Evaluation of Fish Assemblages and Habitat Variables in Streams Bisecting the Going-to-the-Sun Road and Peripheral Roads in Glacier National Park

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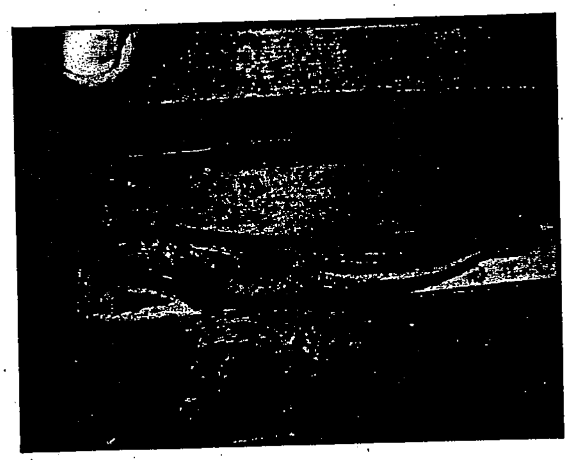

Final Report - 2004

Montana Cooperative
Fishery Research Unit

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Final Report

Andrew M. Dux and Christopher S. Guy

Montana Cooperative Fishery Research Unit
Department of Ecology, Montana State University
Bozeman, MT 59717

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Introduction

Glacier National Park (hereafter referred to as Park) is considering the rehabilitation of the Going-to-the-Sun Road (GTSR). The GTSR was completed in 1932 and is now recognized as a National Historic Landmark. Repairs are needed to preserve the historical character of the road, correct structural deficiencies in the road, and improve safety for travelers. According to the National Park Service, if the GTSR is not rehabilitated it will continue to deteriorate, resulting in further damage to natural, historical, and cultural resources in the Park.

Many of the aquatic resources in the Park have been altered by the introduction of nonnative fishes. However, there are areas within the Park that provide refugia for native fishes and likely support genetically pure stocks. Thus, protecting these populations from anthropogenic factors, such as impacts from road construction, is critical to the persistence of native fishes within the Park. The effect road construction may have on native bull trout *Salvenlinus confluentus*, a species listed as threatened under the Endangered Species Act, is of particular concern. There are eleven native and four nonnative fish species present in the McDonald Creek drainage west of the Continental Divide, while twelve native and five nonnative fish species exist in the St. Mary River drainage east of the Continental Divide (Table 1). The GTSR parallels or crosses waters in both the McDonald Creek and St. Mary River drainages that potentially support these species.

Rehabilitation of the GTSR will involve structural repairs and improvements to the existing roadway and adjacent roadside areas. It is anticipated that rehabilitation activities will result in soil disturbance, erosion, and sedimentation inputs into streams

and lakes. These disturbance are predicted to be short-term. Nevertheless, understanding the potential impacts to fish populations and assemblages in this fragile ecosystem is critical. This understanding should allow rehabilitation efforts to be structured to minimize the influence on fish and aquatic habitats.

Previous research has been conducted on some of the waters located in close proximity to the GTSR; however, limited information exists for many of the streams that the GTSR crosses. The purpose of this study was to evaluate major streams bisecting the GTSR prior to road construction (Avalanche, Baring, Jackson, Logan, Rose, Snyder, Sprague, and Two Dog Creeks; Figures 1 and 2). Additionally, several tributary streams to Lake McDonald (Apgar, Fern, Fish, and Kelly Creeks; Figures 1 and 2) that are bisected by peripheral Park roads were evaluated. Evaluation of these additional streams will provide baseline data useful when considering projects proposed near these streams in the future. The objectives of this study were to: 1) describe the fish assemblages and associated habitats in study streams, 2) identify critical habitat for bull trout and presence or absence of bull trout in stream reaches located near road crossings, and 3) document the locations and types of artificial fish passage structures and natural passage barriers.

Methods

Sampling Sites

Sampling sites (50 m long) were established above and below each road crossing for all of the study streams. Downstream sites were located immediately downstream of the road crossing, while the upstream sites began 50 m upstream from the road crossing. Several exceptions did occur. The upstream site at Rose Creek was moved several hundred meters upstream to allow sampling above a low-head diversion dam. On Kelly

Creek, large quantities of deadfall from 2003 wildfires prevented electrofishing above the road crossing. The mouth of Logan Creek is located immediately below the road crossing, so a downstream site was not established. Additionally, a large waterfall on Baring Creek prevents fish passage as far upstream as the GTSR crossing. Thus, the only site sampled was located several hundred meters downstream of the road crossing and below the waterfall. An upstream site could not be established because of hazardous conditions posed by a steep, bedrock canyon above the waterfall. All sites were sampled between 30 June 2004 and 4 August 2004 when streams were at summer flow levels.

Fish Sampling

A Smith-Root LR-24 backpack electroshocker was used to capture fish from streams. This unit features a quick-setup mode in which adjustments are automatically made to produce 30 Hz, 12% duty cycle, and 25 watts average output power based on water chemistry of the stream. We used this feature to set output for each site sampled. Also, a standard pulse waveform was used for all sampling sites. Single-pass electroshocking was conducted in an upstream direction using two dipnetters. Block nets were placed at the upstream boundary of some streams; however, these nets could not be placed in many of the larger streams because of high water velocity. Fish densities were low in all streams, so the effects of block nets were likely negligible. Captured fish were placed in a bucket and transported to a livecar for processing. Fish were enumerated, identified to species, measured for total length (mm), and weighed (g). Additionally, tissue samples were collected from westslope cutthroat trout *Oncorhynchus clarki lewisi* for genetic analysis.

Habitat Evaluation

Channel dimensions were measured along transects spaced at 10-m intervals within each 50-m sampling unit. Wetted width, channel depth, and channel gradient were measured as described by Peterson et al. (2002). Substrate type was measured at five equidistant points (0, 0.25, 0.5, 0.75, and 1.0 of the wetted width) along each transect using the Wolman pebble count method (Kondolf and Li 1992). The frequency of substrate size classes was analyzed using methods described by Bain (1999). Additionally, substrate embeddedness was visually estimated and rated (Bain 1999). Dominant stream habitat type (riffle, run, pool, pocket water) was determined at each transect. Temperature, dissolved oxygen, and conductivity were measured with a YSI (Yellow Springs Institute) model 85 meter at the time of electrofishing. Large woody debris (LWD; 3 m long by 10 cm diameter) was enumerated within each sampling unit (Peterson et al. 2002). To better assess stream habitat types and locate areas of habitat disturbances, walking surveys were conducted starting at the mouth of each stream and extending approximately 0.85 km upstream. The dominant stream habitat type (riffle, run, pool, pocket water) was identified every 10 m.

Fish Passage Barrier Evaluation

Artificial passage structures at each road crossing were described and photographed. Dimensions of culverts were measured, but bridges were not measured. Natural barriers were located and photographed during the previously described walking surveys.

Results

Fish

Eight fish species were sampled from 27 sites in 12 streams (Table 2). Westslope cutthroat trout were the most abundant and widespread of all species sampled. They were found in every stream and varied in size from 53-203 mm. Mean total length of the 137 westslope cutthroat trout captured from all streams was 97.9 mm (SE = 2.74). Rainbow trout *Oncorhynchus mykiss*, eastern brook trout *Salvelinus fontinalis*, and longnose dace *Rhinicthys cataractae* were found infrequently and in low abundance (Table 2). Slimy sculpins *Cottus cognatus*, mottled sculpins *Cottus bairdi*, burbot *Lota lota*, and redside shiners *Richardsonius balteatus* were also found infrequently, but were locally abundant at some sites (Table 2). Bull trout were not captured at any of the sites sampled. Tailed frog *Ascaphus truei* larvae were found in Apgar, Fern, Fish, Jackson, Logan, and Snyder creeks.

Although westslope cutthroat trout were present in all streams, mean catch rates were higher for streams in the McDonald Creek drainage than for streams in the St. Mary River drainage (Figure 3). Fish Creek had the highest mean catch rate of all streams sampled (Figure 3). Westslope cutthroat trout were always sampled upstream of road crossing structures, except for the site upstream of the diversion dam on Rose Creek.

A total of 120 westslope cutthroat trout tissue samples were collected from streams in the McDonald Creek drainage and stored for possible future genetic analyses. No tissue samples were collected from streams in the St. Mary River drainage.

Habitat Evaluation

Habitat variables were measured for each of the study streams (Table 3). In general, streams in the Park (i.e., for McDonald Creek and St. Mary River drainages) can be characterized as cool, high gradient, shallow, well-oxygenated, and have low total dissolved solids. Additionally, mixed substrate sizes were present in all streams, but larger (pebble, cobble, boulder) substrates dominated (Table 4). All embeddedness measurements were in the negligible (<5%) or low (5-25%) categories. Habitat surveys indicated that riffle habitats were most common in all streams except Fish Creek, where pocket water was the most frequently observed habitat type (Table 5).

Fish Passage Barriers

Eighteen road crossings were documented on the 12 study streams. Bridges were present at nine of the crossings, allowing unimpeded fish passage. At nine road crossings, a variety of sizes and types of culverts allowed streams to pass underneath roads (Table 6). Some culverts were designed to allow for obvious fish passage at a variety of flows; however, many culverts appeared to potentially be restricting fish passage, at least at some flows, because of small diameter, length, and perched height at the downstream end. Additionally, the diversion dam on Rose Creek was identified as an upstream barrier at all flows.

Natural passage barriers were identified on Avalanche and Baring creeks. A narrow bedrock canyon with numerous cascading waterfalls exists approximately 900 m upstream from the mouth of Avalanche Creek. On Baring Creek, a large waterfall (approximately 20 m high) is located 250 m upstream from the stream mouth. High gradient reaches and cascades were encountered on other streams that may restrict fish passage at some flows, but we could not classify any of these areas as barriers with certainty.

Discussion

Fish Assemblages

The low species diversity and abundance for all of the streams sampled was not surprising given the unproductive nature of these streams. The absence of bull trout in all streams was notable; however, it should be considered that our sampling design was not designed to rigorously determine bull trout presence or absence for entire streams. Historical electrofishing data for these streams is lacking, which prevented making temporal comparisons. This is unfortunate, as abundance and distribution data would have been insightful, particularly for bull trout and westslope cutthroat trout.

It seems apparent that at least two distinct populations of westslope cutthroat trout are present in the McDonald Creek drainage. The presence of westslope cutthroat trout in Avalanche and Logan creeks upstream of McDonald Creek Falls suggests that a distinct population exists above the falls. While downstream interchange may occur, it is highly unlikely that fish can ascend McDonald Creek Falls (Fredenberg 2000).

Rainbow trout and eastern brook trout were the only nonnative species captured during electrofishing surveys. Both of these species were present in the St. Mary River drainage, but only eastern brook trout were found in the McDonald Creek drainage. The lack of rainbow trout in the McDonald Creek tributaries was encouraging, considering hybridization concerns with westslope cutthroat trout that exist in many other Flathead River drainage streams (Hitt et al. 2003). Conversely, eastern brook trout are a potential hybridization threat to bull trout (Leary et al. 1993); however, this threat is probably negligible in comparison to ecological impacts posed by nonnative lake trout in the drainage.

Habitat Evaluation

Streams were generally composed of relatively undisturbed and high quality habitats. Notable exceptions occurred on Apgar, Fern, Fish, and Kelly creeks, where the 2004 Robert Fire burned the majority of these drainages. The fish assemblages and habitat conditions in each of these streams will be susceptible to future changes that typically follow wildfire, including increased soil erosion, warmer water temperatures, and an altered flow regime (Swanston 1991).

Areas of human-caused disturbance were localized near areas of development and roadways. Most streams contained a diversity of habitat types capable of supporting multiple life-history stages of native fishes. Nevertheless, the potential for bull trout production appeared limited. Many streams had an apparent shortage of suitable spawning gravels, others were inaccessible because of natural barriers (waterfalls, deltas at stream mouths), and some appeared to be inaccessible because of artificial barriers. Fish Creek appeared to have the highest potential to support bull trout, and evidence suggests that bull trout were present historically (Fredenberg 2000). Apgar, Fern, and Jackson creeks may be capable of supporting bull trout, if passage at culverts is not a problem. The likelihood of bull trout occupying any of the other streams sampled seems low.

All streams sampled supported westslope cutthroat trout and production potential appeared much higher than for bull trout. Areas suitable for spawning and rearing were fairly abundant; however, access to many of these habitats is questionable because of artificial passage structures.

Stream reaches in close proximity to roadways often suffered from habitat disturbances. Footpaths and trampled banks contributed to bank erosion and some channel widening on Rose, Baring, Snyder, Sprague, and Fish creeks. Human manipulations in the lower reaches of Fish Creek are particularly concerning considering this stream appears to have the greatest potential to support bull trout. Additionally, the lower reaches of Apgar, Snyder, and Rose creeks have been manipulated in the past and are now channelized and bank structure has been altered.

Fish Passage Barriers

Several structures were identified that may be posing serious threats to fish passage. The diversion dam on Rose Creek is a barrier preventing upstream movement and access to the majority of the drainage. Juvenile burbot were abundant below this barrier and absent above the barrier; thus, this barrier may be preventing burbot and other native fishes from accessing upstream habitats that may have been historically important. Also, the GTSR bridge crossing on Rose Creek may be a passage threat at some flows. This bridge has a cement bottom that causes increased water velocity under the bridge. Without substrate to provide velocity breaks, fish may have a difficult time ascending this stretch at some flows.

Substrate accumulation inside the cement box culvert on Two Dog Creek has reduced the opening on the downstream end of this culvert. At high flows this culvert may no longer be large enough to pass the necessary volume of water, which could pose threats to fish passage and the structural integrity of the GTSR.

Private homeowners near Kelly Creek have diverted water from Kelly Creek for decades (Bill Michels, Glacier National Park, personal communication). As a result, numerous dilapidated water pipes litter the lower reaches of this stream. These pipes do not pose any immediate threats to fish, but do compromise the natural appearance of the stream. Additionally, the existing water diversion system may impede fish passage at some flows. At the site where water is diverted, the stream is almost completely blocked by wood and plastic diversion structures, making it virtually impossible for fish to navigate upstream.

Jackson Creek passes under the GTSR through an undersized cement box culvert that is perched 0.6 m on the downstream end. The perch height and high water velocity through this culvert likely create a barrier at most flows. If this is the case, nearly the entirety of Jackson Creek is unavailable to native fishes. An earlier study also identified this culvert as a potential passage threat (Fredenberg 2000).

Both of the road crossings on Apgar Creek are potential passage problems. The absence of sculpins and redside shiners upstream of the Grist Road, despite their abundance downstream, suggests that the culverts at the Grist Road may be impassable for these species. Also, the culverts at the Camas Road are long and the downstream end on the main culvert is perched. It seems likely that fish would have a difficult time ascending these culverts, especially at high flows. Fredenberg (2000) suggested the culverts on Apgar Creek might restrict fish passage.

The culvert on Fern Creek at the Camas Road is perched and may pose passage threats similar to those on Apgar Creek. Additionally, one of the culverts on Fern Creek at the Inside North Fork Road has accumulated numerous pieces of large woody debris. If this accumulation worsens, it could reduce the effectiveness of the culvert.

The widespread distribution of westslope cutthroat trout made assessment of fish passage structures difficult. Westslope cutthroat trout were present upstream of all passage structures, except the diversion dam on Rose Creek, which would seem to suggest that all structures are passable. However, fish may only pass upstream occasionally or at certain flows. Also, resident populations may exist upstream of impassable structures.

Management Recommendations

Proposed construction on the GTSR will inevitably create localized disturbances on streams bisecting the road. We coarsely described the effects that construction may have on bull trout in the matrices for the McDonald Creek and St. Mary River drainages (Appendices A and B). Construction activities should be designed to minimize negative influences on indicators in the bull trout matrix, particularly for indicators we identified as having potential to be degraded by construction. In addition to bull trout, other native fishes, including westslope cutthroat trout, could suffer from improper construction practices. If indicators in the bull trout matrix are not degraded, it follows that threats to other native fishes will likely be minimized. Monitoring upon completion of construction should be conducted to assure fish assemblages and stream habitats are not compromised.

The extent to which artificial structures may be restricting fish passage is difficult to determine; however, it is apparent that many structures are poorly designed. Additionally, some structures are deteriorating and could fail in the future if not repaired or replaced. Some streams could benefit from construction if passage structures are repaired or replaced. Conversely, if problematic passage structures are not improved native fishes will continue to suffer the consequences of restricted movement and habitat isolation. We recommend that fish passage be improved whenever possible during the construction process. Additionally, construction near streams should be carefully designed to prevent creation of new passage barriers.

Human development and heavy visitor use have created localized disturbances on each of the streams we evaluated. Many of these disturbances can be seen in pictures on the accompanying CD. Some disturbances can be improved with relatively little effort. For instance, the water diversion system on Kelly Creek should be manipulated to allow easier passage for fish. Additionally, abandoned water pipes, rock dams, and other debris should be removed from streams, such as Kelly, Jackson, Rose, and Snyder creeks. Footpaths have created eroding banks on many streams, especially the lower portion of Fish Creek. Strategic placement of rocks or woody debris may be an effective method to divert foot traffic away from these areas.

In the McDonald Creek drainage bull trout abundance has declined from historical levels. Thus, critical habitats must remain intact to help prevent their continued decline. Streams that currently may not support bull trout could contribute to future bull trout recovery efforts in the drainage. Additionally, some streams (especially those in the upper McDonald Creek drainage) likely provide westslope cutthroat trout with important refugia from nonnative fishes and human disturbances. Because of the importance of stream habitats to native fishes, human activities need to be carefully managed to prevent degradation of these habitats. Monitoring protocols should be established to identify future changes to habitats and fish assemblages.

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Table 1. Native and nonnative fish species previously known to inhabit the McDonald Creek and St. Mary River drainages of Glacier National Park. Many of these species were not captured in our sampling.

	McDonald Creek		St. Mary River	
Species	Native	Nonnative	Native	Nonnative
Arctic grayling				X
Brook trout		X		X
Bull trout	X		X	
Burbot			X	
Kokanee		X		X
Lake trout		X	X	
Lake whitefish		X	X	
Largescale sucker	X			
Longnose dace			X	
Longnose sucker	X		X	
Mottled sculpin	X		X	
Mountain whitefish	X		X	
Northern pike			X	
Northern pikeminnow	X			
Peamouth chub	X			
Pygmy whitefish	X			
Rainbow trout		X		X
Redside shiner	X			
Slimy sculpin	X			
Spoonhead sculpin			X	
Trout-perch			X	
Westslope cutthroat trout	X		X	
Yellowstone cutthroat trout		X		X

Table 2. Total number of fish captured by electrofishing in Glacier National Park streams in summer 2004 (WCT=westslope cutthroat trout; RBT=rainbow trout; EBT=eastern brook trout; SS=slimy sculpin; MS=mottled sculpin; LND=longnose dace; BUR=burbot; RSS=redside shiner).

		Species							
Stream	**Site**	**WCT**	**RBT**	**EBT**	**SS**	**MS**	**LND**	**BUR**	**RSS**
Apgar	1	3			10				9
	2	4		1					
	3	1		1					
	4	2							
Avalanche	1	5							
	2	2							
Baring	1	1		1		5			
Fern	1	10							
	2	3							
	3	10							
	4	6							
Fish	1	19		1					
	2	8		1					
	3	7							
	4	12							
Jackson	1	4							
	2	3							
Kelly	1	6		1					
Logan	1	4							
Rose	1	1	1			11	3	14	
	2								
Snyder	1	8							
	2	11							
Sprague	1	4							
	2	2							
Two Dog	1		2	1					
	2	1	1	2					
Total	**All**	**137**	**4**	**9**	**10**	**16**	**3**	**14**	**9**

Table 3. Habitat variables measured from study streams in Glacier National Park in 2004. Measurements from each 50-m site sampled were used to calculate mean measurements and standard errors by stream. Water chemistry measurements were measured at the time of sampling. Pools per mile were calculated from habitat-type classifications collected during walking surveys.

Stream name	Date sampled	Sites (#)	Mean channel depth (m)	Mean wetted width (m)	Mean wetted width:depth ratio	Mean channel gradient (%)	Pools per mile (#)	Mean LWD (#)	Water temp. (°C)	Dissolved oxygen (mg/L)	Conduct-ivity (μS/cm)
Apgar	30 June	4	0.5±0.03	4.7±0.3	11.5±1.1	2.8±0.90	9.4	3.5±0.7	9.4	11.1	102.3
Avalanche	3 August	2	0.7±0.04	8.5±0.4	12.3±1.2	0.8±0.13	9.4	3.0±3.0	12.3	9.5	55.0
Baring	2 August	1	0.6±0.03	4.9±0.3	8.2±0.6	1.9[a]	13.3	4.0[a]	6.5	11.4	62.5
Fern	1 July	4	0.4±0.05	4.2±0.2	14.4±1.4	3.6±0.47	5.6	2.8±0.5	11.6	10.1	81.2
Fish	1-2 July	4	0.4±0.04	4.5±0.4	13.7±1.6	2.2±0.09	6.2	9.0±1.3	9.8	10.7	84.7
Jackson	4 August	2	0.5±0.05	3.9±0.2	10.0±1.4	3.7±0.83	0	6.5±6.5	11.3	10.0	18.3
Kelly	2 July	1	0.3±0.07	3.3±0.6	19.5±5.8	7.3[a]	9.4	17.0[a]	10.2	10.8	166.4
Logan	3 August	1	0.1±0.02	4.4±0.6	36.2±8.3	4.1[a]	1.9	0[a]	12.7	9.3	58.2
Rose	2 August	2	0.4±0.05	6.9±0.3	17.7±2.4	2.6±0.45	0	4.5±3.5	12.1	9.5	49.6
Snyder	3 August	2	0.4±0.08	5.2±0.4	19.7±3.1	5.7±0.03	1.9	2.5±1.5	14.3	8.8	20.9
Sprague	2 July	2	0.2±0.02	4.4±0.4	40.2±9.8	3.7±1.58	39.0	9.0±5.0	12.3	8.2	25.3
Two Dog	6 July	2	0.4±0.03	2.7±0.2	6.8±0.7	2.3±0.53	9.4	0.5±0.5	8.1	11.4	121.7

[a]Means were not calculated because only one measurement was taken within a single sampling site; thus, standard errors could not calculated.

Table 4. Substrate composition for study streams in Glacier National Park, 2004. Thirty samples were collected from each sampling site in a stream. Each substrate observation was coded according to the following scale: 0=silt and clay, 1=sand, 2=gravel, 3=pebble, 4=cobble, 5=boulder.

Stream	Samples (n)	Dominant (mode)	Mean	Standard error	Inferred substrate composition
Apgar	120	4	3.37	±0.10	Intermediate mixture
Avalanche	60	3	3.08	±0.13	Intermediate mixture
Baring	30	4	3.37	±0.18	Intermediate mixture
Fern	120	5	3.56	±0.13	Intermediate to large mixture
Fish	120	4	3.17	±0.12	Intermediate mixture
Jackson	60	4	3.83	±0.14	Intermediate mixture
Kelly	30	4	2.80	±0.31	Intermediate mixture
Logan	30	3	3.30	±0.21	Intermediate mixture
Rose	60	5	4.03	±0.14	Intermediate to large mixture
Snyder	60	5	3.98	±0.15	Intermediate to large mixture
Sprague	60	3	3.35	±0.13	Intermediate mixture
Two Dog	60	4	3.52	±0.17	Intermediate mixture

Table 5. Percent of riffle, run, pool, and pocket water habitat types determined from 10-m habitat surveys on study streams in Glacier National Park, 2004. Surveys started at the mouth of each stream.

Stream	Date	Distance surveyed (m)	Habitat type (%)			
			Riffle	Run	Pool	Pocket water
Apgar Creek	30 June	850	75.3	15.3	5.9	3.5
Avalanche Creek	18 July	860	81.2	8.2	5.9	4.7
Baring Creek	2 August	240	79.2	12.5	8.3	0
Fern Creek	7 July	850	58.8	9.4	3.5	28.2
Fish Creek	7 July	1030	27.2	19.4	3.9	49.5
Jackson Creek	20 July	850	98.8	0	0	1.2
Kelly Creek	20 July	850	74.1	5.9	5.9	14.1
Logan Creek	20 July	850	96.5	1.2	1.2	1.2
Rose Creek	6 July	850	70.6	9.4	0	20.0
Snyder Creek	19 July	850	85.9	5.9	1.2	7.1
Sprague Creek	8 July	860	50.0	14.0	24.4	11.6
Two Dog Creek	6 July	850	55.3	8.2	9.4	27.1

Table 6. Road crossing structure locations, types, and culvert dimensions for study streams in Glacier National Park, 2004. Photo identification numbers refer to images on the accompanying CD.

Stream and location	Number of structures	Structure type	Width (m)	Height (m)	Length (m)	Culvert perch height (m)	Photos
Apgar Creek at Grist Road	2	Circular Culvert	1.3	1.25	25.2	0	1, 3-5
		Circular Culvert	2.2	1.7	25.2	0	
Apgar Creek at Camas Road	2	Circular Culvert	1.3	1.6	50.1	0	13-16
		Circular Culvert	No data	No data	No data	0	
Avalanche Creek at Sun Road	1	Bridge (open bottom)	-	-	-	-	18
Baring Creek at Sun Road	1	Bridge (open bottom)	-	-	-	-	-
Fern Creek at Inside North Fork Road	2	Circular Culvert	1.8	1.8	9.8	0.1	29-33
		Circular Culvert	1.8	1.8	9.8	0.1	
Fern Creek at Camas Road	1	Circular Culvert	1.9	2.3	50.0	0.5	39-42
Fish Creek at Campground Road	1	Bridge (open bottom)	-	-	-	-	53
Fish Creek at Inside North Fork Road	2	Circular Culvert	2.4	2.4	9.9	0.2	59-64
		Circular Culvert	2.4	2.4	9.9	0	
Fish Creek at Camas Road	2	Circular Culvert	1.4	0.9	29.0	0	65-67,69,70
		Circular Culvert	1.4	0.9	29.0	0.3	
Jackson Creek at Sun Road	1	Box Culvert	1.9	1.3	13.4	0.6	72-77
Kelly Creek at Kelly's Camp Road	1	Bridge (open bottom)	-	-	-	-	85
Logan Creek at Sun Road	1	Bridge (open bottom)	-	-	-	-	91-93
Rose Creek at Sun Road	1	Bridge (cement bottom)	-	-	-	-	110-112
Rose Creek at Rising Sun Loop Road	1	Bridge (open bottom)	-	-	-	-	108,109
Snyder Creek at Lake McDonald Lodge	1	Bridge (open bottom)	-	-	-	-	124,125
Snyder Creek at Sun Road	1	Bridge (open bottom)	-	-	-	-	126-129
Sprague Creek at Sun Road	1	Box Culvert	2.4	1.1	21.6	0	131,132,136
Two Dog Creek at Sun Road	1	Box Culvert	1.9	1.3	15.0	0	141-145

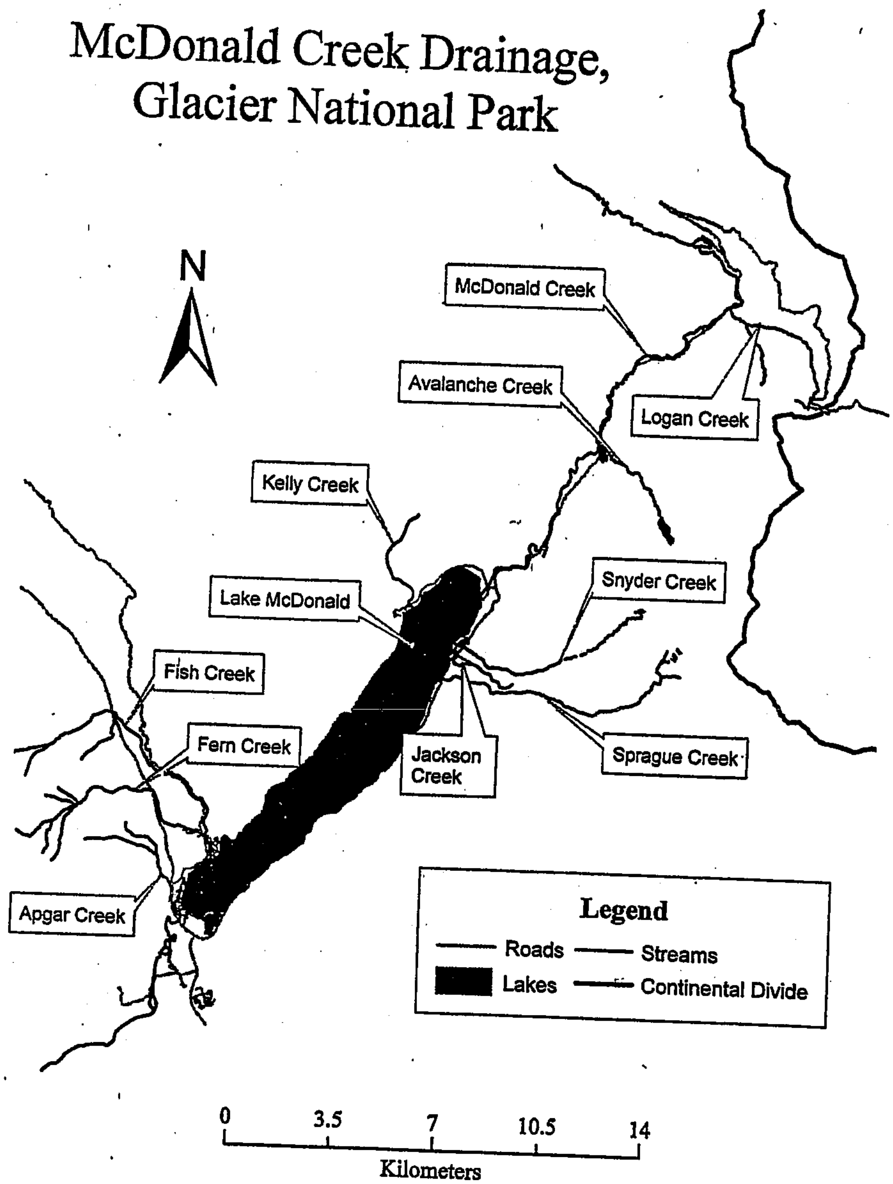

Figure 1. Study streams located in the McDonald Creek drainage of Glacier National Park.

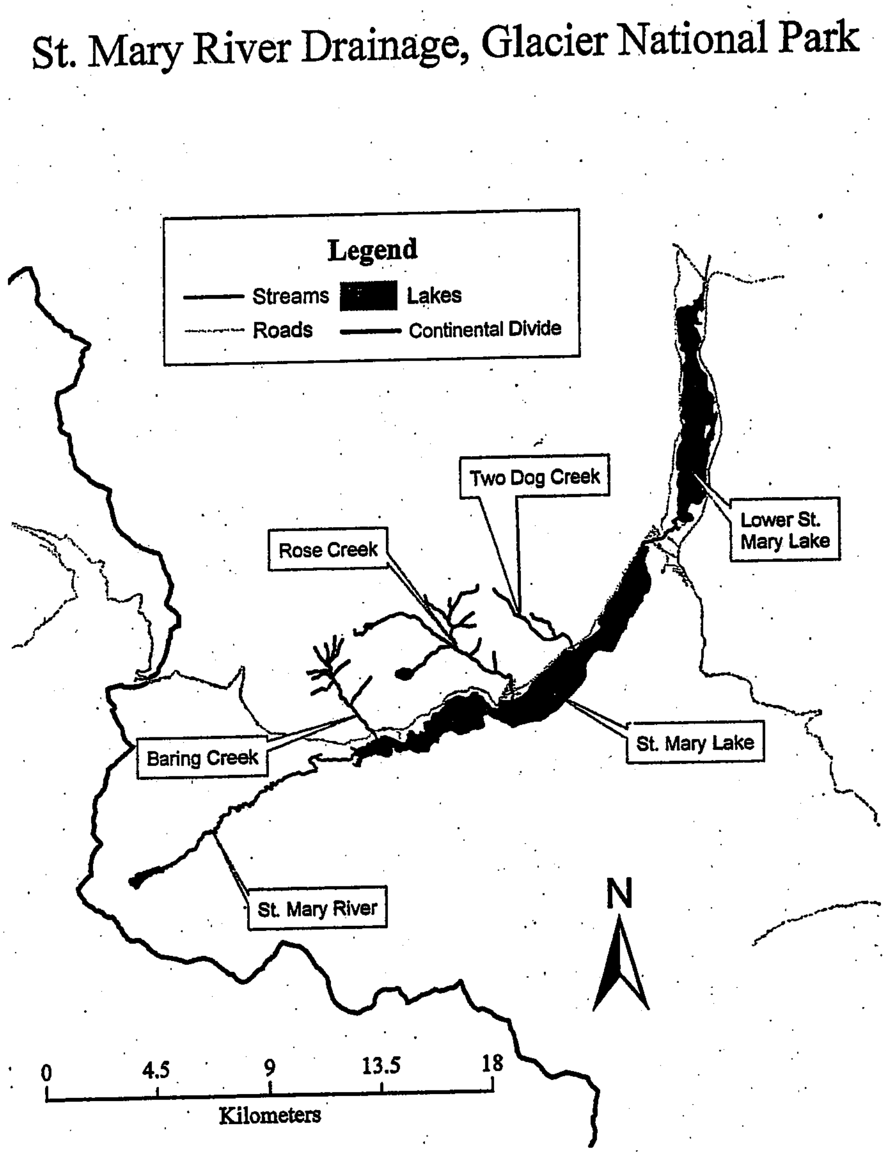

Figure 2. Study streams located in the St. Mary River drainage of Glacier National Park.

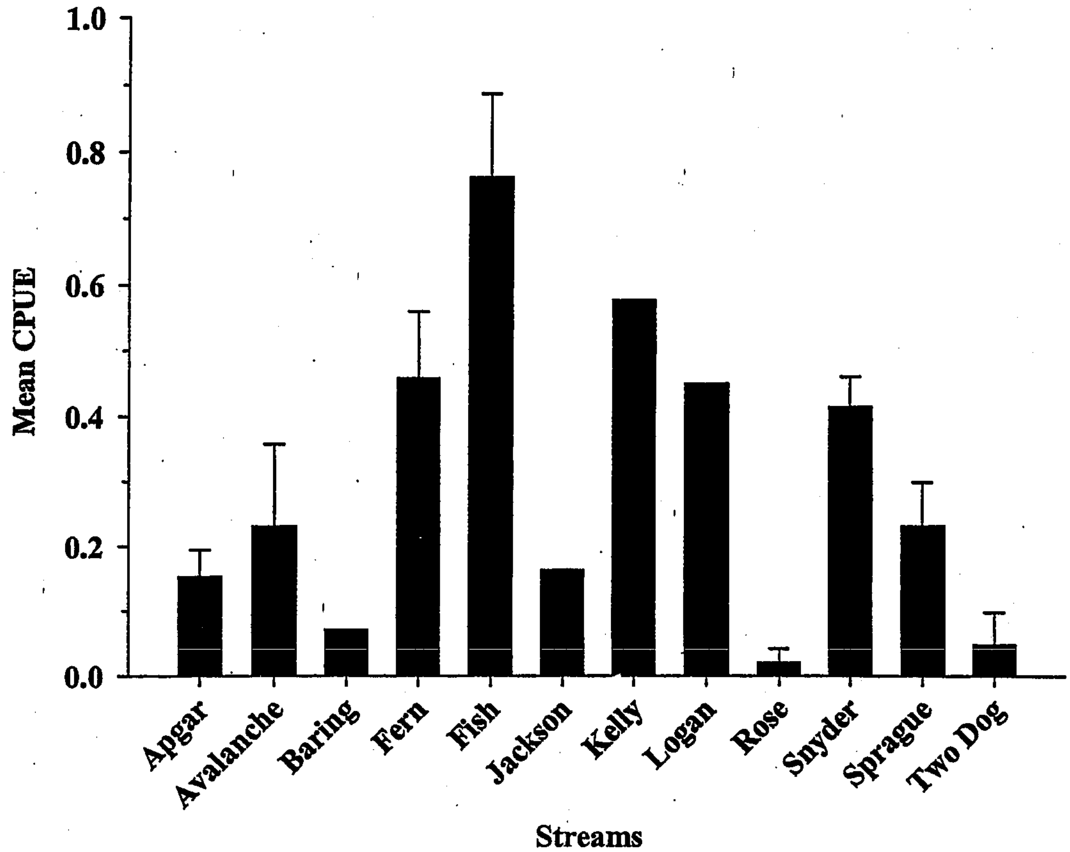

Figure 3. Mean electrofishing catch-per-unit-effort (CPUE; number per minute) and standard errors for westslope cutthroat trout sampled in Glacier National Park streams in 2004. Standard errors could not be calculated for Baring, Kelly, and Rose creeks because only one site was sampled on each of these streams.

Appendix A. Checklist for documenting effects of proposed actions on indicators at the bull trout subpopulation watershed scale. This matrix was completed based on data collected from five streams in the McDonald Creek drainage of Glacier National Park that are bisected by the Going-to-the-Sun Road.

DIAGNOSTICS/ PATHWAYS:	POPULATION AND ENVIRONMENTAL BASELINE (list values or criterion and supporting documentation)			EFFECTS OF THE ACTION(S)			
INDICATORS	*Functioning Appropriately*	*Functioning At Risk*	*Functioning At Unacceptable Risk*	*Restore*[1]	*Maintain*[2]	*Degrade*[3]	*Compliance with ACS*
Subpopulation Characteristics: Subpopulation Size	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A
Growth and Survival	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A
Life History Diversity and Isolation	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A
Persistence and Genetic Integrity	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A
Water Quality: Temperature	X				X		N/A
Sediment	X					X	N/A
Chem. Contam./Nutrients	X				X		N/A
Habitat Access: Physical Barriers		X				X	N/A
Habitat Elements: Substrate Embeddedness	X					X	N/A
Large Woody Debris	X				X		N/A
Pool Freq. and Quality	X				X		N/A
Large Pools	X				X		N/A
Off-channel Habitat	X				X		N/A
Refugia[4]	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A
Channel Cond & Dynamics: Wetted Width/Max Depth Ratio	X				X		N/A
Streambank Condition	X					X	N/A
Floodplain Connectivity	X				X		N/A
Flow/Hydrology: Change in Peak/Base Flow	X				X		N/A
Drainage Network Increase	X				X		N/A
Watershed Conditions: Road Density & Location		X			X		N/A
Disturbance History	X				X		N/A
Riparian Conservation Area	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Disturbance Regime	X				X		N/A
Integration of Species and Habitat Conditions:	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A

Existing Species Indicators: The following descriptions correspond to the four species indicators in the bull trout matrix for the McDonald Creek drainage.

1. *Subpopulation Size:* UNKNOWN. No bull trout were captured during electrofishing surveys; however, these surveys were not designed to test for presence or absence of bull trout from entire drainages. Additionally, we do not know to what extent bull trout were historically present in theses streams.
2. *Growth and Survival:* UNKNOWN. We do not have data to adequately assess this indicator.
3. *Life-History Diversity and Isolation:* UNKNOWN. We do not have data to adequately assess this indicator.
4. *Persistence and Genetic Integrity:* UNKNOWN. We do not have data to adequately assess this indicator.

Existing Habitat Indicators: The following descriptions correspond to the 20 habitat indicators in the bull trout matrix for the McDonald Creek drainage.

5. *Temperature:* FUNCTIONING APPROPRIATELY. Thermographs were placed in each of the study streams in this drainage in summer 2004 by National Park Service staff. These thermographs have not yet been retrieved, but should confirm that temperatures are within the parameters of the functioning appropriately category.
6. *Sediment:* FUNCTIONING APPROPRIATELY. Sediment was not directly measured; however, embeddedness was low in all streams and fine sediments were not abundant.
7. *Chemical Contamination and Nutrients:* FUNCTIONING APPROPRIATELY. Streams in the drainage are in near pristine condition, and there is very limited potential for contamination to occur.
8. *Physical Barriers:* FUNCTIONING AT RISK. Several road-crossing structures appear to be limiting upstream fish passage, at least at some flows.
9. *Substrate Embeddedness:* FUNCTIONING APPROPRIATELY. All embeddedness measurements were in the negligible (<5%) or low (5-25%) categories.
10. *Large Woody Debris:* FUNCTIONING APPROPRIATELY. Large woody debris was measured using different dimensions than suggested by the matrix. See report for methods and data. Large woody debris was generally present in quantities that would suggest appropriate function based on the size and types of streams evaluated.
11. *Pool Frequency and Quality:* FUNCTIONING APPROPRIATELY. See report for pools per mile data. Streams had fewer pools per mile than the matrix requires to be functioning appropriately; however, based on the high gradient and relatively undisturbed nature of the streams in the drainage, we believe that pool frequency is sufficient to warrant appropriate function designation.
12. *Large Pools:* FUNCTIONING APPROPRIATELY. Similar to pool frequency, the number of large pools is less than adequate according to matrix criteria. Again, based on the nature of these streams, we believe that they are functioning appropriately with regards to large pools.

13. *Off-channel Habitat:* FUNCTIONING APPROPRIATELY. Streams in this drainage have little off-channel habitat; however, they are high gradient and off-channel habitat was likely limited even historically. There is no evidence that off-channel habitat has be substantially altered from natural conditions.
14. *Refugia:* UNKNOWN.
15. *Average Wetted Width to Maximum Depth Ratio:* FUNCTIONING APPROPRIATELY. This ratio was <10 for all streams sampled, which met the criteria specified in the matrix for appropriate function.
16. *Streambank Condition:* FUNCTIONING APPROPRIATELY. Stream reaches were stable, with only localized areas of instability.
17. *Floodplain Connectivity:* FUNCTIONING APPROPRIATELY. These narrow high gradient streams have limited floodplain areas, but the few that do exist are relatively unaltered and connected to the stream channel.
18. *Changes in Peak/Base Flows:* FUNCTIONING APPROPRIATELY. The flow regime appears to be relatively unaltered from historical natural conditions.
19. *Increase in Drainage Network:* FUNCTIONING APPROPRIATELY. Human disturbances have resulted in minimal changes to active channel lengths.
20. *Road Density and Location:* FUNCTIONING AT RISK. Valley bottom roads exist in the drainage.
21. *Disturbance History:* FUNCTIONING APPROPRIATELY. The majority of the drainage is relatively undisturbed, with localized areas of disturbance.
22. *Riparian Conservation Areas:* NOT APPLICABLE. Riparian conservation areas do no exist.
23. *Disturbance Regime:* FUNCTIONING APPROPRIATELY. Natural processes are stable and natural disturbances are generally short-lived.

Species and Habitat Indicators: The following descriptions correspond to the species and habitat indicator in the bull trout matrix for the McDonald Creek drainage.

24. *Integration of Species and Habitat Conditions:* UNKNOWN. We do not have sufficient bull trout population data to assess this indicator.

Potential Effects to Species, Habitat, and Species and Habitat Indicators: The following descriptions outline the effects that proposed road construction activities may have on indicators in the bull trout matrix for the McDonald Creek drainage.

1. *Subpopulation Size:* UNKNOWN. We do not have sufficient population data to assess effects for this indicator.
2. *Growth and Survival:* UNKNOWN. We do not have data to adequately assess effects for this indicator.
3. *Life-History Diversity and Isolation:* UNKNOWN. We do not have data to adequately assess effects for this indicator.
4. *Persistence and Genetic Integrity:* UNKNOWN. We do not have data to adequately assess the effects for this indicator.
5. *Temperature:* MAINTAIN. Localized construction activities should not alter the temperature regime in these streams.
6. *Sediment:* DEGRADE. Construction activities near streams likely will increase sediment inputs over a short duration. If sediment inputs are short-lived, there should not be substantial threats to native fishes.
7. *Chemical Contamination and Nutrients:* MAINTAIN. The addition of chemical substances or nutrients is not anticipated.

8. *Physical Barriers:* DEGRADE. Construction at stream crossings could potentially worsen fish passage by altering existing bridges and culverts. However, if road culverts that are currently causing fish passage problems are replaced, the proposed actions could RESTORE physical barriers, thus allowing fish access to currently isolated habitats.
9. *Substrate Embeddedness:* DEGRADE. Sediment inputs will likely increase for a short period of time, thus increasing the potential for substrate embeddedness. If sediment increases are short-lived, this should not pose a serious threat to native fishes.
10. *Large Woody Debris:* MAINTAIN. Construction activities should not be creating or removing large woody debris.
11. *Pool Frequency and Quality:* MAINTAIN. Project activities should not alter the number or quality of pools in the streams.
12. *Large Pools:* MAINTAIN. Project activities should not influence large pool habitats.
13. *Off-channel Habitat:* MAINTAIN. Activities will be restricted to roadway areas and should not affect off-channel habitats.
14. *Refugia:* MAINTAIN. Project activities should not affect large-scale habitats.
15. *Average Wetted Width to Maximum Depth Ratio:* MAINTAIN. Changes in this ratio could occur near road crossing, but will not have an effect on width and depth in longer stream reaches.
16. *Streambank Condition:* DEGRADE. Localized areas near roads could suffer from degraded streambank condition.
17. *Floodplain Connectivity:* MAINTAIN. Project activities will not alter floodplain connectivity.
18. *Changes in Peak/Base Flows:* MAINTAIN. Project activities should not affect flow regimes in these streams.
19. *Increases in Drainage Network:* MAINTAIN. The active channel length should not change as a result of this project.
20. *Road Density and Location:* MAINTAIN. The density and location of roads will not change. New roads will not be constructed and changes to existing roads will not change their location.
21. *Disturbance History:* MAINTAIN. This project will not cause large areas of disturbance in the watershed.
22. *Riparian Conservation Area:* NOT APPLICABLE. Riparian conservation areas do not exist.
23. *Disturbance Regime:* MAINTAIN. Project activities will not alter the environmental disturbance regime.
24. *Integration of Species and Habitat Conditions:* MAINTAIN. Activities should not influence this indicator.

Appendix B. Checklist for documenting effects of proposed actions on indicators at the bull trout subpopulation watershed scale. This matrix was completed based on data collected from three streams in the St. Mary drainage of Glacier National Park that are bisected by the Going-to-the-Sun Road.

DIAGNOSTICS/ PATHWAYS:	POPULATION AND ENVIRONMENTAL BASELINE (list values or criterion and supporting documentation)			EFFECTS OF THE ACTION(S)			
INDICATORS	*Functioning Appropriately*	*Functioning At Risk*	*Functioning At Unacceptable Risk*	*Restore*[1]	*Maintain*[2]	*Degrade*[3]	*Compliance with ACS*
Subpopulation Characteristics: Subpopulation Size	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A
Growth and Survival	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A
Life History Diversity and Isolation	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A
Persistence and Genetic Integrity	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A
Water Quality: Temperature	X				X		N/A
Sediment	X					X	N/A
Chem. Contam./Nutrients	X				X		N/A
Habitat Access: Physical Barriers		X				X	N/A
Habitat Elements: Substrate Embeddedness	X					X	N/A
Large Woody Debris	X				X		N/A
Pool Freq. and Quality	X				X		N/A
Large Pools	X				X		N/A
Off-channel Habitat	X				X		N/A
Refugia[4]	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A
Channel Cond & Dynamics: Wetted Width/Max Depth Ratio	X				X		N/A
Streambank Condition	X					X	N/A
Floodplain Connectivity	X				X		N/A
Flow/Hydrology: Change in Peak/Base Flow	X				X		N/A
Drainage Network Increase	X				X		N/A
Watershed Conditions: Road Density & Location		X			X		N/A
Disturbance History	X				X		N/A
Riparian Conservation Area	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Disturbance Regime	X				X		N/A
Integration of Species and Habitat Conditions:	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	N/A

Existing Species Indicators: The following descriptions correspond to the four species indicators in the bull trout matrix for the St. Mary drainage.

1. *Subpopulation Size:* UNKNOWN. No bull trout were captured during electrofishing surveys; however, these surveys were not designed to test for presence or absence of bull trout from entire drainages. Additionally, we do not know to what extent bull trout were historically present in theses streams.
2. *Growth and Survival:* UNKNOWN. We do not have data to adequately assess this indicator.
3. *Life-History Diversity and Isolation:* UNKNOWN. We do not have data to adequately assess this indicator.
4. *Persistence and Genetic Integrity:* UNKNOWN. We do not have data to adequately assess this indicator.

Existing Habitat Indicators: The following descriptions correspond to the 20 habitat indicators in the bull trout matrix for the St. Mary drainage.

5. *Temperature:* FUNCTIONING APPROPRIATELY. The only temperature data available were point samples collected during electrofishing surveys. The temperatures indicate that streams are probably within the criteria range described in the matrix for appropriate function.
6. *Sediment:* FUNCTIONING APPROPRIATELY. Sediment was not directly measured; however, embeddedness was low in all streams and fine sediments were not abundant.
7. *Chemical Contamination and Nutrients:* FUNCTIONING APPROPRIATELY. Streams in the drainage are in near pristine condition, and there is very limited potential for contamination to occur.
8. *Physical Barriers:* FUNCTIONING AT RISK. Some artificial structures appeared to be limiting upstream fish passage, at least at some flows.
9. *Substrate Embeddedness:* FUNCTIONING APPROPRIATELY. All embeddedness measurements were in the negligible (<5%) or low (5-25%) categories.
10. *Large Woody Debris:* FUNCTIONING APPROPRIATELY. Large woody debris was measured using different dimensions than suggested by the matrix. See report for methods and data. Large woody debris was generally present in quantities that would suggest appropriate function based on the size and types of streams evaluated.
11. *Pool Frequency and Quality:* FUNCTIONING APPROPRIATELY. See report for pools per mile data. Streams had fewer pools per mile than the matrix requires to be functioning appropriately; however, based on the high gradient and relatively undisturbed nature of the streams in the drainage, we believe that pool frequency is sufficient to warrant appropriate function designation.
12. *Large Pools:* FUNCTIONING APPROPRIATELY. The number of large pools is less than adequate according to matrix criteria; however, based on the nature of these streams, we believe that they are functioning appropriately with regards to large pools.