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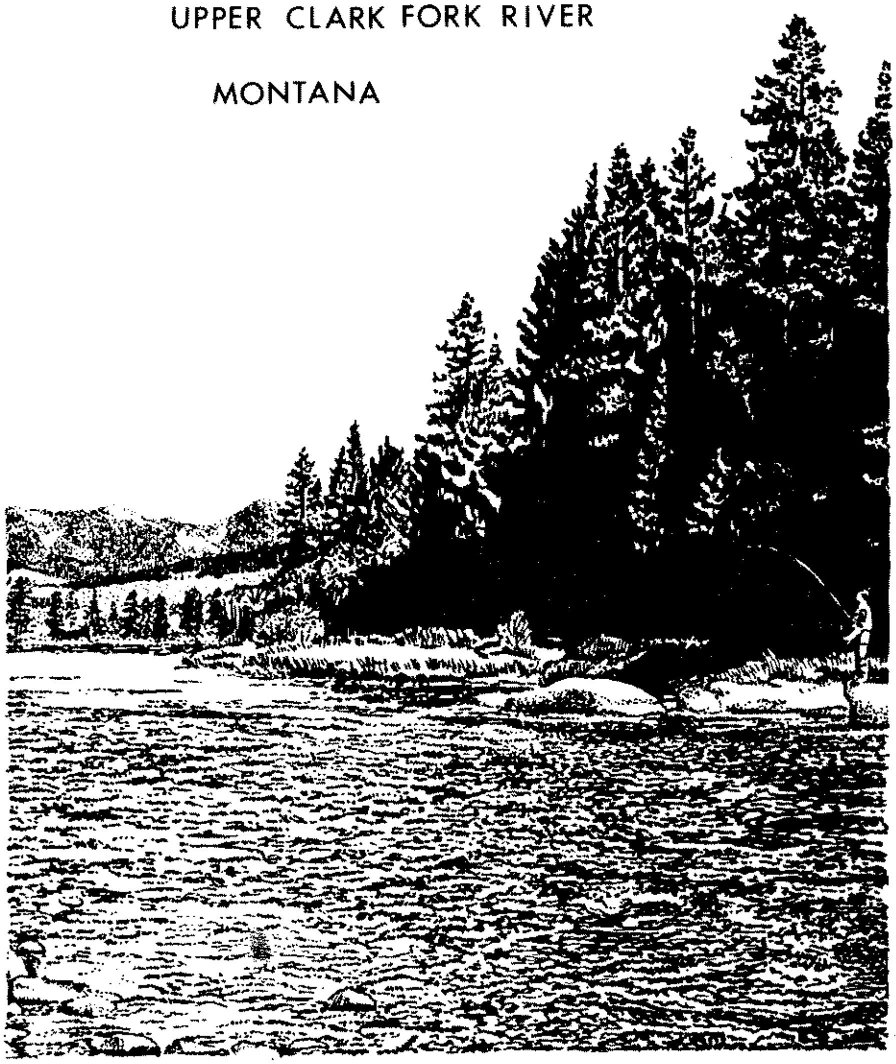
A PRELIMINARY ASSESSMENT OF IMPACTS TO THE TROUT FISHERY - UPPER CLARK FORK RIVER MONTANA



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Graphic by Erich Weber

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I. Introduction

A. Purpose

In response to a growing public awareness about the existence and magnitude of hazardous waste sites throughout the U.S., Congress enacted the Comprehensive Environmental Response Compensation and Liability Act of 1980, hereafter referred to as the Act. Provisions within this far-reaching piece of legislation provide, among other things, for the identification and prioritization of potential hazardous waste sites; the implementation of site-specific studies to determine the magnitude and extent of the impacts caused by sites receiving the highest ranking in this prioritization; and the reclamation by responsible parties of sites determined to be causing injury to land, surface and groundwater, fish, biota and other natural resources. As well, under Sections 107 and 112 of the Act, a state may seek compensation for up to $50,000,000 for damages caused to natural resources by the release of substances from a hazardous waste site. Under criteria provided by these latter provisions of the Act, the State of Montana in November 1983 filed a claim against the Anaconda Minerals Company demanding that the maximum allowable compensation be paid for damages caused by the Company to the Clark Fork River.

The purpose of this report is to substantiate that such damages did and are continuing to occur to the recreational and fishery resources of the Clark Fork River. Preliminary quantification of these damages will also be presented.

B. Background

The upper Clark Fork River was a historical fishing ground for the Salish Indians. In fact, the Salish name for the Missoula, Milltown and Butte area was "Bull Trout", which were caught there (Malouf 1974). The first white people to settle along what is now Silver Bow Creek were struck by the beauty of the area. The origin of the name Silver Bow Creek was recorded by Freeman (1900) in the words of the first prospectors who viewed the stream:

> "Upon a bend of the stream, which forms a perfect figure of a gracefully curved Indian bow, and, from the mountain peaks which surround the valley, the glistening waters of the "Silver Bow" etched in a shimmering sheen upon a dark ground of furzy grass, form a striking feature of the landscape."

Starting with that day in 1864 and continuing until the cessation of the Anaconda Mineral's operation in the early 1980's, the upper Clark Fork River became the center for mining activities in Montana.

Butte, "The Mining City", lived on long after Marysville, Virginia City, Bannack, Diamond City and others became ghost towns. The reason that Butte, and its sister city Anaconda, managed to thrive for nearly a century beyond the time of the other boom towns, was that the headwaters of the Clark Fork contained more than just gold and silver deposits. By 1880, production of these precious metals had nearly ceased at many of the area's operations, including the Anaconda Silver Mine. Marcus Daly, encouraged by rumors of vast copper reserves, promptly purchased this mine. His expectations were amply fulfilled, since the Anaconda "contained the richest bodies of copper sulphate the world had ever seen" (Malone and Roeder 1976). With this discovery in 1882, the headwaters area of the Clark Fork became the center for a massive copper mining and smelting operation. Since Butte did not have a nearby water supply of adequate volume, Daly chose to locate his smelter north of Warm Springs Creek near the present town of Anaconda. This smelter, capable of producing 500 tons per day of copper ore, began production in 1884. The demand for copper and the vastness of the reserves at the "Richest Hill on Earth", prompted the construction of an additional smelter three years later. This "lower works" smelter quadrupled the Company's rate of copper production. Completion of the Washoe Smelter in 1902 tripled this production, making the Anaconda operation the largest producer of copper in the world (Hartman 1975).

For seventy years the Clark Fork River received the untreated effluent from one of the largest mining ventures on earth. In 1954 the Anaconda Company initiated its first attempt to actually treat these waste waters by constructing a series of settling ponds above the confluence of Warm Springs Creek. Almost concurrent with this construction was the passage of the first Montana Water Pollution Control Act in 1955. This Act among other things, set aside Silver Bow Creek, the Clark Fork tributary above the ponds, as "suitable for industrial waste disposal". Even today, the total of Silver Bow Creek, approximately 26 miles in length, is still classified as "E", the lowest possible rating, "suitable only for industrial and agricultural uses other than food processing".

With the establishment of the settling ponds, some improvement in the biological quality of the river was noted. In 1957, Spindler, using crude electrofishing gear and at times explosives, found fish as far upstream as Drummond. A labor strike in 1959, however, returned the river to pre-1954 conditions. Throughout the winter of 1960, fish kills of "undetermined magnitude" occurred in the Clark Fork River above Missoula (Averett 1961). Another strike in the summer of 1967 again caused a shutdown of the treatment system, allowing acidic, metal-laden water to flow untreated into the Clark Fork River (Spence 1968). The U.S. Environmental Protection Agency (1972) documented "red water" incidents on at least four occasions as far downstream as Drummond from August through October of 1970. (The red coloration referred to in the EPA report is caused by high concentrations of ferric hydroxide, and is therefore indicative of high concentrations of mining wastes being present in the river.) Even as late as 1972, red water was observed at Deer Lodge on January 2, and Drummond on March 2 (Peters 1975).

Later in 1972, the Anaconda Company installed a closed treatment system at their Butte operations. This addition to the Company's waste treatment capabilities as well as more consistent control of the "liming" operations at the Warm Springs settling ponds has served to lessen the metal impacts to the river. This is particularly true in the portion of the Clark Fork immediately below the ponds. However, there is strong evidence that the impacts caused by past and continuing discharges of process waters from the Company's facilities and property are continuing to degrade the trout fishery of the Clark Fork River downstream to at least Missoula. Although much publicity has been generated about the recent recovery of the river in its uppermost reach, examination of fish population surveys from several other downstream sections reveal that most of the upper river is still in a sadly degraded condition.

II. Fish Populations

In 1957 the then Montana Department of Fish and Game hired its first fisheries biologist to work in the region that includes the upper Clark Fork River. During the following decade, no actual estimates of fish populations as trout/mile were made. Electrofishing gear capable of sampling streams the size of the Clark Fork was in the early stages of development; the abnormally high concentrations of dissolved solids found within the river also plagued the efforts of early researchers (Whitney 1961).

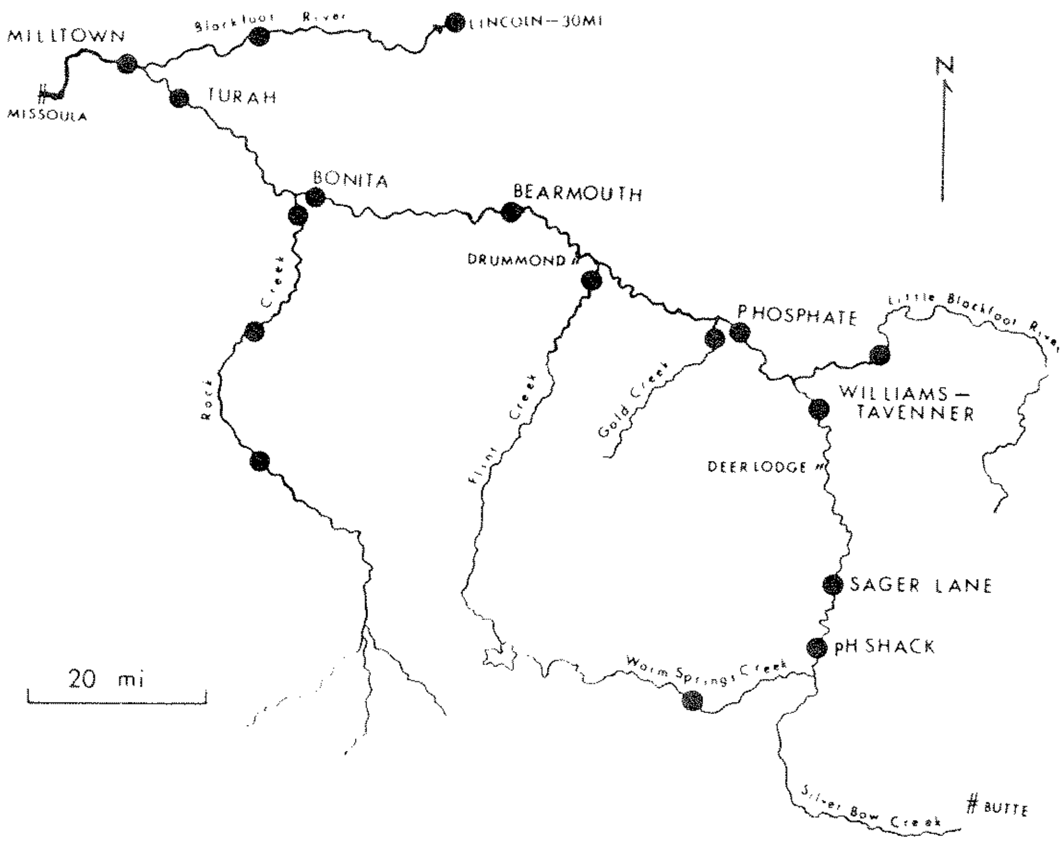
The most significant fisheries data collected during the period of the early 1960's was reported by Whitney (1960). In response to the strike that had shutdown the Anaconda Company's treatment system, rainbow trout were placed in live cages at four locations near Missoula from March 16-20, 1960. All of the trout placed in the "red water" above Missoula were dead within 96 hours. This bioassay data, along with the observations noted earlier concerning extensive fish kills in the river throughout the winter of 1960, indicate that the river had essentially returned to its pre-1954 "biological wasteland" condition.

With the advancement of electrofishing gear and a better understanding of how to control voltage outputs in waters with high electrical conductivity, the first actual estimates of fish populations were made in the upper Clark Fork River in 1967. The remainder of this section will review all of the fish population estimates that have been conducted in the upper Clark Fork system from 1967-83.

A map of the upper Clark Fork, showing sampling locations, is presented in Figure 1. A total of eight separate fish population sections have been sampled at various times on the mainstem Clark Fork above Missoula. Nine tributary sections have also been sampled.

The most extensive monitoring of fish populations has occurred in the uppermost portions of the river at the pH shack and Williams-Tavenner sections. Only one population estimate was made downstream from the Williams-Tavenner section before 1979.

FIGURE 1. Map of the upper Clark Fork River System Showing Mainstem and Tributary Fish Population Sections (●)



Since the pH shack and Williams-Tavenner sections have the most complete historical fish population records, data from these locations are presented in their entirety (Figure 2). Essentially no trout were present at the pH shack until 1973, one year after the installation of the closed treatment system at Butte. From 1973 to 1976, the spring populations at the pH shack stabilized at around 300 trout per mile and the fall estimates at around 600 trout per mile. From 1977-1979 both the spring and fall estimates tripled at this section. Somewhat of a decline in populations can be noted for both seasons at the pH shack section in the period following 1979.

Fish population estimates at the Williams-Tavenner section present a sharp contrast to those at the pH shack section. Although relatively stable throughout the 1967-83 period, they are also conspicuously lower than the "improved" conditions at the pH shack. Whatever brought about the improved conditions for trout in the section just below the Warm Springs ponds did not concurrently enhance the populations further downstream. A marginal trout population continues to exist within the Williams-Tavenner section almost as if no improvements had been made at the Anaconda treatment facilities.

Examination of the rest of the fish population data for the Clark Fork below the Williams-Tavenner section demonstrates that the degraded condition of the trout fishery found at this latter section continues all the way downstream to Missoula. Between 1979 and 1983 even the highest population estimate for any section downstream of the pH shack was lower than even the lowest spring estimate on record at the uppermost section (Figure 3). Data in this Figure also reveals that the drop in trout numbers below the pH shack occurs over a very short distance downstream. The Sager Lane section, which is only about 12 miles below the pH shack section, supports less than 400 trout/mile. Even within the pH shack section, fisheries biologists have observed that they capture progressively fewer fish as the move downstream through the section (Hadley 1984).

The sparce trout populations of the mainstem Clark Fork can be put into better perspective if comparisons are made with the trout population estimates of the river's major tributaries (Table 1). The Blackfoot River has the highest populations in the upper Clark Fork system; both the Lincoln and Johnsrud Park sections support around 2500 trout/mile. Population estimates for Warm Springs

FIGURE 2. Trout Population Estimates for the pH Shack (●) and Williams-Tavenner (○) Sections, 1967 - 1983.

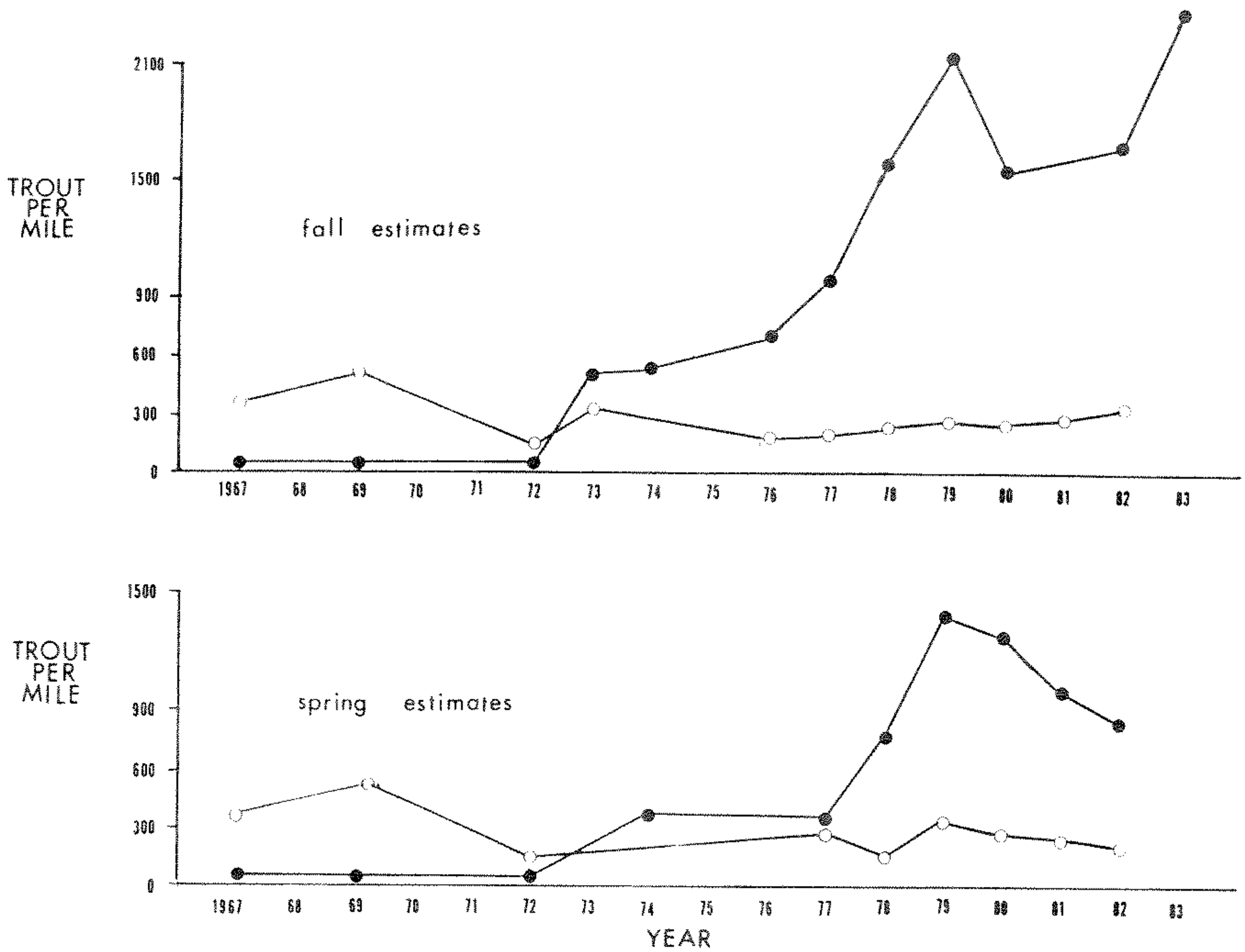


FIGURE 3. Ranges and Averages of Trout Populations in the upper Clark Fork Mainstem, 1979 - 1983.

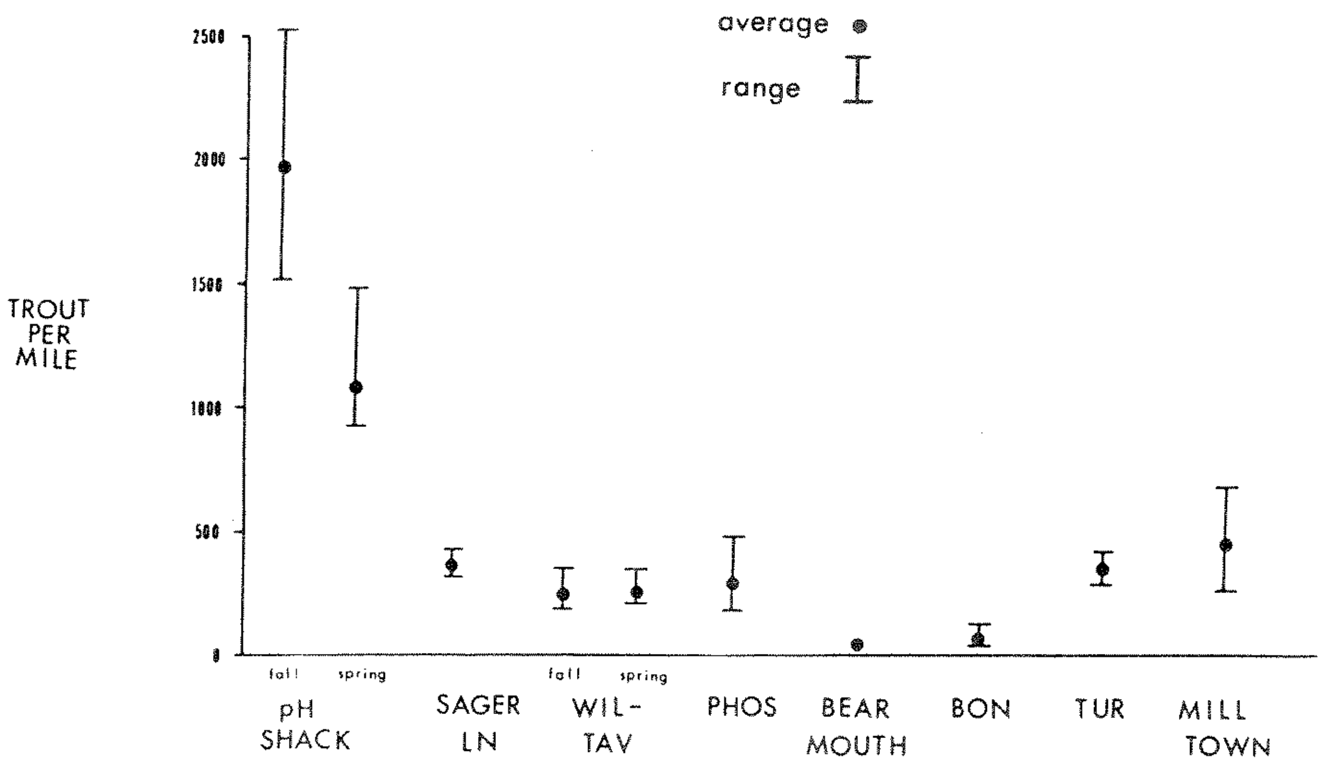


Table 1. Trout Population Estimates and Relative Abundance of Trout Species from Sections of the Upper Clark Fork System.
Mainstem populations are averages of the years 1979-1983

Section	Trout/ Mile	Relative Abundance (%) LL	RB	EB	DV	CT	Reference
Clark Fork River							
pH Shack							
Spring	1132	100					Vashro (1983)
Fall	1908	100					Vashro (1983)
Sager Lane	396	100					Vashro (1983)
Williams-Tavenner							
Spring	267	100					Vashro (1983)
Fall	285	100					Vashro (1983)
Phosphate	302	100					Vashro (1983)
Bearmouth	39	100					Peters (1981)
Bonita	38	70	30				Peters (1981)
Turah	372	70	30				Peters (1981) (1984)
Milltown	485	27	73				Peters (1981) (1984)
Blackfoot River							
Johnsrud Park	2364	2	91		3	4	Peters (1981 (1984)
Lincoln	2670	76	1	16	1	6	Spence (1970)
Rock Creek							
Valley of the Moon	1383	50	50				Marcoux (1973) Peters (1978) (1981)
Fish and Game	1670	2	78		15		Marcoux (1974)
Hogback	1502		93		7		Marcoux (1974)
Warm Springs Creek							
Meyers Dam	1525		40	35		21	Vashro (1983)
Gold Creek							
Near mouth	1486	100					Vashro (1983)
Flint Creek							
Near mouth	1116	100					Marcoux (1974) Vashro (1983)
Little Blackfoot River							
Dana Ranch	852	100					Vashro (1983)

LL = Brown Trout
RB = Rainbow Trout
EB = Brook Trout
DV = Bull Trout
CT = Cutthroat Trout

Creek, Gold Creek and Rock Creek all average around 1500 trout/mile. Flint Creek and the Little Blackfoot River, both of which have some history of hardrock mining, support populations of around 1000 trout/mile. Clearly, the majority of the mainstem Clark Fork contains conspicuously fewer trout per mile than all of the other major streams in the drainage. In the most extreme example (the Blackfoot at Lincoln compared to the Clark Fork at Bearmouth) this difference is about 50-fold.

Comparison of a river to its tributaries may not be a basis for absolute predictions of what the mainstem fish populations necessarily should be, but in the case of the Clark Fork, this method may have considerable merit. This is primarily because Rock Creek and the Blackfoot are not simply small "feeder" streams, but rather, they are very major tributaries that are nearly equal in size to the segments of the Clark Fork near their confluences. For example, U.S.G.S. records (1982) reveal that the average annual discharge rate of Rock Creek is 616 cfs, with a corresponding measurement for the Clark Fork at Drummond being 891 cfs. The Blackfoot River has an average annual discharge rate of 1658 cfs, while that of the Clark Fork above the Blackfoot is 1397 cfs - a value that is actually less than its "tributary" stream.

When evaluated from this perspective, the fish population of the Blackfoot River and Rock Creek certainly seem to be logical prototypes for what the Clark Fork could or should be. The average population of all sections of the Clark Fork above Missoula (excluding the pH shcak section), is roughly 300 trout/mile. However, a considerable length of the river, the segment from Bearmouth to Bonita, only supports around 50 trout per mile. If Rock Creek is used as a standard for comparison, the trout fishery of the upper Clark Fork, at its worst, is only about 50/1500 = 3% of its potential. On the average, it is about 300/1500 = 20% of what it could be. If the average populations of the Blackfoot are used as a standard, these values become 50/2500 = 2% and 300/2500 = 12%.

Another important contrast can be drawn from the data in Table 1. The variety of trout within the major tributaries is much more pronounced than is the case with the mainstem stations. For example, on the Clark Fork above Bonita, only brown trout are present in numbers large enough to allow a valid estimate of their populations. While on the Blackfoot, up to four species of trout are present in large enough numbers to allow such estimates. Healthy aquatic ecosystems normally contain a large diversity of species. Any time that a single species dominates any given trophic level, some factor is likely to be limiting the health and condition of the system.

It is also significant to note that bull trout and cutthroat trout, the two native trout species of the upper Clark Fork system, have been virtually eliminated from the mainstem. Populations of these preferred species of the Salish Indians (Malouf 1979) are still found in Rock Creek or the Blackfoot River despite past policies of intensive plantings of hatchery rainbow trout into both of these streams.

III. Impacts to the trout fishery

In seeking the factor responsible for the degraded trout fishery of the upper Clark Fork River, consideration must be given to all three general categories of potential impacts - dewatering, habitat degradation and water pollution.

Unlike many western Montana trout streams, the Clark Fork presently does not suffer from severe water depletions. The Big Hole, Jefferson, Gallatin and Beaverhead Rivers are much more severely dewatered than is the Clark Fork. However, all four of these rivers sustain much higher trout populations than the Clark Fork.

The fish habitat of the upper Clark Fork has been subjected to some degradation, particularly as a result of the construction of highways and railroads. Again, however, there are many other trout streams that have been subjected to as much or more habitat degradation, without the dramatic plunge in trout populations that is evident on the Clark Fork. The Bonita fish population section provides the most convincing arguement that habitat loss is not limiting the trout fishery of the upper Clark Fork. This section is located away from the streambank disruptions caused by any of the major transportation systems. Livestock grazing and other human-related problems have not effected the riparian zone of this section; streamside vegetation provides ample overhanging cover for trout. Yet the trout populations in the Bonita section remain far more depressed than sections of, say, the Little Blackfoot River, where "instream bulldozing" has caused severe habitat losses (Vashro 1983).

Potential water pollution problems that have been identified in the upper Clark Fork include low dissolved oxygen, high water temperatures and, toxic metals (DHES 1976; Knudson and Hill 1978; Vashro 1983). The first of these three potential impacts is probably the least significant. Although dissolved oxygen concentrations have been shown to drop as low as 5.7 mg/L (due to the nighttime respiration of dense algal populations) at Deer Lodge and Bonita, it is unlikely that these brief, predawn excursions below criteria are a serious problem. The physical reaeration potential of shallow, flowing waters makes it extremely unlikely that algal respiration alone can ever seriously deplete the dissolved oxygen levels of the Clark Fork River.

Any theories about temperature being the cause of the depleted fishery of the Clark Fork were laid to rest by the excellent work of Vincent (1981 and 1983). The Madison River at Norris supports a fishery of over 3000 trout per mile, despite its having an average maximum water temperature that is over 6^{O}F higher than the Clark Fork at Bonita (Table 2). This table shows that for the period from mid July to mid August the Big Hole River also has higher average maximum water temperatures than does the Clark Fork.

Metals toxicity appears to be the primary factor limiting trout production in the upper Clark Fork River. This becomes evident if further examination is made of recent changes in the river's trout populations relative to the changes in the Anaconda Company's waste treatment system.

Prior to the implementation of the closed treatment system at the Butte Operations, this facility discharged between 3000-5000 gallons per minute (6-10 cfs) of copper-precipitation process waste water with a pH of about 4.0 units (EPA 1972). The soluability of metals is highly pH dependent. Generally speaking, the more acidic the water the higher is the dissolved fraction of metals. Until the adition of alkaline salts ("liming") at the Warm Springs ponds became less eratic, and the Butte discharge became better treated (the combination of which occurred around 1972), the dissolved fraction of the metals generated by the Anaconda mining operations were often discharged directly into the upper Clark Fork River. The historical presence of a "cemented" stream bottom in the vacinity of the pH shack section (EPA 1972) was a result of the alkaline waters of Warm Springs Creek and other tributaries causing the dissolved fraction of introduced metals to precipitate as insoluable hydroxides. The rise of the trout populations at the pH shack section is tied to a reduction in the frequency of direct discharging of dissolved metals into the upper river. The fact that this uppermost portion of the Clark Fork's stream bottom is now practically free of this unnatural "armoring" (Peters 1984) indicates that there has been very little precipitating of dissolved metals immediately below Warm Springs Creek in recent years.

TABLE 2. Average Maximum Temperatures
From Three Montana Rivers
July 16 - August 15 (From Vincent 1983)

River/Station	Year	Average Maximum Temperature
Madison	1980	76.5°F
At Norris	1981	72.2°F
Big Hole	1980	71.7°F
39 mi. below canyon	1981	72.2°F
Clark Fork	1980	68.1°F
at Deer Lodge	1981	68.3°F
At Bonita	1980	69.7°F
	1981	70.1°F

There are almost forty river miles between the pH shack and the Williams-Tavenner sections. Significant quantities of ground and surface water, which are relatively alkaline (WQB 1984), enter the Clark Fork along this distance. The periodicity and intensity of dissolved metal contamination, originating from the Butte Operations has usually been reduced before reaching the Williams-Tavenner section. The relative stability of trout population levels at this section from 1967-1983 indicates that Butte Operation's waste waters have recently had little direct influence upon the trout production of the Williams-Tavenner section (With the exception, of course, of the red water incidents noted earlier.) In fact, the highest population ever found at this latter section, 525 trout/mile, was measured in 1969. If anything, over the past 14 years, the trout populations at this station have experienced somewhat of a decline, rather than a substantial rise as has occurred at the pH shack section. The consistantly low trout populations at the Williams-Tavenner section, and at all other sections downstream, indicates the presence of a more widespread and persistent contamination source.

Since the beginning of copper mining and smelting in its drainage the Clark Fork has been subjected not only to the visually-obvious impacts of dissolved metal contamination, but also to more insidious contamination by fine, suspended mining "slimes" and/or tailings. Unlike the dissolved fraction of metals, the concentration of which is actually lessened by dilution, the concentrations of suspended metals (and "resuspended" metals) are often increased during runoff conditions. The toxic metal content of mine tailings prevents them from ever being naturally revegetated. This, along with their characteristically small grain size, makes them highly susceptible to erosion. For the seventy years prior to the installation of the settling ponds at Warm Springs, mine tailings originating from the Anaconda Company's copper mining and smelting facilities, flowed onto the Clark Fork River's floodplain. Even during the past three decades the mine tailing contamination of the upper river's floodplain has been exacerbated by the periodic by-passing of the Company's Warm Springs Ponds (Phillips 1984). During years when runoff has been substantial enough to cause overland flooding, tailings have been, and continue to be, spread and deposited throughout much of the river's floodplain.

Two areas where deposition has likely been most pronounced are the Deer Lodge and Drummond valleys. Both are areas characterized by a marked drop in stream gradients (Ganser 1983). As the Clark Fork meanders through the alluvial deposits of these valleys, it has had ample opportunity to drop out much of its suspended load. Vashro (1984) for example, has noted that non-vegetated tailing deposits are very obvious throughout the Deer Lodge valley. They are present, in fact, along the river channel near the end of the pH shack section.

A recent study by Ray (1983) confirmed and quantified the existence of highly concentrated metal deposits along the floodplain of both the Deer Lodge and Drummond valleys. The metal concentrations found in the deposited sediments near Drummond were comparable or higher than those found as far upstream as Rocker (Table 3). With metal contamination of the Clark Fork's floodplain so widespread, the potential for the reintroduction of metals at levels likely to be harmful to trout is very high, especially during the erosion-inducing conditions of high water. Water samples collected during the 1980 runoff period indicate that this is indeed happening.

Figure 4 displays the concentration of copper from two water quality runs conducted during May of 1980 (WQB 1984). It can be seen that copper concentrations did not drop off significantly except at Turah on May 13, 1980. During these sampling runs, the discharge of the river was increasing at each downstream station. If not for the presence of sources capable of supplying additional copper, the concentrations of this metal should have substantially decreased with dilution.

If the copper concentrations from Figure 4 are plotted as exceedences of safe instream levels (EPA 1980)[1], the magnitude of the impact of this one metal alone to the downstream trout populations of the upper Clark Fork River can be seen (Figure 5). During the May 27 run, the safe instream level for copper was exceeded by over threefold even at Turah, the furthest downstream station.

[1]The EPA (1980) has determined that, as a criterion to protect freshwater life, the total recoverable copper concentration (in µg/L), should not exceed the numerical value given by $e^{(0.94 [\ln(\text{hardness})] - 1.23)}$ at any time. If this hardness-adjusted value is divided into the actual, measured instream concentration for this metal, the factor by which the "safe" criterion is exceeded can be determined.

Table 3. Concentrations of Copper, Cadmium, and Arsenic in Riverside Sediments, Reported as µg/gr on a Dry Weight Basis (± Standard Deviation) from Ray 1983

Location	No. of Samples	Copper	Cadmium	Arsenic
Rocker	3	1102 ± 691	10.0 ± 5.1	164 ± 47.6
Racetrack	8	2375 ± 1036	11.6 ± 6.0	402 ± 114
Garrison	8	1587 ± 1291	5.0 ± 1.0	629 ± 205
Drummond	7	4155 ± 1552	12.9 ± 4.9	578 ± 166

FIGURE 4. Copper Concentrations in the upper Clark Fork River during Spring Runoff in May, 1980 (8/8/79 sample run included to show baseflow conditions).

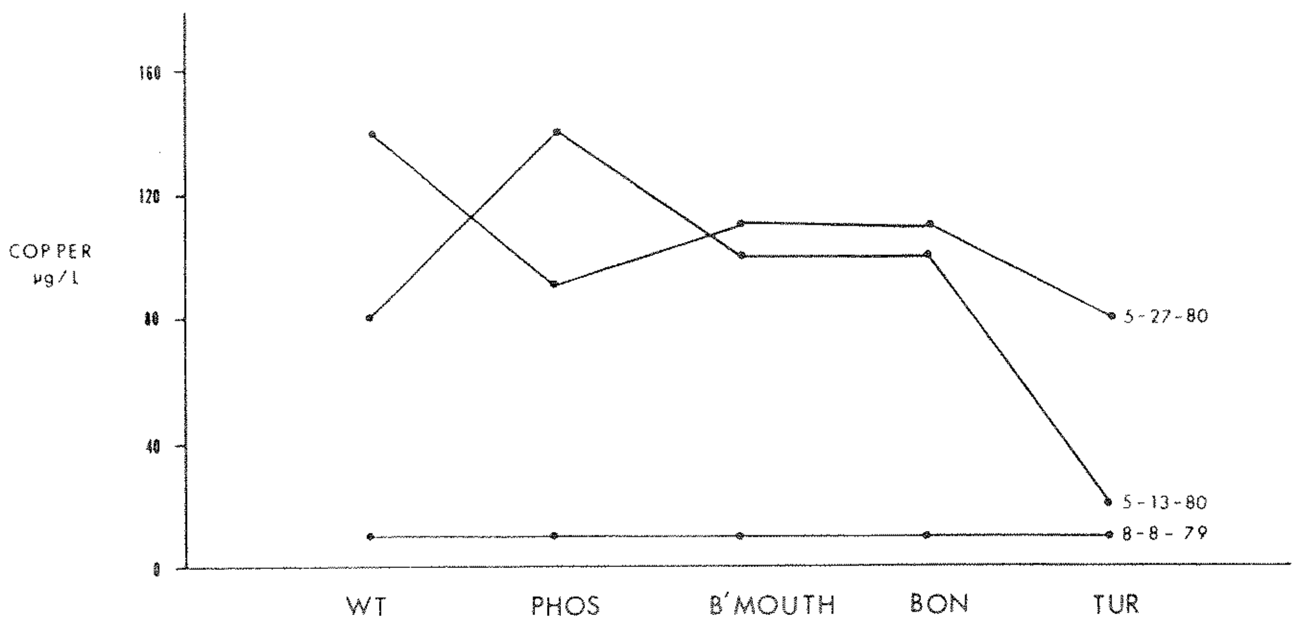
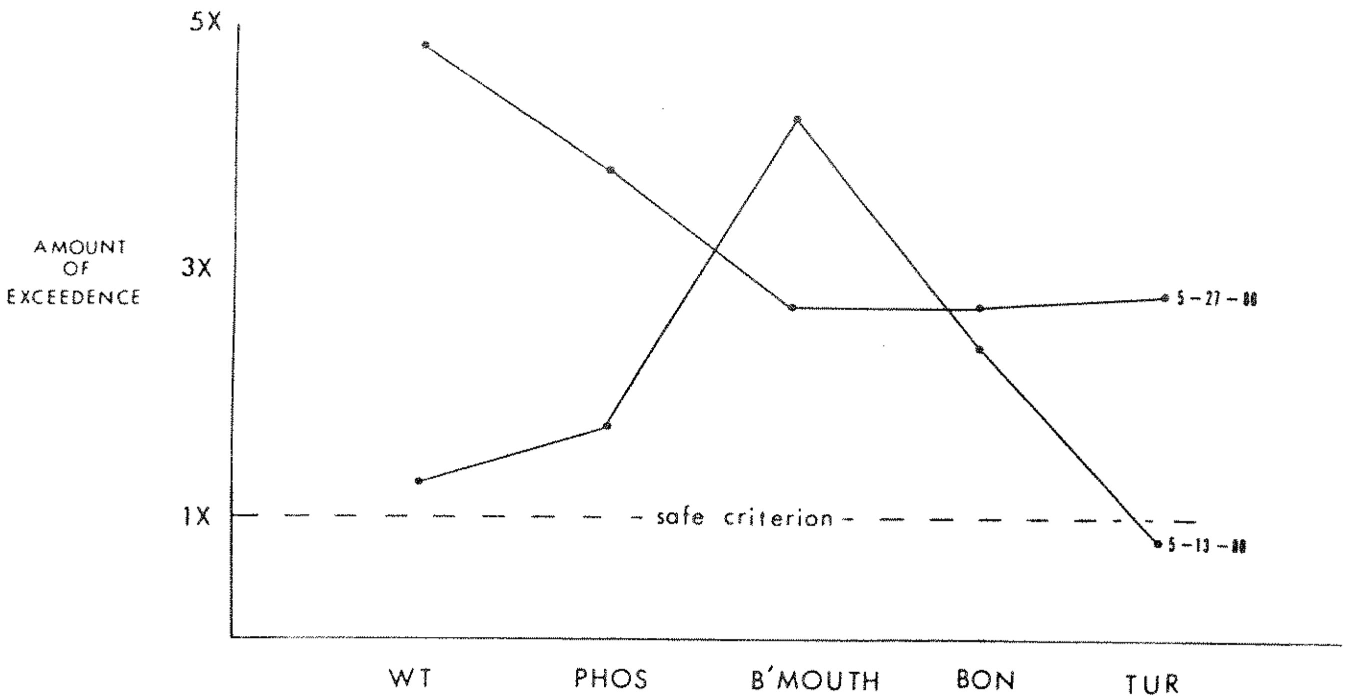


FIGURE 5. Amounts by which Safe Copper Criterion were exceeded at Clark Fork River Stations during May, 1980.



The Milltown section provides a vivid example of how toxic metals, contained within resuspended mine tailings, are impacting the trout fishery of the upper Clark Fork River. This section is located below Milltown Dam, a small hydroelectric facility which was built just below the confluence of the Blackfoot and Clark Fork Rivers in 1907. Due to its placement and its pre-1954 construction date, the reservoir behind this dam became the first actual settling basin for mining wastes originating from the Anaconda Operations.

The historical operation of this dam has required "operational drawdowns" of the reservoir every year just after high water. The Milltown Reservoir has also been periodically drawn down to to inspect and repair the dam. The annual operational drawndowns require lowering the level of the reservoir by two to three feet. The "inspectional" drawdowns are more pronounced, requiring a drop in the reservoir level of up to six feet (Greene 1984).

Whenever the reservoir level is dropped, suspended sediment levels increase in the river below the dam. The first documentation of the impacts of these sediments to the trout fishery was made by Marcoux (1971). During a reservoir drawdown in the spring of 1971, rainbow trout were placed in live cages 0.5 mile below the dam. In two separate 96 hour studies, the test fish suffered 80% and 100% mortality. It is significant to note that during the 1971 drawdown, the copper concentration below the dam was found to be as high as 4000 µg/L.

In Figure 3, trout population data is from two years, 1980 and 1983. In 1980, the population estimate was 289 trout/mile (Peters 1981). In 1983 this value had more than doubled, up to 705 trout/mile (Peters 1984). Prior to the 1980 estimate, an inspectional drawdown of the Milltown Dam had been conducted. During this drawdown, on July 7, 1980, the copper concentration in the Clark Fork River at the I-90 bridge, about one mile below the dam, was found to be 470 µg/L (WQB 1984). Assuming that a hardness value of around 150 mg/L was present (which is a high value for the river at Missoula during near-runnoff conditions), the safe instream criterion for copper was exceeded by nearly fifteen-fold during this drawdown.

Since 1981 there have only been operational drawdowns at the dam. Even these relatively smaller drops in reservoir level have been more carefully conducted. The dam's owner, the Montana Power Company, has very slowly dropped the reservoir level, sometimes by as little as six inches per day in an effort to minimize the resuspension of metal-laden sediments. As a result, since 1980, the copper concentration in the Clark Fork River below the Milltown Dam has not been found to exceed 90 $\mu g/L$ (WQB 1984).

The 1984 trout population estimate for the Milltown section was about the same as 1983 (Peters 1984). However, the further recovery of this section of river is demonstrated by the reappearance of cutthroat trout. Although still present in very small numbers, about 3% of the total trout population estimate, the reappearance of this native trout species is closely related to the reduced intensity of "slugs" of heavy metals originating from the sediments of Milltown Reservoir.

The situation at Milltown is therefore the best example of a cause-and-effect relationship between toxic metals and the depressed trout fishery of the upper Clark Fork River. However, the erosional processes that resuspend the deposits of mine tailings within the Milltown Reservoir are really no different than the high water conditions that resuspend tailings that have been deposited along the Clark Fork River floodplain. Both processes are the result of the increased sediment transport force of the river cutting into depositional areas.

The Milltown Reservoir is a very obvious depositional area. However, along the over 100 miles of river floodplain between the Warm Springs Ponds and Milltown, there are numerous low-gradient stream reaches and flood channels. These natural depositional areas release their metals into the Clark Fork River at least once per year during the high water period. Although the extent of this contamination has not as yet been totally quantified physically or chemically, it certainly has been quantified biologically, at least in terms of a very degraded trout fishery.

IV. Impacts to the Recreational Industry of the Clark Fork River

The water quality conditions that have reduced the fishery resource of the upper River to a mere vestige of what it could be, have also reduced the area's fishery-related industry to a very minimum. Communities bordering the river like Drummond and Deer Lodge were, and still are to a large degree, precluded from developing the floating/outfitter business, tackle shops, motels and cafes that provide a healthy and sustainable economic base for Ennis, Livingston, Gardner or Dillon. The potential for this kind of stable economy was certainly present before the copper era. In 1876, R.N. Sutherlin, the well-traveled newspaperman, who knew the territory as well as anyone, chose Deer Lodge as "the most Beautiful City in Montana" (Malone and Roeder 1975).

The Clark Fork proper has always been very visable and readily accessible to the touring public, since it is located along the major east-west transportation corridor through Montana. However, not until the mid 1970's and certainly not before 1960 would even the most naive of tourist consider making fishing the upper Clark Fork a point of interest on their visit to or through the state. Even as late as 1979 visits by non-residents to the upper Clark Fork for the purpose of fishing was very low - 11.7 percent, a figure that includes Rock Creek (Hagman 1979).

In his preliminary estimate of the recreational value of the upper Clark Fork and its tributaries, Duffield (1981) stated that Rock Creek is the only portion of the entire upper Clark Fork drainage with any significant non-resident market. (His analysis did not include the Blackfoot River which is attracting an ever-expending regional recreational market.) Contrast this almost non-existent tourist market to the Madison River, where it has been estimated that non-resident users alone contribute up to $15,000,000 annually to the economy of the area surrounding the river (Shouse 1984). The fish populations of the Madison River are very similar to the Blackfoot, with a section near Ennis supporting around 2500 trout/mile. It is therefore not unreasonable to surmise that a completely healthy Clark Fork, with recovered fishery levels approaching those of its major tributaries, could potentially support a fisheries-based recreational industry similar to that of the Madison River. Fifteen million dollars per year is therefore an upper value for the lost recreational potential for the upper Clark Fork area.

The present annual economic value of the upper Clark Fork and its tributaries above the Blackfoot has been estimated to be only 0.5 to 1.4 million dollars per year (Duffield 1981). Nearly 3/4 of this annual value was attributable to Rock Creek. (The recreational value of Rock Creek was possibly underestimated, since development of a regional model to correctly assess the non-resident market of Rock Creek was not undertaken in Duffield's preliminary work.) Given that the Clark Fork above the Blackfoot is nearly twice as long as Rock Creek and actually more amenable to large-scale floating, it should at least be supporting as much of a recreational-based industry as Rock Creek or any other of its tributaries. The annual recreational value of Rock Creek could well approach two million dollars if the travel cost method applied in the preliminary estimate is significantly lower than what could be found with an expanded regional model. Two million dollars per year is therefore a lower value for the lost recreational potential for the upper Clark Fork area.

When estimating the total value of the impacts to the fishery-based industries along the upper Clark Fork consideration must, of course, be made for the historical duration of these impacts: for over seventy years, people living along the upper Clark Fork were denied the simple amenity of a fishable or swimmable river.

It is just as important however, to quantify the present and project the future impacts: not only have the "glistening waters" for the last century often been red, but also much of the "furzy" floodplain of the Clark Fork above Missoula has been covered with mine tailings; and there are upstream replacements to last for centuries.

A substantial portion of the Clark Fork River's floodplain above Missoula has become a receptacle for hazardous wastes. Until reclamation of these wastes is undertaken along much of the stream's floodplain, the extremely depressed climate for fishery-based industries will continue to indefinately persist.

V. Suggestions for Solidifying the State's Position

The State's case against the Anaconda Minerals Company at this point is not as strong as it should or could be. However, over the next few months it can be built into a very defensible posture by the following actions:

1. Continuation of the river-wide water quality runs that have been initiated by the Montana Department of Fish, Wildlife and Parks.

This collection of metal samples from Warm Springs to Clinton (Turah) should be continued on at least a monthly basis during the baseflow periods and on a weekly basis during the pre-to post-runoff period. Consideration should also be made for establishing an additional station at Milltown. Provisions should also be made to collect runs during periods of mid to late winter snowmelts and immediately following intense late summer thundershowers or early autumn rains. These samples would help clarify whether or not "slugs" of metals enter the stream at times other than runoff. (During summer trout would be more susceptible to metal poisoning because of elevated stream temperatures and lowered dissolved oxygen values.) The fact that depressed trout populations have not as yet been conclusively tied to elevated metal concentrations, especially as hardness-adjusted toxicity values, weakens the State's position.

2. Mapping of deposition areas throughout the floodplain from Warm Springs to Milltown, along with metal analyses of the sediments from a selected number of deposition areas.

More information needs to be gathered to expand Ray's sediment work. During the mapping process, close attention should be paid to locate significant stream gradient changes below depositional areas. Any of these deposits that could be subjected to real or potential head cutting should definately be identified.

Major headcuts are likely present just above the Garrison and Bearmouth canyons. The natural drops in river gradient near these locations have been intensified by highway and railroad channel changes.

3. Continuation or reactivation of all eight mainstem fish population sections.

For the first time ever, a complete set of water quality runs has been collected along the entire length of the upper river throughout the runoff period. Fish population estimates definately need to be taken during the late summer or autumn of 1984 to determine fish population/metal concentration relationships. Population estimates from an additional section or sections between Sager Lane and the pH shack would also help quantify the rapid decline in trout numbers between these two sections.

4. Collection of brown trout for metal analyses of tissues and organs; fish for these analyses should be collected from all eight mainstem shocking sections as well as controls from the Rock Creek Valley of the Moon and Fish and Game sections.

Vashro (1983) found that brown trout that were tagged within the pH shack, Williams-Tavenner and Phosphate sections exhibited very little upstream or downstream movement; most, in fact, were recaptured within a mile of their initial tagging site. These strong "residency trends" along with the fact that brown trout are the dominant, upper trophic level species at all of the sections but Milltown, makes them highly suitable for use as river-wide biomonitors.

A minimum of ten age class III or older fish should be collected from each section. Liver and gills, two major detoxifying organs, should at a minimum be analyzed for copper, zinc and cadmium. Also as a minimum, the tissue of the fish should be analyzed for cadmium, a bioaccumulative element. These latter analyses will not only determine if there are any potential impacts to the health of the fish (although this will be better determined by the liver and gill analyses), but it will also determine if there are any potential health effects to humans who consume the fish.

Fish for these analyses should be collected as shortly after runoff as possible to 1) measure the metal levels of the fish immediately after the period of highest instream metal concentrations, and 2) preceed the fall spawning migration. Ideally, this sampling should be repeated in the early winter or spring, several months after the runoff/high metal concentrations. In all cases the condition factors of the fish should be carefully measured.

5. Expansion and refinement of the monetary value of recreational use on the upper Clark Fork.

The damage to the recreational industry is clear, but more precision in the economic analysis is desirable. An economist like Duffield or the AMEC group out of Bozeman, who performed the economic analysis for the Madison River, should review the Madison and Clark Fork studies to see if they can or need to be integrated, solidified or expanded. Regional models to better assess the recreational value of Rock Creek and the Blackfoot River need to be developed. Economically quantifying the value of these two major tributaries, and then comparing these figures to the meager recreationally-based income of the mainstem, would provide a better estimate of dollars lost to local economies.

6. Further review into the validity of using the fish populations of tributaries as a basis to project the populations within mainstem segments of river systems.

Particular attention should be paid to similar-sized cold water systems that have annual average discharge ratios equating to Rock Creek and the Blackfoot versus the segments of the Clark Fork above these streams, i.e., 1:1:1. The Yellowstone, Madison and headwater rivers of the Missouri are possible choices.

7. Additional research into the early and pre-mining history of the upper Clark Fork region.

Deer Lodge's newspaper The New Northwest was, in 1876, one of the best in the territory (Malone and Roeder 1975). Research of any existing copies of this newspaper may provide more insight into the changes that occurred to the area and river because of the copper boom. The journals of Captain Mullen, Major Owen, Father De Smet and others are extensive, but worthy of review for their historical descriptions. Dr. Malouf has likely gathered more information on the hunting and fishing practices of western Montana Indian tribes. More historical documentation would serve to strengthen the case for "the Clark Fork that was".

The state's position in this case is very winnable when evaluated in terms of impacts to the fishery resource and its related recreational industry.

It would be nearly unconscionable for anyone to argue that the recreational base of the upper Clark Fork was anything but devastaged until at least 1960. Even since 1960, it has but only poorly recovered. The relatively small amount of cost and time that it will take to implement the above additional investigations will definately pay off in terms of creating a much stronger case that the past and continuing discharges of hazardous wastes by the Anaconda Company have impacted, and are continuing to impact the recreational base of the river.

By 1915 the Anaconda Copper Mining Company was the giant of the world's copper industry, with a copper production capacity of three hundred million pounds per year:

> "Its Montana empire included thrity mine shafts on the Butte Hill, reduction works and smelters at Anaconda, Great Falls, and East Helena, a big lumber operation based at Bonner, scattered coal fields, a railroad, hardware stores, hotels, and, ominously, a growing chain of newspapers that by now included most of the state's major dailies.
>
> The Anaconda had crushed and absorbed its opposition, and by 1910-15 it clearly dominated the Montana economy and political order. In contrast to the old days, when Marcus Daly seemed to manage the Company with Montana's interests in mind, local folks now found themselves locked in the grip of a corporation controlled from Wall Street and insensitive to their concerns." (Malone and Roeder 1976.)

Today "The Company" is gone. Much of the wealth it extracted from the upper Clark Fork has long since been distributed among its Wall Street stock-holders. Left behind are the unemployed and the devastated river. The course of action taken by the state should be guided by these realizations.

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