrier and Culvert	***Trout Unlimited***	***11/3/2014***

	COUNTY	ROAD NO.	TASK
	Granite	***Mullan Trail***	***Fish Barrier Replacement - Alternative 3 - Cast-In-Place Concrete Velocity Barrier***

ITEM NO.	*DESCRIPTION*	*UNIT*	*QUANTITY*	*PRICE*	*AMOUNT*
1	Mobilization	10%	1	$5,800.00	$5,800.00
2	Temporary Soil Erosion and Pollution Control	Lump Sum	1	$5,000.00	$5,000.00
3	Construction Staking	Lump Sum	1	$1,000.00	$1,000.00
4	Structure Excavation	Lump Sum	1	$6,000.00	$6,000.00
5	Removal of Existing Structure	Lump Sum	1	$4,000.00	$4,000.00
6	Cast-In-Place Concrete (Includes dissipation structures)	Cubic Yards	28	$1,100.00	$30,800.00
7	Bedding Material	Cubic Yards	25	$50.00	$1,250.00
8	Placed Riprap (Riprap Apron)	Cubic Yards	25	$100.00	$2,500.00
9	Hydraulic Excavator with Thumb	Hour	6	$150.00	$900.00
		SUBTOTAL			$57,250.00
		Contingency		**15%**	**$8,587.50**
		Engineering Design		**14%**	**$8,015.00**
		TOTAL			**$73,852.50**

PRELIMINARY OPINION OF PROBABLE COST

PROJECT	CLIENT	DATE
Harvey Creek Fish Barrier and Culvert	***Trout Unlimited***	***11/3/2014***

	COUNTY	ROAD NO.	TASK
	Granite	***Mullan Trail***	***Culvert Replacement - Alternative 1 - Corrugated Pipe Arch - 103" Span x 71" Rise x 40' long***

ITEM NO.	*DESCRIPTION*	*UNIT*	*QUANTITY*	*PRICE*	*AMOUNT*
1	Mobilization	10%	1	$2,600.00	$2,600.00
2	Temporary Soil Erosion and Pollution Control	Lump Sum	1	$1,000.00	$1,000.00
3	Construction Staking	Lump Sum	1	$1,000.00	$1,000.00
4	Structure Excavation/Embankment	Lump Sum	1	$4,000.00	$4,000.00
5	Removal of Existing Culvert	Lump Sum	1	$2,000.00	$2,000.00
6	Bedding Material	Cubic Yard	15	$50.00	$750.00
7	Placed Riprap	Cubic Yard	15	$90.00	$1,350.00
8	Crushed Aggregate	Cubic Yard	20	$55.00	$1,100.00
9	103" Span x 71" Rise, Corrugated Steel Pipe Arch, 3" x 1" Corrugations	Linear Foot	40	$290.00	$11,600.00
10	Hydraulic Excavator with Thumb	Hour	4	$150.00	$600.00
		SUBTOTAL			$26,000.00
		Contingency		**15%**	**$3,900.00**
		Engineering Design		**14%**	**$3,640.00**
		TOTAL			**$33,540.00**

PRELIMINARY OPINION OF PROBABLE COST

PROJECT	CLIENT	DATE
Harvey Creek Fish Barrier and Culvert	***Trout Unlimited***	***11/3/2014***

	COUNTY	ROAD NO.	TASK
	Granite	***Mullan Trail***	***Culvert Replacement - Alternative 2 - Concrete Box Culvert - 8' Span x 5' Rise x 40' long***

ITEM NO.	*DESCRIPTION*	*UNIT*	*QUANTITY*	*PRICE*	*AMOUNT*
1	Mobilization	10%	1	$5,500.00	$5,500.00
2	Temporary Soil Erosion and Pollution Control	Lump Sum	1	$1,000.00	$1,000.00
3	Construction Staking	Lump Sum	1	$1,000.00	$1,000.00
4	Structure Excavation	Lump Sum	1	$4,000.00	$4,000.00
5	Removal of Existing Culvert	Lump Sum	1	$2,000.00	$2,000.00
6	Bedding Material	Cubic Yard	15	$50.00	$750.00
7	Placed Riprap (Upstream)	Cubic Yard	10	$90.00	$900.00
8	Crushed Aggregate	Cubic Yard	20	$55.00	$1,100.00
9	8' Span x 5' Rise, Four Sided Concrete Box Culvert	Linear Foot	40	$825.00	$33,000.00
10	Precast Concrete Wingwalls	Each	2	$2,500.00	$5,000.00
11	Hydraulic Excavator with Thumb	Hour	4	$150.00	$600.00
		SUBTOTAL			$54,850.00
		Contingency		**15%**	**$8,227.50**
		Engineering Design		**14%**	**$7,679.00**
		TOTAL			**$70,756.50**

SECTION 9 SITE PHOTOS

SITE PHOTOS

Photo #1 – View of roadway looking west over culvert.

Photo #2 – View of roadway looking east over culvert.

Photo #3 – View of existing culvert inlet, note poor stream alignment and aggradation upstream.

Photo #4 – View of Harvey Creek looking upstream from culvert inlet.

Photo #5 – View of culvert outlet and fish barrier.

Photo #6 – View of fish barrier and channel looking downstream of culvert.

Photo #7 – View of culvert condition near outlet. Note corrosion and deformation.

Photo #8 – View of culvert failure approx. 15' from inlet. Note complete section loss and corrosion.

Photo #9 – View of existing timber fish barrier.

Photo #10 – Another view of timber fish barrier. Note crib member loss at right and area of visible undermining.

Photo #11 – View of undermined (4') area under Sill #4 at west.

Photo #12 – Another view of undermining under Sill #4.

Photo #13 – View of past repair efforts with rebar on wall members, note split and ineffectiveness of rebar.

Photo #14 – View of timber coring taken on upper sill at west side.

SECTION 10 TIMBER BORING LOGS

CORING LOGS		
No.	**Location**	**Depth, Results**
1	Sill #5, Top of Sill, West Side	0-1/4", Light Decay ¼" – 5", Sound Material
2	Sill #5, Downstream Face, West Side, 4' from End	0-1/2", Surface Decay ½" – 5", Early Decay
3	Sill #4, Top of Sill, West Side, 6' from end	0-1/2", Decay ½" – 1", Moderate Decay 1" – 5", Sound Material
4	Sill #2, Top Sill, West Side	0"-5", Moist Material, Moderate Decay