BOULDER RIVER
JEFFERSON COUNTY
MONTANA

A REVIEW OF IMPACTS TO THE TROUT
FISHERY AND INITIAL RECLAMATION
RECOMMENDATIONS

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CONSULTING BIOLOGIST

AUGUST 1984

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COVER GRAPHIC BY ERICH WEBER

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I. Purpose

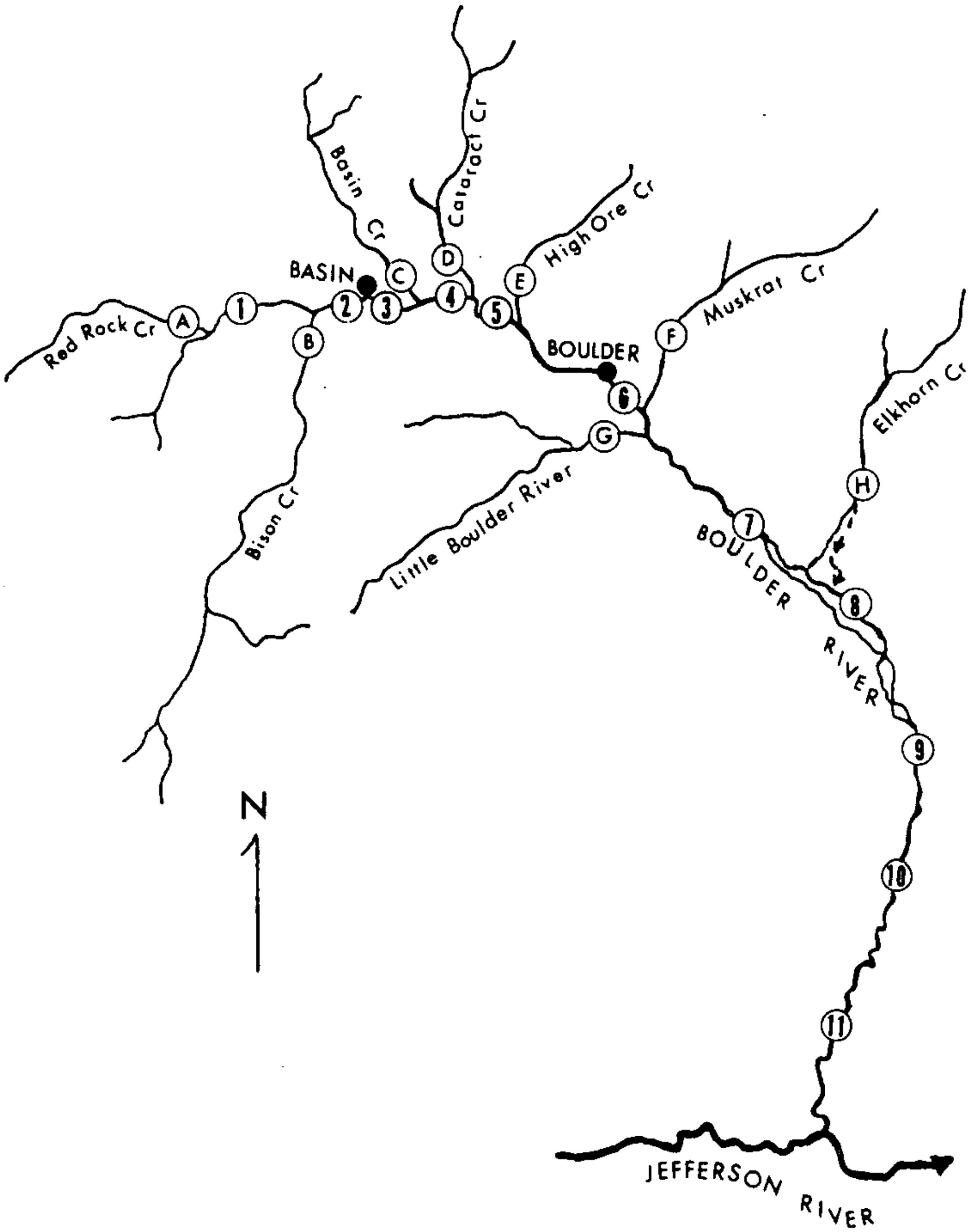
Plagued by streambank and channel alternations, excessive sedimentation, dewatering and pollution from mining operations, the Boulder River has a significantly impacted trout population for most of its length below the Town of Basin. If the river is to be capable of providing a sustainable recreational base, all of its human-caused impacts should eventually be rectified.

Starting in the 1970's and continuing until 1986, the scheduled completion date, activities associated with the construction of Interstate 15 have impacted, and continue to impact, the Boulder River and Bison Creek. Many of the impacts caused to fish habitat by this construction, including alternations to streambanks and channels, have been mitigated on-site as an integral part of the highway design. However, impacts to some stream reaches, particularly above Basin, simply could not be satisfactorily mitigated within the steep and narrow canyons of this headwater area. Recognizing these unavoidable on-site impacts and realizing that a variety of factors limit the stream's trout fishery, the Montana Department of Highways and the Federal Highway Administration agreed to provide funding to mitigate one or more of the other problems. The purpose of this report is to review and prioritize the various trout-limiting impacts to the river and suggest specific corrective procedures for the impact(s) identified as being most significant.

II. Introduction

The Boulder River originates along the Continental Divide in Jefferson County, Montana. It flows in a southeast direction for nearly 80 miles to its confluence with the Jefferson River (Figure 1). At the Town of Boulder, which is below most of its major tributaries, it has an average annual discharge rate of 121 cubic feet per second (USGS 1972). Above the Town of Boulder, the river is generally confined within a steep,

FIGURE 1. Boulder River Drainage
Showing Sampling Locations for Mainstem (Numbers)
and Tributary (letters) Water Quality Stations



narrow canyon. Most agricultural use of the drainage occurs below Boulder, where the stream assumes a broader, more sinuous pattern on an alluvial flood plain.

Vincent (1975) and Nelson (1976) have described the status of the trout fishery of the Boulder River: Above the town of Basin, the river contains a healthy population of fish, capable of supporting a significant recreational fishery. Below Basin the number of fish and their condition begins to deteriorate. After the confluence of High Ore Creek, above five miles below Basin, trout numbers drop even further, to only about 15% of the population found above Basin. This degraded condition of the trout fishery continues almost all the way to the river's mouth.

Vincent and Nelson, as well as Gardner (1977), list several factors that contribute to the Boulder River being unsuitable for trout in what amounts to nearly fifty miles of the stream's length:

1. Loss of fish habitat.
2. Excessive suspended sediment.
3. Dewatering.
4. Toxic metals.

Considered together, each of these impacts no doubt contribute to the overall reduction of the trout fishery below the Town of Basin. Examined separately, it becomes apparent which impact needs initial reclamation emphasis.

III. An Overview of Impacts to the Trout Fishery of the Boulder River

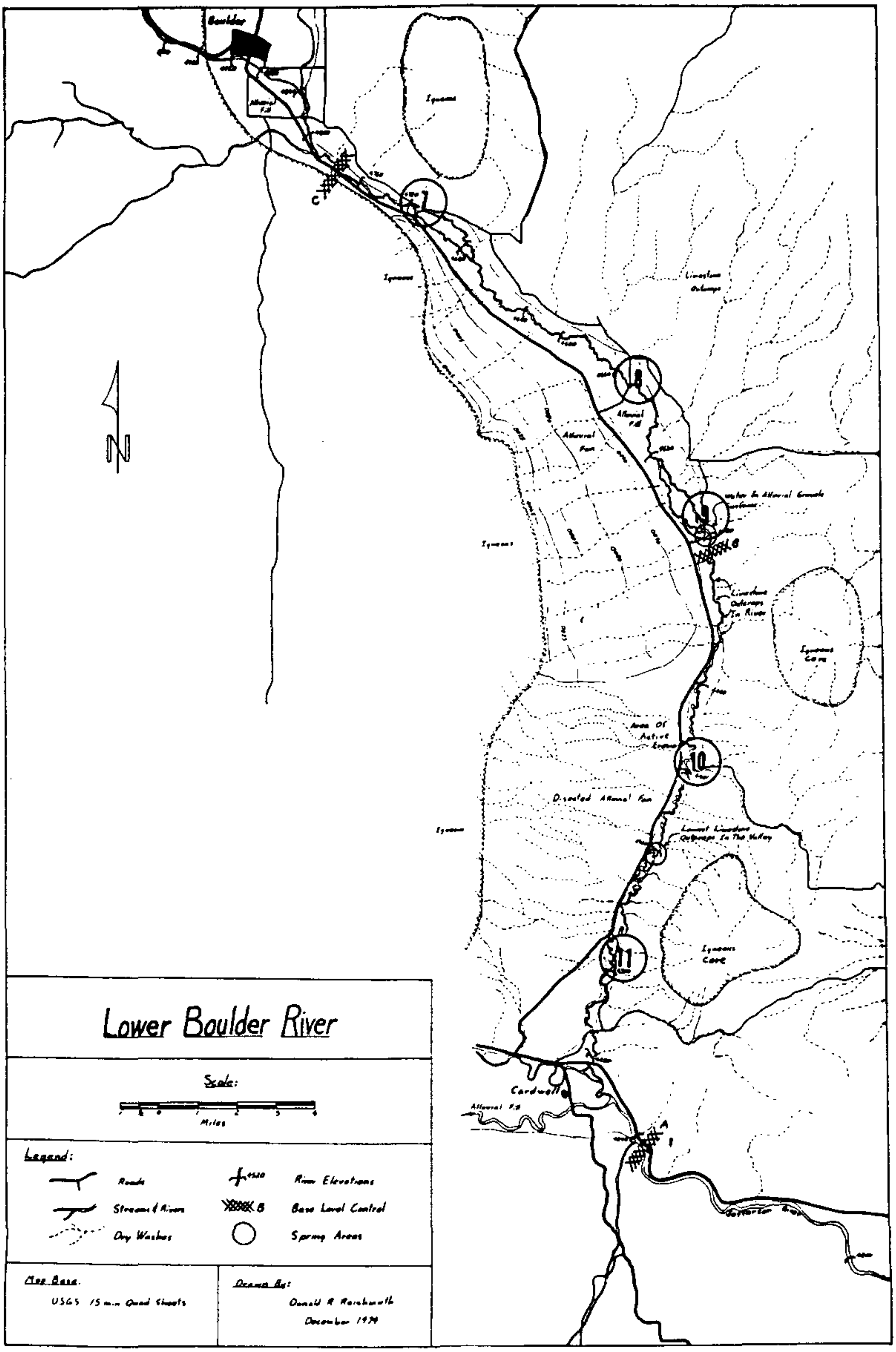
Loss of fish habitat has definitely occurred in the upper portion of the drainage due to the construction of the railroad and at least two major highways. Construction of these transportation corridors has resulted in the shortening of the stream's channel and removal of vital streambank vegetation. Also, in some reaches of the lower river, rip-rapping and overgrazing has resulted in loss of bank cover.

Excessive sedimentation, which suffocates trout eggs and their food sources is closely tied to the conditions that cause the loss of fish habitat. For example, the straightening and shortening of stream channels increases their erosive force. Overgrazed channel banks eventually collapse into the stream. Reichmuth (1984) has pointed out that the Boulder River is naturally headcutting in an attempt to adjust to a shift in the elevation of the Jefferson River that occurred sometime after the last retreat of the glaciers. As this headcut continues to progress upstream, active erosion of the valley's depositional materials continues to occur (Figure 2). Very high concentrations of suspended sediment are produced by this headcut every year, especially during high stream discharge periods.

Dewatering reduces available living space for trout, dries up spawning and food production sites and increases water temperatures. During most irrigation seasons, nearly thirty miles of the Boulder River contains less water than is needed to sustain an optimal fishery.

The three categories of impacts just discussed are the result of hundreds of separate streambank and channel alterations, non-point pollution sources and/or irrigation diversions. In order to properly address these fish-limiting factors and prescribe suitable reclamation procedures, a stream and channel habitat inventory should be conducted throughout the Boulder River Drainage. This inventory could also address the dewatering problem, and thus serve as the basis for a corridor management plan, whereby problem sites in the drainage could be prioritized for reclamation. Collection of the extensive data base that would be necessary to quantify these impacts is beyond the scope of this present review. However, an inventory and management plan should eventually be undertaken in the Boulder River Drainage, so all of the river's fish-limiting factors can be properly mitigated.

FIGURE 2. Diagram of the Lower Boulder River, Showing Relationship of Sampling Stations to Alluvial Fill (From Reichmuth, 1984)

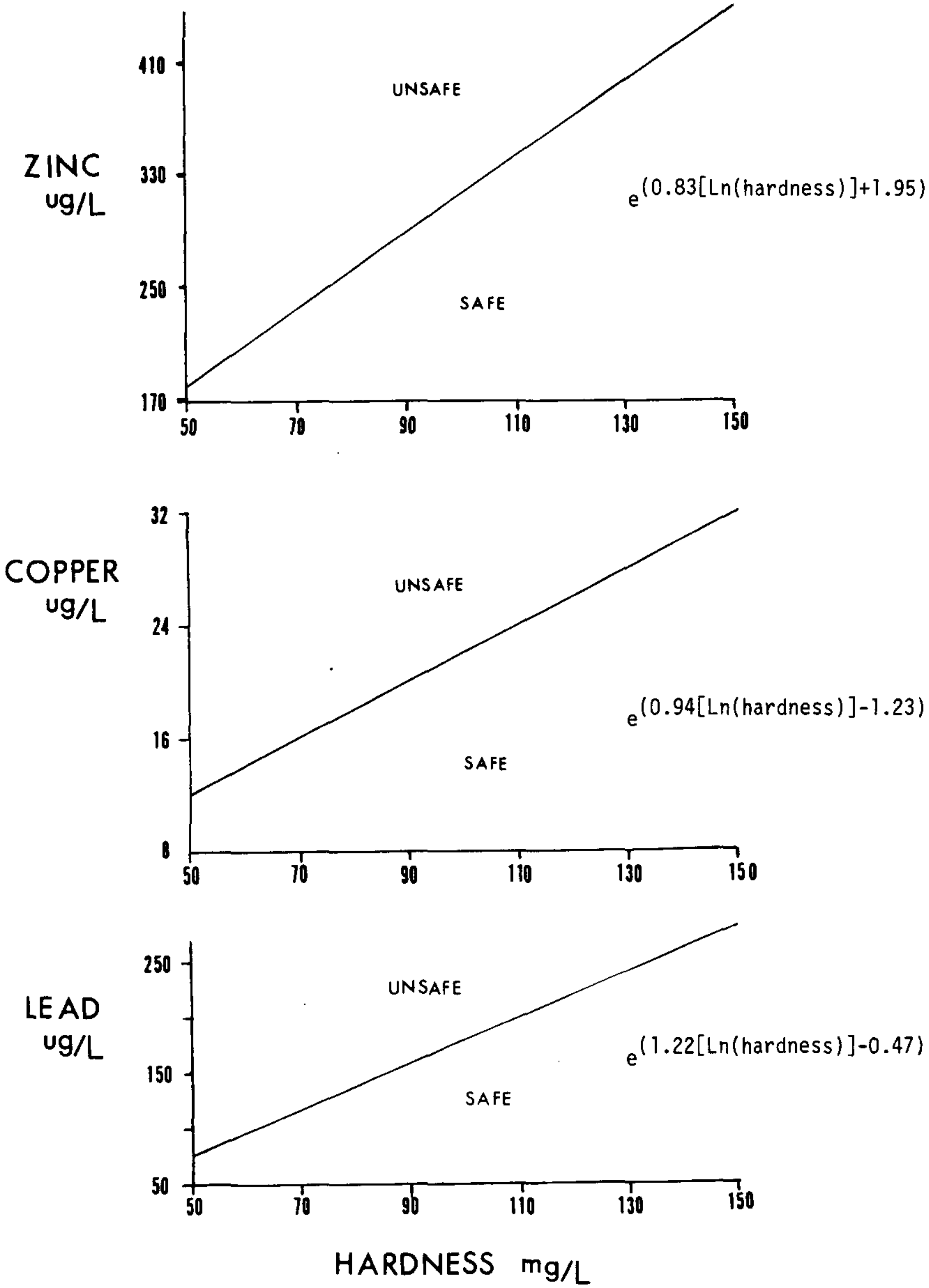


Toxic metals, originating from active, and abandoned mining operations, severely limit fish production in the Boulder River. Unlike the other three categories of impacts previously mentioned, sufficient data does exist to quantify the sources and effects of metals. Acceptable instream criteria for metals are exceeded by nearly twentyfold at certain times and places on the Boulder River. These toxic conditions preclude the need to address any other trout-limiting factors until the sources of toxic metals are rectified. The remainder of this report will, therefore, review the impacts of metals to trout, delineate the sources of metal contamination to the Boulder River and prescribe in initial reclamation plan to reduce these impacts.

IV. Impacts of Metals to Trout

Prolonged exposure to metals tends to disrupt the circulatory, respiratory and nervous systems of all animals. Trout are among the most susceptible of all organisms to these impacts (EPA 1976). The presence of very minute quantities of metals may prohibit production and reduce the growth and survival of trout. The hardness of water, which is primarily a function of its calcium and magnesium concentrations, tends to buffer the toxic impacts of metals. This is because these non-toxic elements successfully compete with metals for sites of binding and uptake on biological tissues (EPA 1980). This latter EPA publication also gives equations and quantifying the relationship between toxic metal levels and hardness, so calculations can be made to determine whether a given instream metal concentration is above or below a safe level for trout and other aquatic life. Figure 3 graphically illustrates this relationship for selected metals and provides the formulas for estimating safe instream levels. For example, with zinc the limit for safe instream concentrations is 180 µg/L at a hardness of 50 mg/L, while at a hardess

FIGURE 3. Approximate Hardness/metal Criteria Exceedence Relationships. The Exact Criterion to Protect Trout And Other Freshwater Life, levels that "should not be exceeded at any time" (EPA 1980), can be calculated by using the formula given for each metal.



of 150 mg/L, a zinc concentration of 450 µg/L would still be acceptable for trout. Figure 3 only presents the hardness/ metal relationships for zinc, copper and lead, the toxic metals most frequently analyzed during previous water quality evaluations of the Boulder River.

Typical of most flowing waters, the hardness values for the Boulder River and its tributaries exhibit a wide range of seasonal and spatial variation, i.e., values during runoff are typically lower than those found during summer and winter, and values found in the headwaters are normally lower than those found further downstream. To properly determine the impacts of toxic metals on trout, instream metal concentrations must be compared to calculated "safe" levels at different levels of hardness. Using the formulas in Figure 3, hardness-adjusted, "safe" instream values (in µg/L) can be calculated for each metal. When these calculated concentrations are divided into the actual instream concentrations, quotients greater than 1.00 represent "exceedences" or unsafe levels for trout and other aquatic life.

V. Toxic Metals and Fish Populations in the Boulder River

Table 1 provides a summary of toxic metal analyses for the mainstem Boulder River. Maximum and minimum metal values are reported for each station as well as the mean, or average, and median, or most common, intermediate value. In this table the most directly quantifiable measurement of impacts to the trout fishery are the columns entitled "frequency of exceedences". These columns display the percentage of samples for each metal at each station where the actual instream concentrations divided by hardness-adjusted metal concentration exceeded a value of 1.00. From this table it can be seen that metal contamination, although somewhat present throughout the drainage, increases below Cataract Creek and dramatically increases below High Ore Creek.

TABLE 1. Toxic Metals Summary - Boulder River Mainstem Stations
All Values in µg/L and reported in total recoverable form

Station/ Description	- ZINC - # Samples	Min Conc.	Max Conc.	Median	Mean	Frequency of Exceedences	- COPPER - # Samples	Min. Conc.	Max. Conc.	Median	Mean	Frequency of Exceedences	- LEAD - # Samples	Min. Conc.	Max. Conc.	Median [2]	Mean [2]	Frequency of Exceedences
1 Upper Fork 6N6W22ACC	2	<10	<10	<10	<10	0%	2	<10	<10	< 10	< 10	0%	2	< 20	< 20			0%
2 Below Bison Creek 6N6W23AAA	14	<10	50	20	20	0%	14	<10	10	10	10	14%	14	< 50	< 50			0%
3 Above Basin Creek 6N5W18DBB	4	<10	110	20	40	0%	4	<10	20	10	10	50%	4	< 20	< 20			0%
4 Above Cataract Creek 6N5W16CBB	4	60	100	70	90	0%	4	20	70	50	40	100%	4	< 50	< 50			0%
5 Below Cataract Creek 6N5W22AAA	12	90	250	130	120	25%	12	<10	90	20	30	92%	12	< 20	20			0%
6 Below High Ore Creek[1] 5N4W3CAD 6N4W32AAD	32	70	1300	250	250	88%	32	10	130	30	40	100%	32	< 20	120			22%
7 Elkhorn Br. 5N3W19BAC	14	140	490	240	280	36%	14	10	150	40	50	72%	14	< 20	100			36%
8 Quaintance Br. 4N3W12DBC	14	180	750	240	410	43%	14	10	240	30	80	79%	14	< 20	190			29%
9 Carey Ranch Br. 4N3W32BDB	14	140	1000	240	320	36%	14	<10	340	40	60	57%	14	< 20	240			21%
10 Below McKanna Spring Cr. 3N2W31AAA	14	80	720	200	290	36%	14	10	220	30	40	43%	14	< 20	120			7%
11 Elliot Ranch Br 2N3W24BBC	14	30	430	120	190	29%	14	<10	140	20	30	36%	14	< 20	70			0%

[1] Composite of two "Near Boulder" stations, includes four 1972-73 samples
[2] too many "less than" (<) values to allow accurate calculations for lead

It should be noted that three of the four stations above Cataract Creek were only sampled on four occasions, primarily during spring runoff. Metal values at other, more frequently sampled stations were found to be highest during runoff. Therefore the 100% exceedence frequency reported for station 4 in Table 1 is probably too high. Sampling frequency aside, Table 1 does imply that High Ore Creek is by far the largest source of metals to the Boulder River, particularly for zinc and lead. This observation is further confirmed by Table 2, which summarizes the metal contributions by the major tributaries of the Boulder River. It can be seen that Basin, Cataract, High Ore and Elkhorn Creeks all contribute metals to the mainstem Boulder River. Elkhorn Creek, *however, is diverted for irrigation during much of the* year, so it seldom discharges directly into the Boulder River. High Ore Creek is clearly the most contaminated tributary examined, with zinc and lead levels five to twenty times higher than those found in the other tributaries. Gardner (1977) states that the average flow of High Ore Creek is about 20% of the average flows of Cataract and Basin Creeks; even after adjusting for these flow differences, he concluded that High Ore Creek is responsible for at least half of the total metal contamination of the Boulder River.

Much of the data summarized in Table 1 was compiled from monthly water samples collected during 1975 and 1976. Data for these years was collected in a series of daily water quality "runs", whereby the researcher would begin collecting samples at the mouth of the river and systematically proceed upstream to the headwaters. Fourteen sets of samples from eight stations were collected in this manner, with each run reflecting the river-wide conditions on a given collection day. Table 3 illustrates this 1975 and 1976 data as hardness-adjusted exceedences for copper, lead and zinc. However, rather than simply reporting the frequency of exceedences as

TABLE 2. Toxic Metals Summary - Boulder River Tributaries
All Values in µg/L and reported in total recoverable form

Station/ Description	- Z I N C -					- C O P P E R -					- L E A D -				
	# Samples	Min. Conc.	Max Conc.	Median	Mean	# Samples	Min. Conc.	Max. Conc.	Median	Mean	# Samples	Min. Conc.	Max. Conc.	Median	Mean
A Red Rock Cr at mouth 6N 6W 23BAA	2	<10	<10	<10	<10	2	<10	<10	<10	<10	2	<20	<20	<20	<20
B Bison Cr Near Mouth 6N 6W 22DBB	3	<10	30	10	10	3	<10	20	10	10	3	<20	<20	<20	<20
C Basin Cr at Mouth 6N 5W 17CBB	3	110	310	200	210	3	<10	30	20	20	3	<20	<20	<20	<20
D Cataract Cr at Mouth 6N 5W 16CBB	5	250	960	540	530	5	30	230	70	90	3	<20	<20	<20	<20
E High Ore Cr at mouth 6N 5W 22AAA	7	640	5700	4200	3820	7	10	260	120	130	7	<20	8200	160	1330
F Muskrat Cr near mouth 6N 4W 34CAA	3	<10	<10	<10	<10	3	<10	100	50	30	3	<20	20	<20	<20
G Little Boulder River Near mouth 5N 4W 10DBD	3	<10	20	10	<10	3	10	20	10	10	3	<20	<20	<20	<20
H Elkhorn Cr at[1] Irrigation Diversion 5N 3W 10ACC	9	40	610	70	160	6	<10	30	10	20	6	<20	170	20	50

[1]four miles from Boulder River

was done in Table 1, Table 3 graphically displays the magnitude of these exceedences, i.e., the percentage of samples that exceeded acceptable levels for trout by 1.0-5.0, 5.0-10.0 or greater than 10.0 times the hardness-adjusted criteria. To add further insight into the degree of suitability of Boulder River stations for trout, this table also separates the "safe" levels into two categories - the percentage of samples that were less than the 1.00 criteria and the percentage of these samples in which the metal levels were calculated to be less than half, or 0.50, of the exceedence level for trout.

The number of trout per **mile** of stream length found by Vincent (1975) and Nelson (1976) have also been included in Table 3. Analysis of the data in Table 1 and Table 3 reveals significant correlation between metal contamination and the resulting fish populations. For example, at stations 6 through 9, the latter of which is over thirty miles downstream from the major mining areas, acceptable instream criteria for copper are exceeded more often than not. At stations 8 and 9, the criteria for zinc is at times exceeded by over fivefold and that for copper by over tenfold. Even considering the other categories of trout-limiting factors discussed in Sections II and III, the aforementioned data strongly suggests that trout numbers are being limited by metals.

As expected metal levels increase and fish populations drop sharply at station 6, below the confluence of High Ore Creek (Table 3). Howver, metal levels continue to increase below this station until station 11, probably because of tailings distributed in the floodplain that are resuspended during high flows. Refering again to Figure 2, it is significant to note that stations 7 though 9 define the upper and lower limits of the major depositional area (alluvial fill) for the Boulder River drainage.

TABLE 3. Number of Trout per Mile and Magnitude of Metal Criteria Exceedences for Boulder River Mainstem Stations. Numbers Reported as Percentage of Samples Within Each Range of Values per Each Metal. See Text for Further Explanation.

Station Number	- COPPER - "Safe" <0.5	0.5-1.0	1.0-5.0	5.0-10.0	>10.0	- ZINC - "Safe" <0.5	0.5-1.0	1.0-5.0	5.0-10.0	- LEAD - "Safe" <0.5	0.5-1.0	1.0-5.0	Trout/Mile
2	57	29	14	0	0	100	0	0	0	100	0	0	1135
5	8	0	59	33	0	0	75	25	0	100	0	0	635
6	0	0	64	29	7	0	14	86	0	72	21	7	185
7	0	29	50	0	21	0	64	36	0	72	0	28	232
8	7	14	44	14	21	0	57	29	14	65	7	28	—
9	14	29	29	21	7	0	64	29	7	71	0	29	275
10	21	37	14	21	7	14	50	36	0	72	21	7	216
11	57	7	29	0	7	64	7	29	0	86	14	0	1225

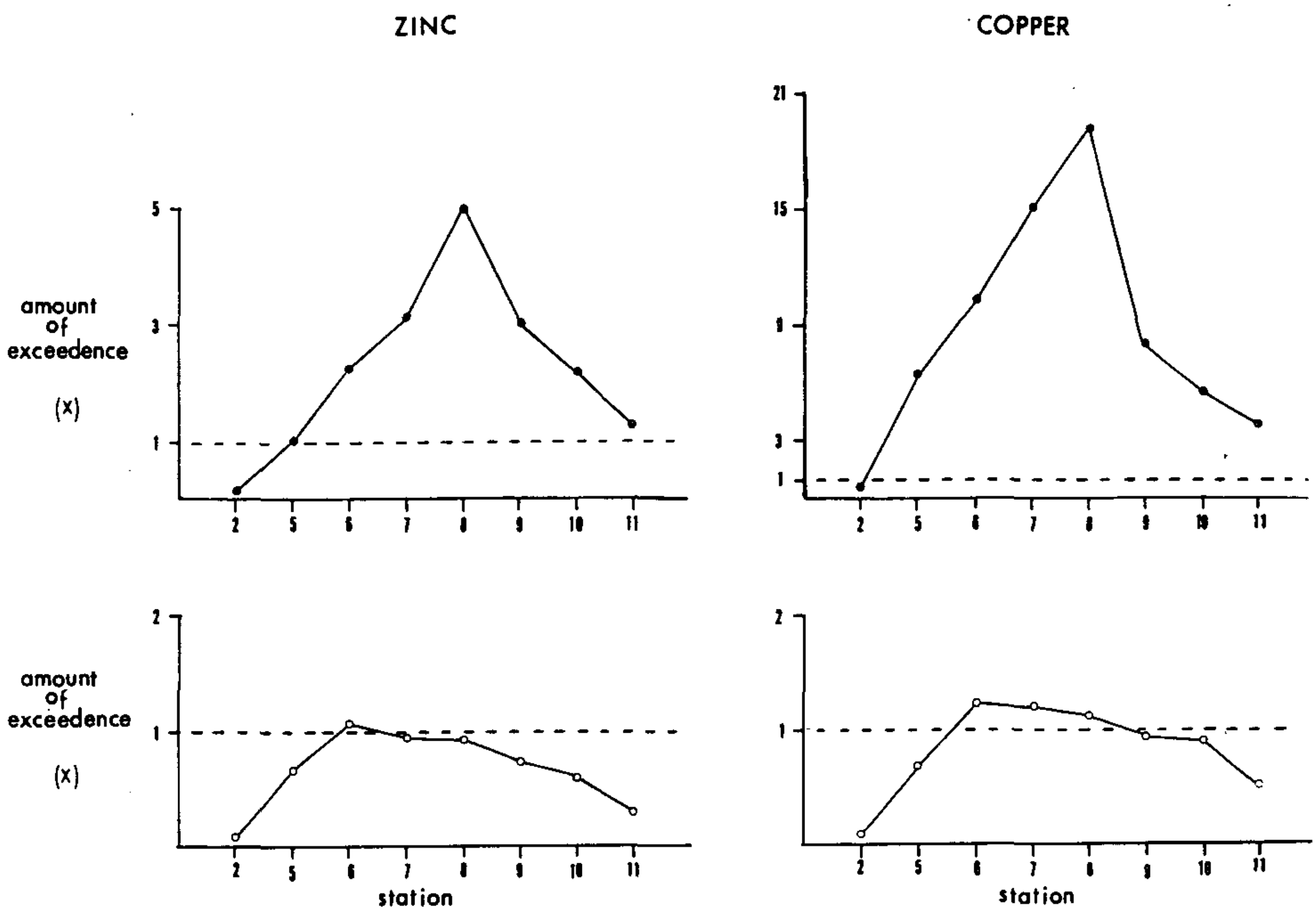
If zinc and copper exceedence levels are plotted for the winter-low flow versus spring runoff conditions that occurred during 1975 and 1976, the extent and magnitude of resuspended or "secondary" metal impacts becomes more clear (Figure 4). In order for the downstream secondary metal impacts to be so severe in 1975, primary metal contributions from the upper river drainage, and particularly from High Ore Creek, were probably greater in earlier years. This conclusion is somewhat confirmed by noting that high water conditions in 1973 caused zinc and copper exceedence values to be considerably higher at station 6 than were measured there during 1975. As well, the single lead measurement taken from High Ore Creek during the 1973 spring runoff was over ten times as high as any recorded there during 1975-1976. (WQB 1984).

VI. Characterization of Metal Contributions from Mining Sites

When hardrock mining operations are abandoned two types of metal sources typically remain - direct discharges from adits and erosion from tailings piles. The first source is characterized by low-volume seepages of acidic groundwater, laden with high concentrations of dissolved metals. Streams receiving this type of mine waste are impacted most severely at the point of entrance of the seepage. With increasing distance downstream, dilution and natural alkalinity cause the metal and acid-related impacts to dissipate. The water quality of a stream impacted by this type of mining waste is normally in its worst condition during summer and winter low flows (EPA 1977).

Streams impacted primarily by the erosion of tailings are normally in their worst condition during high flow or storm-event periods. Conversely, low flows generally bring about improvements in the stream's water quality, since such erosion is less pronounced.

FIGURE 4. Amounts of Zinc and Copper Water Quality Criteria Exceedences (EPA 1980), comparing Spring Runoff with Low-Flow Conditions. Numbers Represent Factors by which Safe Criteria levels were Exceeded. (Note difference in exceedence scales).



Runoff values (●) are averages of 6/2/75 and 6/10/75 data.

Low-Flow values (○) are averages of 12/15/75 and 1/10/76 data.

Although both seepage and erosion of tailings are actively occurring in the upper Boulder River Drainage (Pedersen 1977), the data in Figure 4 indicates that primary and secondary erosion of tailings is the dominant cause of metals contamination to the river. It is, therefore, apparent that major primary sources of mine tailings should receive the highest priority for initial reclamation. By so doing, the secondary sources of tailings will also eventually be reduced.

VII. Major Sources of Metals to the Boulder River

The above discussion of metal impacts to the Boulder River and the reports by Roby et al. (1960), Braico and Botz (1974) and Pedersen (1977) all indicate that there are generally four primary metal producing areas in the drainage: Basin Creek, Cataract Creek, tailings deposits within the Town of Basin and High Ore Creek.

Most of the mining sites in the Basin Creek Drainage are located near the headwaters of this stream. The fact that most of these potential metal producing sites are far removed from the Boulder River probably accounts for metal levels collected from the mouth of this stream being relatively low; this is true at least for 1975, when metal values from Basin Creek on any given date were lower than those found in the Boulder River proper below High Ore Creek.

There are more abandoned mining sites within the Cataract Creek Drainage than are present along Basin Creek. The Eva May and Crystal Mines are significant contributors of metals to this stream (Pedersen 1977). Most of the metal sources in the Cataract drainage appear to be related to seepage rather than erosion of tailings. Relatively high copper values were at times found at the mouth of this stream.

The abandoned mill site along the boulder River within the Town of Basin contributes significant quantities of tailings to the stream during high water and storm events. However, data that has been collected thus far does not allow for a clear differentiation between the relative impacts of the Basin tailings versus Cataract Creek.

High Ore Creek is the largest single contributor of metals to the Boulder River, particularly zinc and lead. Most, if not all, of these metals can be attributed to one source - the old Comet Mine; and although there is at least one small, year-round discharge from an abandoned adit, the Comet's massive tailings deposits approximately ten acres in size, appear to be the major contributor of both primary and secondary metal problems to the Boulder River.

This observation is supported by the fact that High Ore Creek was rated third in a recent, computerized water quality severity analysis of all Montana streams (Bahls 1984). In this analysis, a rank of one is the worst water quality; neither of the other two streams that received worse rankings are found in the Boulder River drainage.

A fish kill in the Boulder River below High Ore Creek in August 1984 also points to the severity of water quality problems originating from this tributary. Investigations determined that mine tailings, washed into the river during an intense thunderstorm, was the cause of this fish kill (Pedersen 1984). Although some of these tailings may have also come from other upstream sources, the High Ore Creek drainage was certainly a major contributor.

VIII. Initial Reclamation Recommendations for Sources of Metals to the Boulder River

A. Sources Other than High Ore Creek

Metal contributions from Basin and Cataract Creeks result from several scattered sites. More intensive water quality surveys are needed in these drainages to better delineate the relative contribution of each specific source. As an initial step, these surveys should confirm whether adit seepage or erosion of tailings is more damaging to the Boulder River. Existing data indicate that the sealing of discharging adits needs to eventually be undertaken at certain sites in the Cataract Drainage.

The tailings within the Town of Basin are more clearly in need of immediate reclamation if for no other reason than their close proximity to the Boulder River. Unlike the Basin and Cataract Creek problems, this source of metal contamination is easily locatable and clearly defined.

Partial reclamation of this site will be accomplished during construction of Interstate 15. Special provisions in the Bernice to Basin Unit 3 contract provide for up to 18,000 cubic yards of tailings to be incorporated into the highway embankment (Garrett 1984). The tailings will be sealed with a soil blanket to minimize water movement and oxidation.

Pending the outcome of discussions and litigation between the Montana Department of Health and Environmental Sciences and the Cumberland Mining Corporation, most of the remaining tailings in Basin may be moved away from the river's floodplain (Brown 1984). If both of these efforts fail to totally rectify the Basin problem, consideration should be given to spend at least a portion of the off-site mitigation funds to complete this reclamation, since the need for immediate disposal of these tailings is second only to the High Ore Creek problem.

Secondary sources of tailings, those deposited along the Boulder River below High Ore Creek, are extensive. It is beyond the scope of this review and certainly beyond the means of the mitigation funds presently provided, to suggest reclamation of vast portions of the river's floodplain. However, if any funds are still available after reclamation of the Basin tailings and the Comet Mine (discussed below), limited work on secondary tailing sources could be undertaken. As an initial step, the small tailing deposits in sections 30 and 31, T6N, R4W and Section 25, T6N, R5W, between the confluence of High Ore Creek and the Town of Boulder, should be removed or isolated.

B. High Ore Creek

Elimination of the erosion of tailings from just one site in this drainage, the Comet Mine, could potentially eliminate nearly one-half of the Boulder River's primary metal sources. In considering ways to reclaim the Comet Mine tailings, three alternatives were considered:

1. Complete Removal of the Tailings

This would involve either burying the tailings, preferably at a site far removed from surface or groundwater, or hauling the tailings to an active mill site where they could be reprocessed. The former option would require finding an environmentally suitable site, probably on public land, where impacts to other values like wildlife, forage and aesthetics would be minimal; excavation of a burial site would also be required. The latter option would require the availability of a mill willing to accept tailings that have already been worked at least once. For both of these options, considerable cost would be incurred just to transport the tailings over what would likely be a substantial distance.

2. Diversion of High Ore Creek Around the Comet Tailings

A small diversion ditch is presently in place that diverts High Ore Creek around the Comet Mine tailings. However, this ditch is not large enough to handle significant runoff or major storm flows. The size and slope of this ditch is also insufficient to prevent it from freezing during harsh winters (Braico and Botz 1974). Even suitably-sized diversion ditches, such as the one around the McLaren Mill tailings on Soda Butte Creek, are subject to seepage (U.S. EPA 1977). Total isolation of a stream from tailings can only be accomplished through the additional expense of water-tight seals like bentonite or plastic liners. Ice jams and accidental infringement by heavy equipment can damage such seals, requiring the need for periodic inspection and maintenance. Then, too, at the Comet Mine, not all of the erosion of the tailings is due to High Ore Creek alone. A considerable amount of runoff occurs from the ridge to the south of the tailings. None of this water would be intercepted by the present diversion ditch, which runs along the opposite side of the tailings. Finally, even the best surface diversion will not intercept groundwater flows, which tend to move down-slope toward the abandoned channel.

3. Sloping and Revegetating the Tailings and Reconstructing a Stream Channel through the Tailings

This third alternative appears to offer the best long-term solution to the metal contamination problem originating from the tailings. Ever since the collapse of the mill's tailings dam some 20 or 30 years ago, runoff and storm flows have carved their way through the tailings. This headcutting is simply a basic fluvial response to an elevation change below highly erodible stream materials. This "flushing" has wrecked havoc with the down-stream trout fishery, but in so doing, it has begun to delineate the vestiges of a stream channel through the tailings. What this alternative prescribes then, is to accomplish in one year what High Ore Creek would naturally accomplish in 50 to 100 years, and do so, of course, without any additional detriment to the Boulder River.

High Ore Creek has nearly cut down to its old channel elevation along most of its length through the tailings. The slope of the tailings surrounding this "channel" is very steep, almost vertical in places. The first step in this alternative would be to remove enough of these tailings to reduce their slope toward the channel to about 2:1. This could be done by conveying the excess tailings a short distance to an area below the mine's road, just to the west of the existing tailings. The topsoil from this burial site would need to be removed and then replaced after the tailings are deposited and compacted along the hillside.

The tailings that would remain along the channel would also have to be covered with topsoil and revegetated. A nearby source for this fill already exists in the form of overburden from the now-active Rumley Claim just above the Comet Mine. In fact, a portion of this operation's overburden is presently being deposited upon the Comet's tailings.

The recreated stream channel of High Ore Creek will likely need to be stabilized to prevent errant meanderings through the revegetated tailings. This can be accomplished by carefully stabilizing the inside streambends, and if necessary, by the addition of check dams, drop structures or other elevation control devices.

Finally, consideration should be made for the runoff that occurs from the hillside to the south of the tailings. Past runoff has already carved one or two small channels through this side of the tailings, perpendicular to the main flow of High Ore Creek. These channels should be stabilized to accommodate the runoff from this area.

The existing diversion around the Comet tailings is, and will remain, valuable for two purposes: First, it will divert High Ore Creek around the tailings during the actual reclamation work, allowing equipment to work "in the dry". Second, if left partially in place, it will continue to intercept runoff from the road and from areas to the north of the tailings, thus decreasing erosion while vegetation is establishing on the reclaimed area.

Implementation of the above, initial reclamation recommendations should substantially improve water quality conditions for trout, particularly in the reach of the Boulder

River between the Towns of Basin and Boulder. Increases in numbers of trout in this reach will bring corresponding increases in recreational opportunities for anglers. Access to the area is good, since most of the surrounding lands above Boulder are public. This reach is also only thirty minutes driving time from Butte and Helena. The public benefits from these initial reclamation efforts will therefore be very high.

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APPENDIX 1. FURTHER DESCRIPTION OF SECTIONS
WHERE FISH POPULATION ESTIMATES WERE CONDUCTED

Section	Approximate Location	Length (feet)	Nearest Water Quality Sampling Station
2	T6N,R6W, Sec. 24	2900	Station 2 at Upper End of Section
5	T6N,R5W, Sec. 16	2800	Station 5 about one mile downstream from end of section
6	T6N,R5W, Sec. 25	3300	Station 6 about three miles downstream from end of section
7	T5N,R3W, Sec. 19 and 29	8500	Station 7 at upper end of section
9	T3N,R2W, Sec. 8	3200	Station 9 two miles above upper end of section
10	T3N,R2W, Sec. 31	12200	Station 10 at lower end of section
11	T2N,R3W, Sec. 24	6150	Station 11 at upper end of section