

**Preliminary Study of the Effects of the Arrastra
Creek Effluent on Benthic Macroinvertebrates of
the Big Blackfoot River**

**Submitted in Partial Fulfillment for Graduation with Honors to the Department of
Natural Sciences at Carroll College, Helena, Montana**

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April 10th, 2000**

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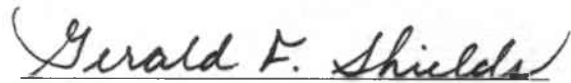


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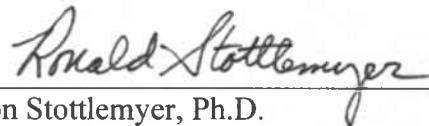
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Abstract

I sampled benthic macroinvertebrates from three replicate sites above and three sites below the confluence of Arrastra Creek and the Big Blackfoot River. A total of 15 families were collected and identified from the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). A t-test determined that the diversity and abundance of macroinvertebrates was significantly lower below the confluence of Arrastra Creek and the Blackfoot River than above. The cause of the decrease in macroinvertebrate populations and family richness may be due to increased sediment coming from the Arrastra Creek effluent. My personal observations suggest that the increased sediment may be due to cattle destroying the riparian zone. The destruction of the riparian zone may lead to increased erosion and therefore increased sediment into Arrastra Creek.

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Introduction

From the late 1970s to 1980s the number and size of trout in the Big Blackfoot River declined (Peters 1975, 1990). Associated with the drop in the number and size of trout was a decrease in the abundance of benthic macroinvertebrates (Ingman et al., 1990), a staple food source for trout. Abundance and richness of macroinvertebrates are useful indicators of the health of stream ecosystems (Weber 1973, Waters 1995, Rosenberg and Resh 1993, Ingman et al., 1990). Macroinvertebrates have a long life cycle (up to three years), making them vulnerable to environmental impacts. A decrease in macroinvertebrate populations and diversity can be caused by the presence of toxic levels of acids; heavy metals, such as mercury; chemical pollutants, such as nitrogen; and sedimentation (Waters 1995, Reice and Wolenberg 1993).

Sediment, in particular, can reduce the abundance and diversity of macroinvertebrates within streams (Cummins et al., 1966). An association between sediment and macroinvertebrates was first observed in studies below dams (Waters 1995). Dams allow the sediment within the stream to settle to the bottom of the reservoirs, greatly decreasing the amount of deposited sediment downstream of the dam. This decrease in sediment results in an increase in the diversity and abundance of benthic macroinvertebrates (Waters 1995). Sedimentation may also influence macroinvertebrates in streams free of dams. Bjornn (1974) concluded that large amounts of deposited sediment within the streambed could drastically lower the abundance and diversity of benthic macroinvertebrates. Furthermore, he observed that the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) are the taxa most affected by deposited sediment because they prefer cobbles and gravel free from sediment (Bjornn 1974).

There are many sources of sediment with differing effects on the water quality of a stream. Short-term disturbances of streamside habitats (e.g., construction) may have little effect on abundance and diversity of macroinvertebrates because of the short duration of the disturbance (Waters 1995). In contrast, agricultural sources may significantly decrease macroinvertebrate abundance because sediment caused by agriculture is usually a long-term problem (Waters 1995). Erosion from open fields with little or no vegetation can input large amounts of sediment into the stream, particularly during rainy periods (Waters 1995). Likewise, cattle traffic on stream banks can lead to increased erosion that will continue as long as cattle are present (Waters 1995). Platts (1981) concluded that overgrazing by livestock was a major problem in the western United States because of landowners' poor grazing practices. Moreover, Clary (1992) concluded that a diminished riparian zone caused by overgrazing could lead to a significant increase in the amount of sediment in streams. The Big Blackfoot River of Montana (Figure 1), as well as its tributaries, have several miles of streamside cattle grazing which may adversely affect the Blackfoot's riparian habitat.

Rothrock et al., (1999) studied water quality and macroinvertebrates on the tributaries of the Big Blackfoot River. She concluded that Nevada Creek and Union Creek (Figure 1) had the greatest amount of environmental stress of any agricultural-use streams on the Blackfoot and that environmental stress was the result of sediment. This study did not include Arrastra Creek, and macroinvertebrate studies have not been conducted on this stream in the past 30 years. The purpose of my study was to determine if the Arrastra Creek effluent has been affecting the macroinvertebrate population and

diversity on the Blackfoot River. I surveyed macroinvertebrates and sediment on the Blackfoot River above and below the confluence of Arrastra Creek.

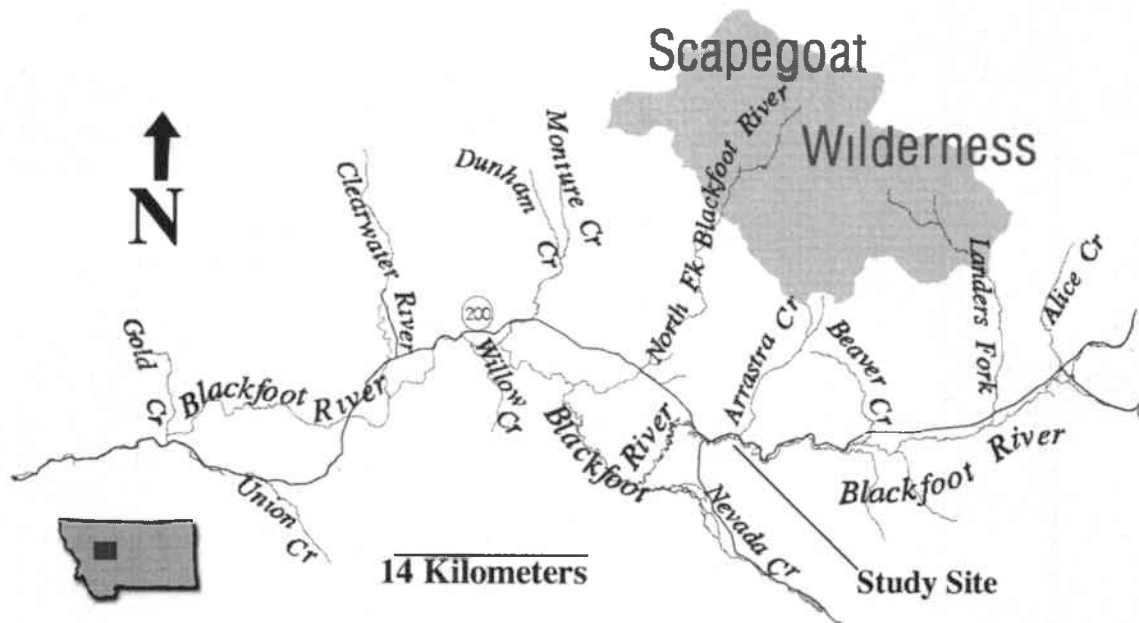


Figure 1. The Big Blackfoot River and Arrastra Creek.

Description of Study Site

The Big Blackfoot River is a major tributary of the Upper Clark Fork of the Columbia River. The Blackfoot has 65 perennial tributaries and drains an area approximately 5,931 square km (NRIS website). It flows 196 km from its headwaters near Lincoln, Montana to its confluence with the Clark Fork River near Bonner, Montana (Figure 1). The Blackfoot is classified by the Montana Department of Health and Environmental Sciences as a Class I trout stream and a B-1 river, meaning that its water can be used for drinking, recreation, and trout fishing (MDHES 1994). The watershed is owned by the following groups: The USDA Forest Service manages 44 percent; private landowners own 24 percent; Plum Creek Timber Co. owns 20 percent; the State of Montana manages 7 percent; and the Bureau of Land Management manages 5 percent

(MDHES 1994). Arrastra Creek is managed by the USDA Forest Service and private landowners.

Arrastra Creek flows into the Big Blackfoot River 137.6 km above the confluence with the Clark Fork River. Arrastra Creek has its origin just south of the Scapegoat Wilderness and winds 20 km down to the Blackfoot River. Through its course to the Blackfoot, Arrastra flows through approximately 2 km of grazing pasture (NRIS website).

Sampling Methods

I sampled for macroinvertebrates from 4-5 August 1999 on the Big Blackfoot River near Arrastra Creek. I established three replicate sample sites 125m upstream and 125m downstream from the confluence of Arrastra Creek and the Blackfoot. Locations for the replicates were chosen for their habitat similarity (Table 1). I established distance from the north shore to the sample site by stretching a string across the river and marking each sample site on the string. Stream velocity was measured by timing a floating cork over a 12m distance. Size of cobbles and stream depth were determined using a meter stick. I made visual assessments of instream sedimentation, riparian habitat quality, and stream structural abnormalities in accordance with the Environmental Protection Agency's Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (Barbour et al., 1999).

I used a 0.1 square meter Hess sampler to collect the macroinvertebrates. I placed the Hess sampler in the river and rocks were scrubbed with a soft-bristle brush to release the macroinvertebrates into the water thus allowing them to flow into the sampler. A metal rod was then inserted into the gravel in the river and used to stir up the bottom. I

emptied the trap net into a Tupperware container followed by the addition of 70% EtOH to cover the sample. Macroinvertebrates in the orders Ephemeroptera, Plecoptera, and Trichoptera were identified to level of family (Merritt and Cummins 1996). I kept the samples in 70% EtOH throughout the identification. In accordance with the protocols for EPT evaluations I used a simple t-test for significance to test for differences in upstream and downstream sites (Plafkin et al., 1989). I compared upstream and downstream sites with respect to total macroinvertebrate family diversity, the total abundance of macroinvertebrate individuals, and the family diversity and abundance within each EPT order.

Results

There was no significant difference between the upstream and downstream sites for the quantified habitat parameters (Table 2). There were differences in the visually determined sediment parameter. I qualitatively observed light sedimentation for the upstream replicates as sediment was not covering the gravel or cobbles. Heavy sedimentation was observed in the downstream replicates because the deposited sediment completely covered the cobbles and gravel. I observed cattle tracks within the riparian zone as well as a lack of shrub and tree riparian vegetation (Figures 2, 3, 4). These observed indicators suggest that lower Arrastra Creek has a severely degraded riparian zone. I also noted a sediment bar at the confluence of the Blackfoot River that suggests long-term sedimentation from Arrastra Creek.

Table 1. Habitat description of replicate sites above and below the confluence.

A. Above the confluence

Feature	Sample 1	Sample 2	Sample 3
Stream Depth (cm)	24	45	39
Stream Velocity (m/s)	2.16	3.42	2.6
Distance from North Bank (m)	2.12	4.32	5.21
Max. Size of Rocks (cm)	7	15	15
Flow (cfs)	765	765	765

B. Below the confluence

Feature	Sample 1	Sample 2	Sample 3
Stream Depth (cm)	27	33	38
Stream Velocity (m/s)	2.02	3.12	2.92
Distance from North Bank (m)	1.97	3.97	7.23
Max. Size of Rocks (cm)	7	7	7
Flow (cfs)	765	765	765

Table 2. Statistical Test of habitat variation.

Habitat Feature	t-statistic	Std Dev	df	p-value
Stream Depth	1.66	7.8cm	4	0.267
Stream Velocity	1.54	0.55cm	4	0.424
Max. Size of Rocks	1.22	3.25cm	4	0.128
Stream Flow	0	0	4	1

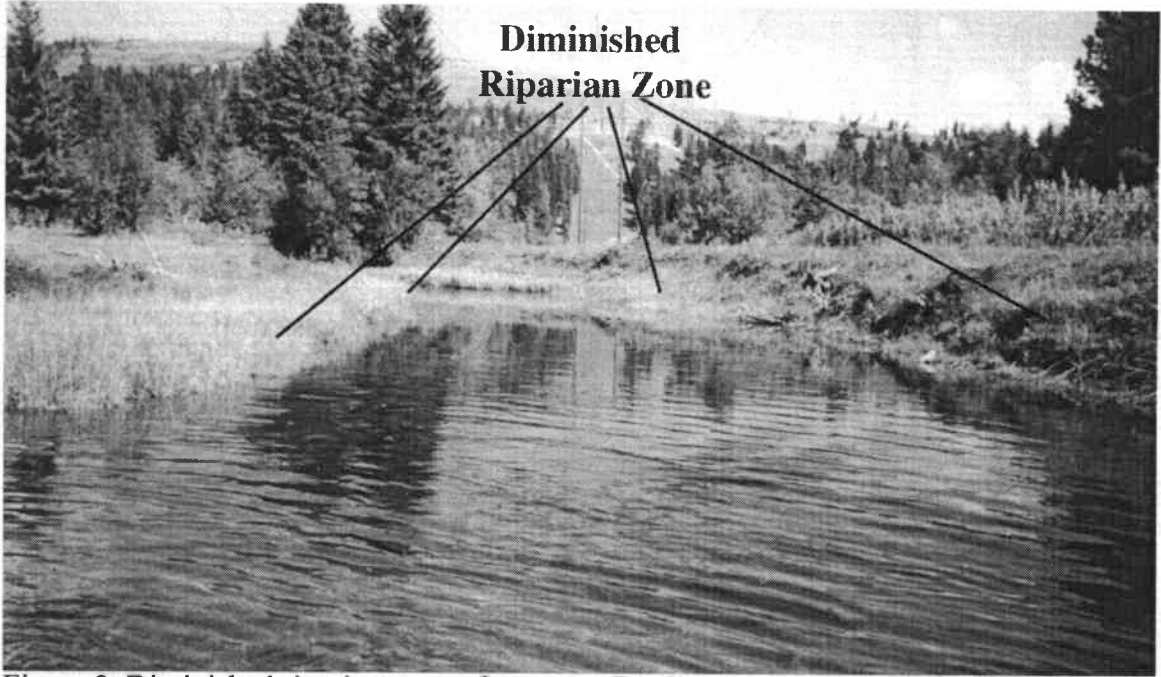


Figure 2. Diminished riparian zone of Arrastra Creek.

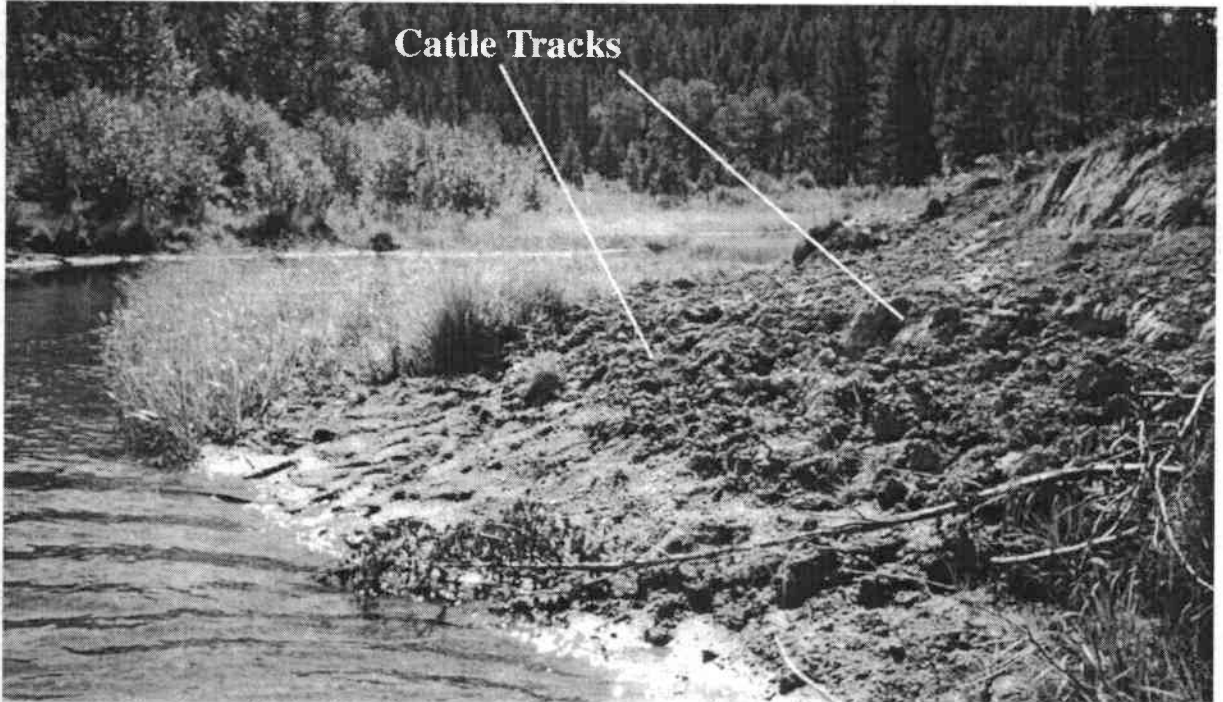


Figure 3. Cattle tracks in riparian zone of Arrastra Creek.

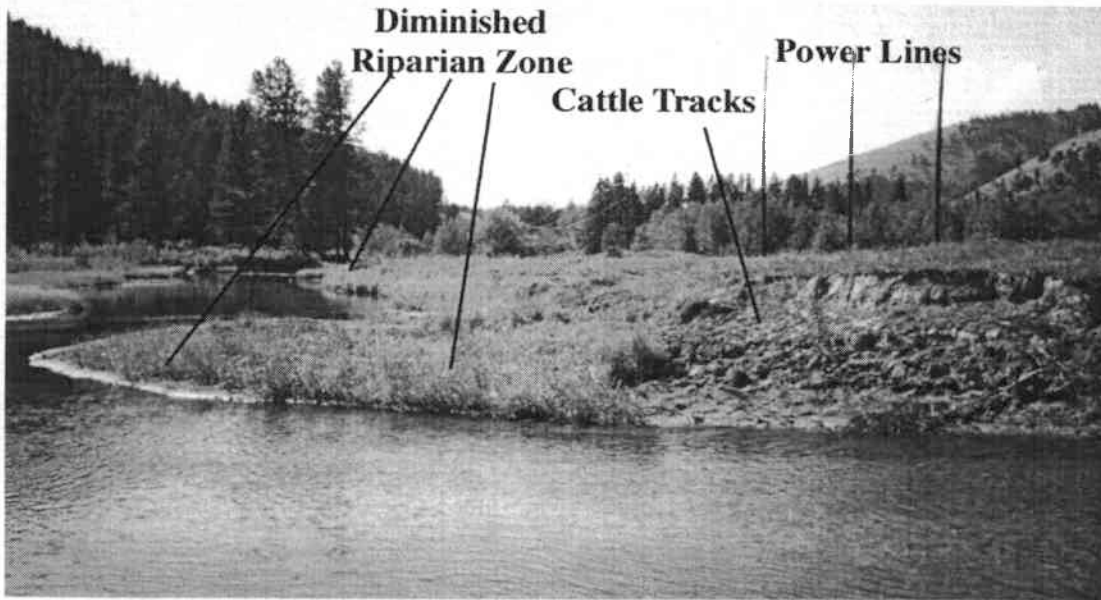


Figure 4. Power lines stretching across Arrastra Creek.

I collected a total of 15 families from samples above and below the confluence of Arrastra Creek and the Big Blackfoot River. T-test results revealed that the total macroinvertebrate diversity and abundance were significantly different between the upstream and downstream sites. Family diversity and individual abundance within each EPT order were not significantly different between the sites (Tables 3-4).

Table 3. Abundance of macroinvertebrate individuals with associated statistical test.

	Mean Above	Mean Below	Std Error Above	Std Error Below	t Statistic	df	p-value
Total	118.6	28.6	2.39	0.87	3.02	4	0.039
Ephemeroptera	42.3	18.6	1.55	1.16	1.60	4	0.172
Plecoptera	5.3	0.33	0.67	0.25	2.12	4	0.101
Trichoptera	71	9.667	2.62	1.33	1.65	4	0.172

Table 4. Family diversity of macroinvertebrates with associated statistical test.

	Mean Above	Mean Below	Std Error Above	Std Error Below	t Statistic	df	p-value
Total	10	4.33	0.33	0.51	3.90	4	0.017
Ephemeroptera	3.33	2.66	0.25	0.36	0.89	4	0.422
Plecoptera	4.33	1.33	0.41	0.41	2.41	4	0.074
Trichoptera	2.33	0.33	0.36	0.25	2.68	4	0.055

Discussion

My results suggest that sediment from the Arrastra Creek may be influencing the water quality of the Blackfoot River. Total individual abundance and total family richness for EPT orders were significantly lower downstream from the confluence than upstream. The difference in the amount of sediment I observed between the upstream and downstream sites and the similarity of the other environmental variables suggest that the cause for the difference in macroinvertebrates may be due to sedimentation (Tables 1-2). However, I did not quantify sedimentation, cattle use, or lack of riparian vegetation along Arrastra Creek. Furthermore, other unmeasured habitat parameters (e.g., the amount of coarse detritus and physiochemical characteristics) may also influence macroinvertebrate distribution and abundance (Hauer and Resh 1996). Further studies are needed to address these concerns.

Only the total abundance and total family richness of macroinvertebrates were significantly different between the sites. Within each EPT order, abundance and family richness were not significantly different between the upstream and downstream sites. The lack of significance was due to the amount of variation between replicate samples. For example, there was a large difference in the number of Ephemeroptera, Plecoptera, and Trichoptera between each sample taken above the confluence. Variability between samples is probably explained by variation in the size of particles in the substrate between sample sites.

Small particle size from sedimentation is often associated with a decrease of macroinvertebrate abundance (Waters 1995). Small particles disrupt available living space and decrease the input of organic detritus (Waters 1995). By decreasing water flow,

the sedimentation lowers oxygen levels and reduces the amount of nutrients that can flow through the cobbles. The decrease in nutrients caused by sedimentation increases competition among macroinvertebrates, which leads to a lower abundance (Waters 1995).

A decline in benthic macroinvertebrate abundance is often associated with a decrease in the fish population because macroinvertebrates are a primary source of food for *salmonids* (Waters 1995). Increased sedimentation also degrades ideal spawning habitat for fish. Chapman (1988) noted that preliminary observations of the amount of sediment within the stream were useful to determine the placement of spawning beds of *salmonids*. Chapman also found an inverse association between sediment depth and spawning of fish.

The sediment within lower Arrastra Creek is at least 1m deep (personal observation). The sediment may have led to a change in the type of organisms within the creek itself. In addition to the differences in macroinvertebrates described above, I observed a large number of leeches in the creek. Typically, cold water Rocky Mountain feeder creeks free of sediment do not have leeches (Hynes, 1970).

Sediment may occur for several reasons. I observed that the riparian habitat was not the typical willow/tree flora, but instead, was grassy marshes, if any vegetation was present. Maintenance of the power lines has required the continual removal of vegetation from around the poles. The removal of this vegetation may have resulted in increased cattle traffic. Structural barriers, such as a fence, will keep the cattle from trampling the riparian zone vegetation. Fencing experiments by Stuber (1985) in parts of the Western United States have led to less sedimentation, better stream bank conditions, improved habitat, and an increase of benthic macroinvertebrates which led to an increase of fish

populations. Willow sprigs may also be planted to help re-establish the willow population along the creek. Removal of the deposited sediment within the creek is another option that would help remediate the Blackfoot River.

The results of my study, as well as personal observations, suggest that sedimentation from the Arrastra Creek effluent may be responsible for a decline in macroinvertebrate abundance and diversity in the Big Blackfoot River. The sediment bar at the confluence suggests that this is a long-term problem, which has been occurring for many years. My observations of the Arrastra Creek stream bank suggest that the sediment may be due to poor grazing practices because the cattle are allowed to trample the riparian zone. The decline in macroinvertebrates may lead to adverse impacts on fish populations both within the river and the creek. Remediation efforts have improved similar stream conditions across Montana, and their use may be justified for Arrastra Creek.

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