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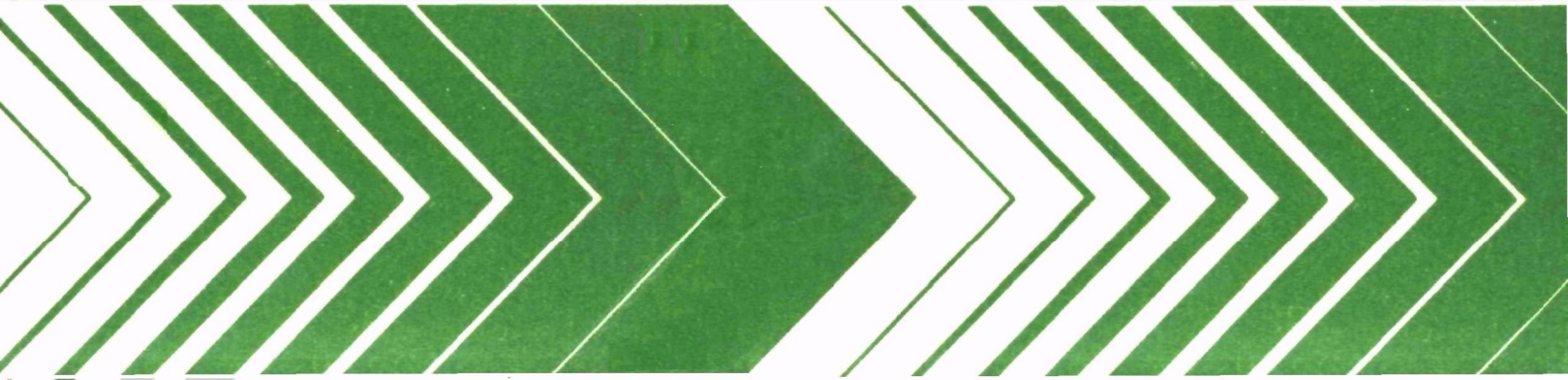
# Environmental Effects of Western Coal Combustion

## Part I
## The Fishes of Rosebud Creek, Montana



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EPA-600/3-78-098
November 1978

# ENVIRONMENTAL EFFECTS OF WESTERN COAL COMBUSTION
## Part I - The Fishes of Rosebud Creek, Montana

by

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# FOREWORD

This report describes the response of fish populations to a coal-fired, mine-mouth power plant after initial start-up. While no major adverse effects were found during the study period, additional units coming on line and the progress of time warrant follow-up surveys in subsequent years.

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## ABSTRACT

Fish populations have been studied during 1975 and 1976 in Rosebud Creek, a prairie stream which flows through the Fort Union Coal Basin in southeastern Montana. The objective of this study was to collect fish population data to determine any immediate effects, and to act as a yardstick for assessing possible future effects of accelerated activities of coal mining and coal combustion in this region.

Fishes were inventoried at nine stations and included 21 species representing nine families. The species composition and fish distribution were representative of other streams in this region. Game fishes included northern pike found throughout the stream, brook trout which occurred in the headwater areas, and sauger, walleye, channel catfish, and burbot which were found near the confluence with the Yellowstone River. The most abundant nongame species were white sucker and shorthead redhorse. Fish species diversity increased in a downstream direction, and tributaries contained many of the same fish species as in Rosebud Creek. The seasonal occurrence of reproductively mature game fishes in the lower region of Rosebud Creek suggests that it is used for spawning by fishes from the Yellowstone River.

During the study, there was no apparent effect of either coal mining or coal combustion activities on the distribution of fishes in Rosebud Creek.

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# SECTION I

## INTRODUCTION

The fish populations of Rosebud Creek (Bighorn and Rosebud Counties), Montana, were inventoried between fall 1975 and fall 1976 for species composition, distribution, and relative abundance. Observations were also made on some physical and chemical characteristics of the stream. The objective was to collect fish population data to enable assessment of possible future impacts of mine-mouth coal combustion power plants now operating in and planned for this region of Montana.

Rosebud Creek provides water for human and livestock consumption, crop irrigation, and recreation. Strip mining operations and coal combustion facilities are currently being expanded in Colstrip, Montana, near Rosebud Creek. The continued expansion of these coal-energy related activities has the potential to affect both the quality and quantity of water in Rosebud Creek.

Coal was first mined at Colstrip in 1924 by the Northwestern Improvement Company, a mining subsidiary of the Northern Pacific Railway Company. During 1924 to 1947, over 31 million tons were mined. The energy crisis in the early 70's brought renewed interest in coal and the Colstrip mines became active again. Projected production by the Western Energy Company at Colstrip for 1978 is 10.2 million tons, for 1979 it is 11.5 million tons, and for 1980 it is 14.1 million tons.

Two coal-fired power plants began operation at Colstrip in late 1975 and early 1976. Two additional coal-fired power plants are now in the planning stage. The mean winter wind direction at Colstrip is southeast toward Rosebud Creek; consequently, gases and particulates in the power plant plume are dispersed toward this Creek. Hydrologic flow patterns from the eastern portion of the coal mines at Colstrip extend in the direction of Rosebud Creek, which flows within 12 km of the mines. The Creek, therefore, may be affected by atmospheric fallout from the power plants, and also by subsurface water quality changes resulting from mining activities at Colstrip.

## SECTION II

## CONCLUSIONS

1. No immediate adverse effects on fishes in Rosebud Creek from coal combustion or coal mining activities at Colstrip were apparent. This conclusion is based on data collected immediately prior to and during the first year the Colstrip power plants were in operation.

2. Fish species diversity in Rosebud Creek increased in a downstream direction. This situation is typical of most healthy streams that originate in the mountains and flow out onto the plains, and results from gradual increases in flow, temperature, and nutrient input as the stream runs its course.

3. Game fishes occurring in Rosebud Creek included brook trout at the headwaters, northern pike at all but the uppermost stations, and walleye, sauger, burbot, and channel catfish near the mouth. Abundant nongame species included mountain sucker at the headwaters, white sucker and shorthead redhorse throughout, and flathead chub and carp in the lower reaches.

4. Tag returns from Rosebud Creek fishes and observations on similar tributaries to the Yellowstone River suggest that Rosebud Creek is utilized for spawning by certain fishes from the Yellowstone River.

5. The Rosebud Creek fishery is under-utilized, probably due to the low human population density in the area and the fact that most of the creek is surrounded by private ranches.

## SECTION III

## RECOMMENDATIONS

1. A water chemistry monitoring program should be reimplemented to detect physical or chemical changes that may occur in Rosebud Creek as a result of coal combustion or mining at Colstrip.

2. Fish distribution in Rosebud Creek should be restudied both before and after the start of operation of the two additional coal combustion power plants now being planned for construction at Colstrip, or sooner if noticeable changes occur in the characteristics of Rosebud Creek.

## SECTION IV

## DESCRIPTION OF THE AREA

Rosebud Creek is a meandering prairie stream flowing north through the Fort Union coal fields of southeastern Montana (Figure 1). From its headwaters on the eastern slopes of the Wolf Mountains, it flows about 326 km to its confluence with the Yellowstone River just upstream from the village of Rosebud. It drains an area of over 3,100 $km^2$ with an elevation drop of 530 m from source to mouth (Figure 2).

The headwaters (North and South Forks) rise within the Crow Indian Reservation. Indian Creek, Spring Creek, and Cache Creek are small, clear-flowing tributaries which enter the upper Rosebud. Its middle reaches wind through the Northern Cheyenne Indian Reservation. Muddy Creek and Lame Deer Creek are the major tributaries in this portion. Long, deep pools are common here, with riffles poorly defined. The stream broadens in the lower reaches and pool-riffle periodicity increases (with riffles more abundant). Major tributaries in this portion are Greenleaf Creek, Cow Creek, and Cottonwood Creek.

Groundwater is recharged by Rosebud Creek providing subirrigation during summer. Irrigation is limited primarily to spring flood waters, using spreader dikes. Riparian vegetation is generally undisturbed, helping hold the stream within its banks.

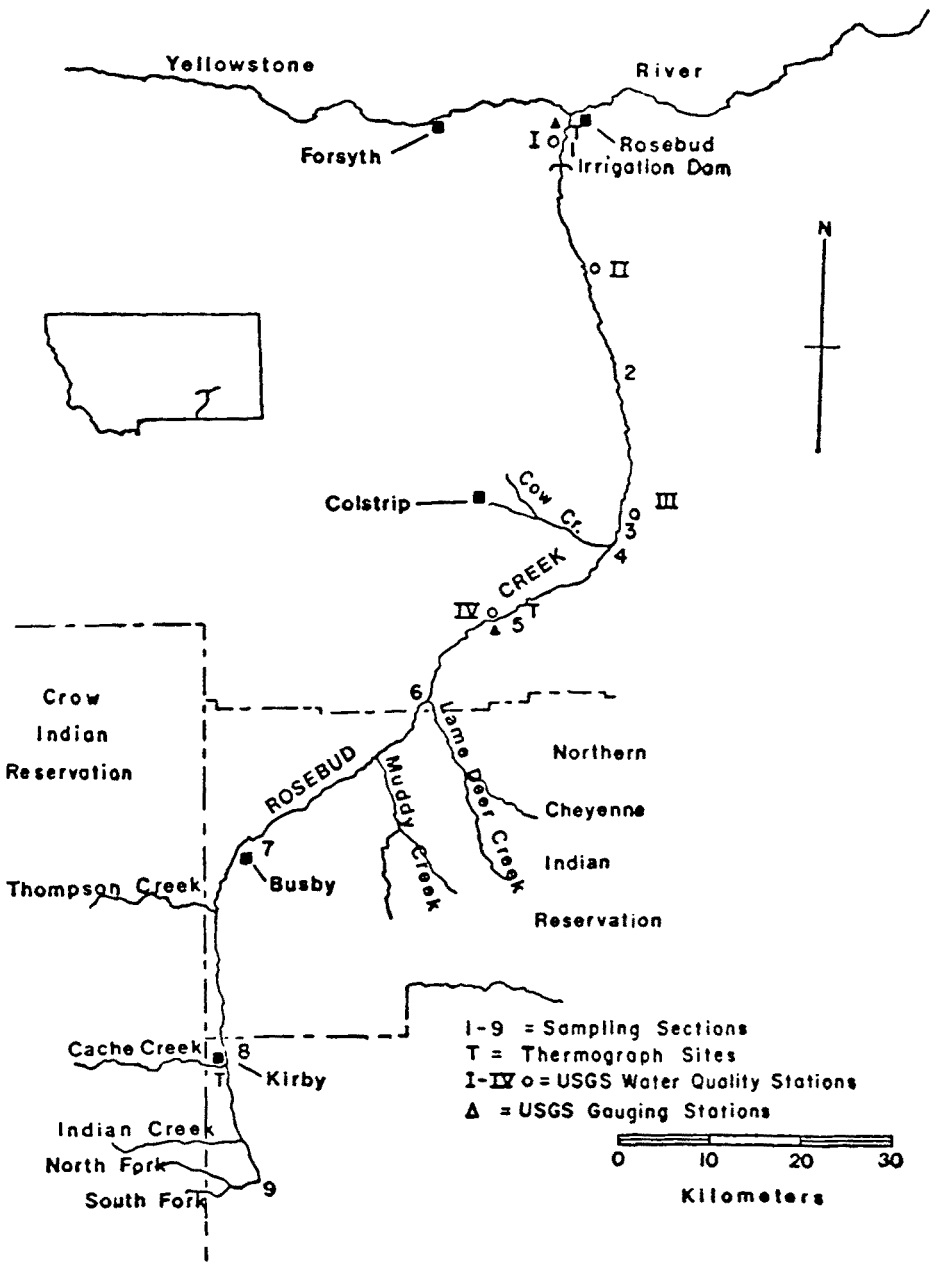


Figure 1. Map of Rosebud Creek showing sampling sections, gauging stations, and thermograph locations.

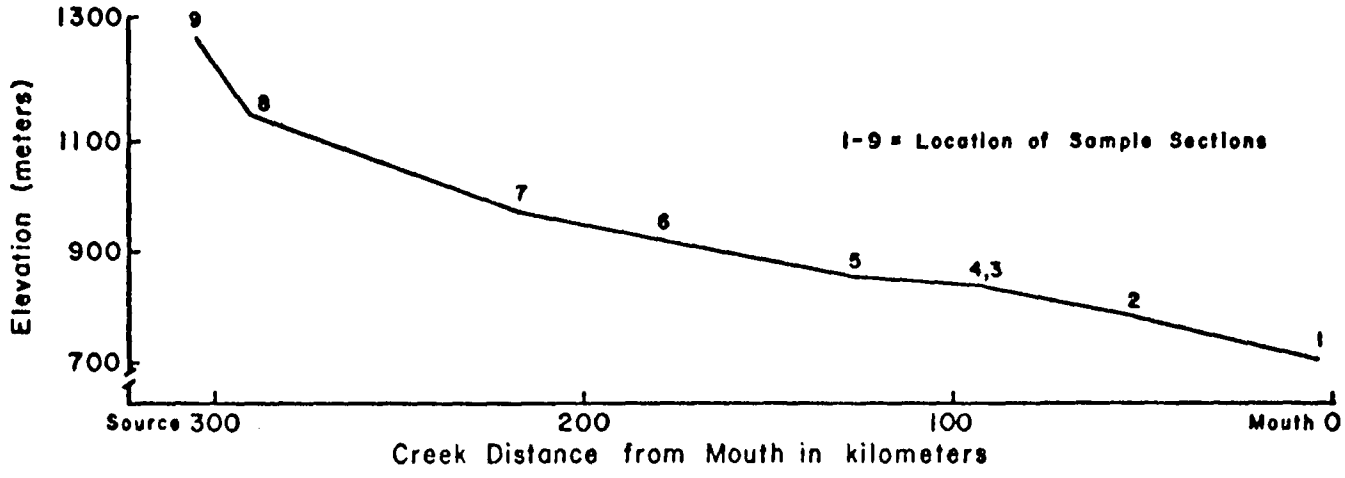


Figure 2. Longitudinal profile of Rosebud Creek.

## SECTION V

## METHODS

Physical conditions, water quality, and fish populations were determined in nine study sections. All study sections included both pool and riffle type habitats. Sections were selected partially on the basis of accessibility and sampling ease. Additional sampling was performed between primary sections to augment fish distribution data.

Surface discharge and water quality records for Rosebud Creek have been recorded by the United States Geological Survey (USGS) during selected years. Discharge was recorded by USGS continuously at two stations during 1974-1975 and 1975-1976, and water quality parameters and instantaneous discharge were measured monthly by USGS during 1974-1975 at four stations. In addition, thermographs were installed at three locations along the creek as part of this study. The positions of the thermographs and the USGS sites relative to the fish sampling stations are shown in Figure 1.

General stream morphology (Table 1) was delineated from measurements taken in the field as part of this study and from aerial photographs (Agricultural Soil Conservation and Stabilization Service photographs; scale: 12.6 cm per km) taken in 1968. U.S. Geological Survey quadrangle maps (7.5 minute series; scale: 1:2400) were used to determine general physical characteristics of the creek.

Fish sampling was primarily by electrofishing, utilizing gear with an output of 0-500 volts variable direct current, from a fiberglass boat as described by Vincent (1971). A 7.6 m × 1.2 m, 0.63 cm mesh bag seine was used to sample fish in the lower reaches of the creek. Baited box traps constructed of metal rods covered with 1.9 cm tarred nylon netting were placed along cutbanks. A temporary trap was installed near the mouth of the creek to monitor migrant fishes. The trap consisted of a wire cloth (2.54 cm mesh) stretched across the stream with a frame structure for a collecting box.

All fishes were measured to the nearest mm and weighed to the nearest gram. Floy anchor tags were employed to mark sauger, walleye, northern pike, and brook trout. A dangler tag inserted just ventral to the dorsal fin, as described by Haddix and Estes (1976), was used on channel catfish and burbot. Fin clips were used to detect tag loss or to mark nongame fishes. Pectoral spines were collected from channel catfish and were sectioned for aging as described by Marzolf (1955) and Sneed (1951). The sections were cleared with glycerin, and annuli were counted with the aid of a binocular microscope. A translucent ring was considered an annulus when it appeared distinct and continuous in all areas of the section (Marzolf, 1955).

TABLE 1. CHANNEL MEASUREMENTS IN NINE SECTIONS OF ROSEBUD CREEK, 1976

| Parameter | Section[a] 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Area (ha) | 0.71 | 0.39 | 0.31 | 0.43 | 0.53 | 0.53 | 0.40 | 0.21 | 0.03 |
| Length (m) | 926.2 | 586.4 | 595.9 | 750.4 | 842.3 | 909.4 | 820.1 | 799.1 | 213.5 |
| Average pool depth (m) | 0.74 | 0.69 | 0.63 | 0.54 | 0.58 | 0.57 | 0.62 | 0.42 | 0.36 |
| Average riffle depth (m) | 0.24 | 0.48 | 0.29 | 0.28 | 0.34 | 0.32 | 0.29 | 0.18 | 0.09 |
| Average pool width (m) | 9.00 | 8.08 | 5.37 | 5.58 | 6.41 | 5.80 | 4.00 | 2.32 | 2.01 |
| Average riffle width (m) | 6.43 | 5.34 | 5.19 | 5.80 | 6.19 | 5.80 | 5.67 | 2.85 | 1.22 |
| Sinuosity[b] | 1.68 | 1.87 | 3.28 | 2.86 | 2.70 | 2.05 | 2.55 | 2.65 | 2.13 |
| Pool-riffle periodity[c] | 6.7 | | | | 5.8 | | | 4.2 | |
| Gradient (%) | 0.14 | 0.12 | 0.09 | 0.20 | 0.10 | 0.11 | 0.11 | 0.33 | 0.56 |

[a] See Figure 1 for location.

[b] Defined as channel length divided by down valley distance.

[c] Distance between successive riffles divided by average width, expressed as average widths.

# SECTION VI

# RESULTS

## PHYSICAL AND CHEMICAL PARAMETERS

Mean and extreme monthly flows near the mouth of Rosebud Creek (Station I) during the water years 1974-1975 and 1975-1976 are summarized in Figure 3. In addition, the mean monthly flows for these two years are compared to those recorded in years 1947-1948 and 1952-1953 (Figure 4), which were considered to be representative of more "average" years. The 1974-1975 water year was characterized by exceptionally high runoff while 1975-1976 was more representative of the normal.

For a detailed account of the USGS water quality records the reader is referred to the original reports (U.S. Geological Survey, 1976, 1977). However, a general trend with respect to the water quality of Rosebud Creek as it relates to discharge changes and distance downstream should be noted (Table 2). As discharge increased there was an increase in suspended sediment concentration resulting in a corresponding increase in turbidity, especially at the lower two USGS stations. However, specific conductivity and alkalinity did not evidence any large change or trend between stations. Conductivity averaged 1123, 1245, 1163, and 1235 μmhos and alkalinity averaged 382, 377, 351, and 336 mg/liter (as $CaCO_3$) at Stations I, II, III, and IV, respectively (Table 2). Both conductivity and alkalinity tended to decrease as flow increased, presumably due to a dilution effect. The highest conductivity record was 2060 μmhos at Station I in January 1975 and the lowest was 310 μmhos at Station IV in March 1975. Alkalinity extremes were 522 mg/liter $CaCO_3$ at Station I in January 1975 and 108 at Station IV in March 1975.

Five-day average maximum and minimum temperatures for April-October 1976 are summarized in Figure 5. Temperatures at all three stations exhibited the same general trend with peaks in April, June, and July--the July peak being the yearly maximum. Temperatures declined steadily from July through October, at which time the minimum values for this time period were recorded. Maximum temperatures were: Section 8 (Kirby) 22.2°C, Section 5 (McRae) 23.3°C, and Section 1 (Harstad) 27.0°C.

Average stream depth and width increased in a downstream direction (Table 2). All of Rosebud Creek is meandering with sinuosities (channel length/down valley distance) ranging from 1.68 at the mouth to over 2 for the remainder of the creek (average 1.86).

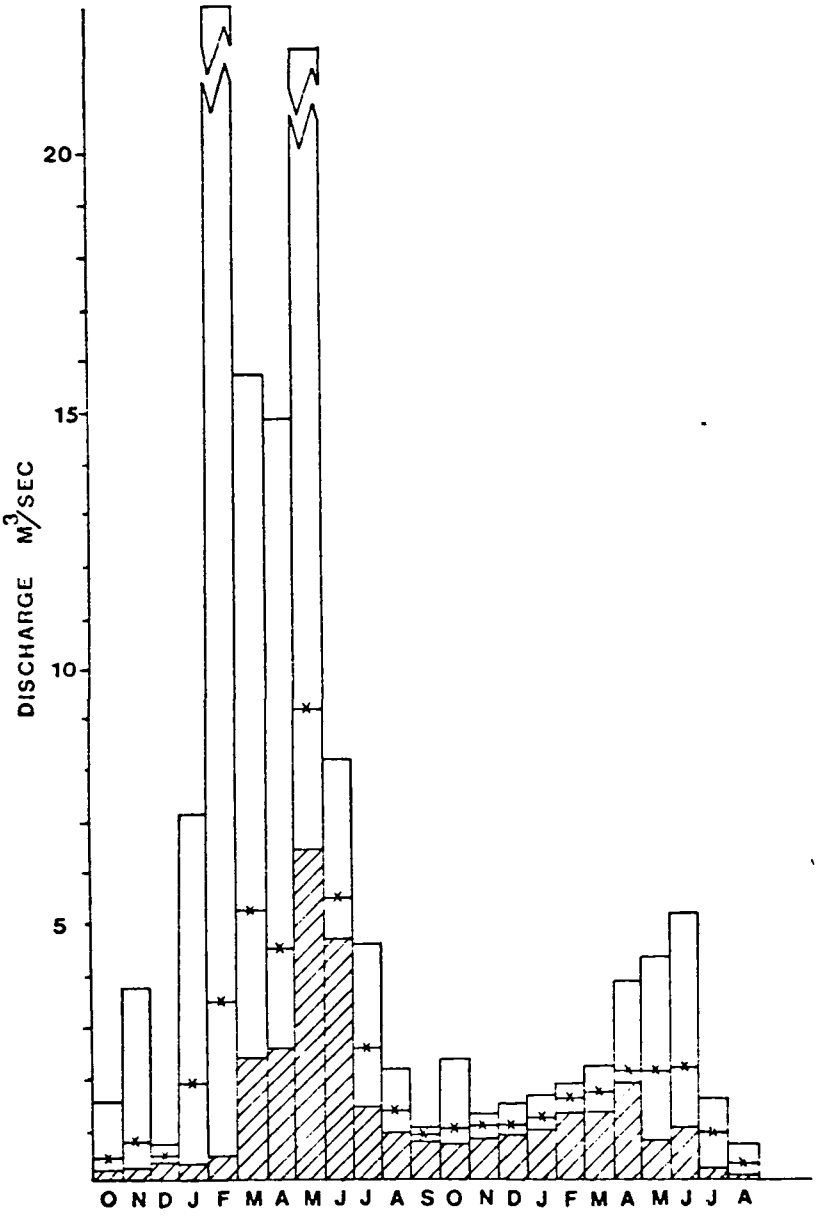


Figure 3. Discharge of Rosebud Creek near the mouth, October 1974 to August 1976.[a/] (Hatched bars are the monthly minimum; open bars are the maximum; cross lines with asterisk are the mean.)

[a/]Abstracted from U.S. Geological Survey (1976, 1977).

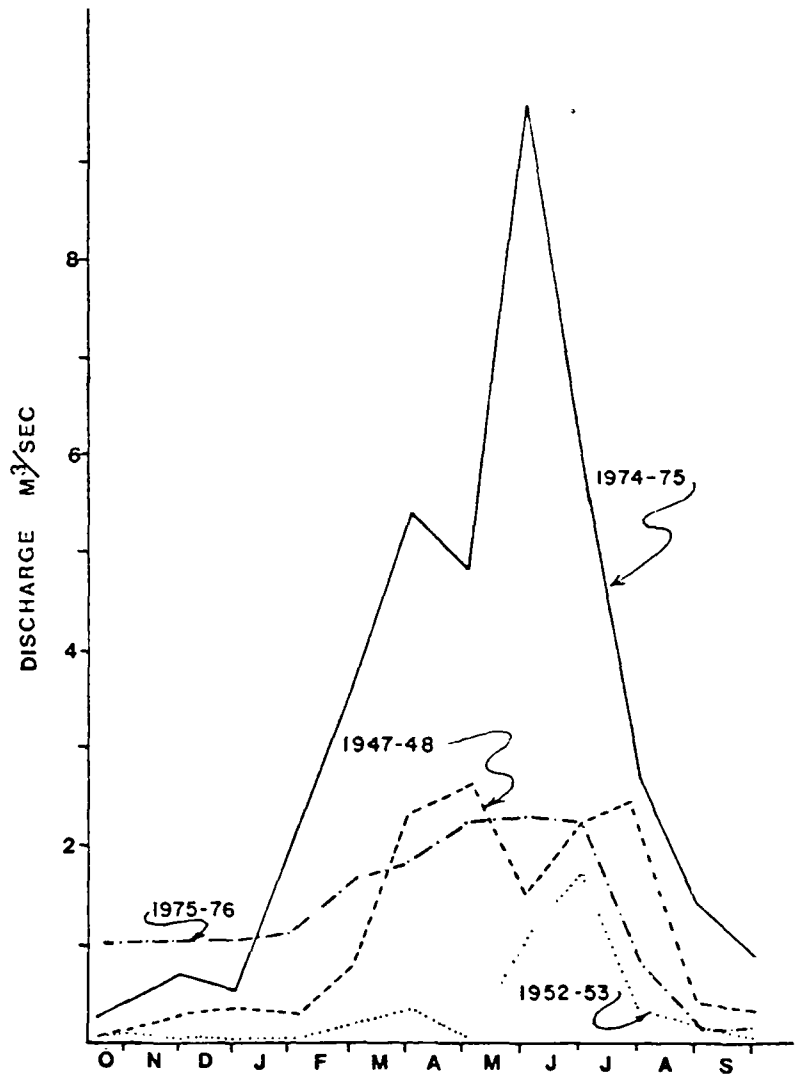


Figure 4. Average monthly flows[a/] for Rosebud Creek near its mouth for 1947-1948, 1952-1953, 1974-1975, and 1975-1976.

[a/]Abstracted from U.S. Geological Survey (1959, 1964, 1976, 1977).

TABLE 2. ROSEBUD CREEK WATER QUALITY AND DISCHARGE DATA FOR OCTOBER 1974 TO SEPTEMBER 1975[a/]

| USGS station | Parameter | 1974 Oct | 1974 Nov | 1974 Dec | 1975 Jan | 1975 Feb | 1975 Mar | 1975 Apr | 1975 May | 1975 June | 1975 July | 1975 Aug | 1975 Sept |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IV (above Cow Creek) | Instantaneous discharge (cfs) | 20 | 27 | 20 | 26 | 34 | 233 | 64 | 218 | 217 | 124 | 52 | 36 |
| | Syspended sediment (mg/ℓ) | 58 | 30 | 33 | 39 | 35 | 216 | 274 | 560 | 361 | 489 | 187 | 77 |
| | Turbidity (JTU) | 10 | 20 | 10 | 5 | 10 | 60 | 140 | 200 | 110 | 180 | 66 | 30 |
| | S.E.C. (μmhos/cm, 25°C) | 1500 | 1120 | 1750 | 1700 | 1310 | 310 | 1020 | 1000 | 945 | 905 | 930 | 980 |
| | Alkalinity (mg/ℓ $CaCO_3$) | 417 | 395 | 497 | 487 | 433 | 108 | 427 | 361 | 373 | 373 | 359 | 351 |
| III (below Cow Creek) | Instantaneous discharge (cfs) | 15 | 31 | 18 | 19 | 42 | 200 | 74 | 253 | 192 | 112 | 52 | 31 |
| | Suspended sediment (mg/ℓ) | 79 | 28 | 30 | 32 | 12 | 120 | 194 | 235 | 259 | 525 | 214 | 156 |
| | Turbidity (JTU) | 20 | 20 | 10 | 7 | 10 | 70 | 100 | 120 | 100 | 200 | 80 | 7 |
| | S.E.C. (μmhos/cm, 25°C) | 1500 | 1280 | 1600 | 1860 | 1000 | 400 | 1400 | 1900 | 990 | 950 | 1000 | 1060 |
| | Alkalinity (mg/ℓ $CaCO_3$) | 411 | 391 | 495 | 506 | 371 | 115 | 395 | 364 | 387 | 372 | 350 | 365 |
| II (above irrigation dam) | Instantaneous discharge (cfs) | 13 | 29 | 22 | 18 | 42 | 230 | 86 | 312 | 191 | 119 | 54 | 33 |
| | Suspended sediment (mg/ℓ) | 100 | 110 | 69 | 79 | 18 | 531 | 584 | 701 | 321 | 513 | 825 | 131 |
| | Turbidity (JTU) | 70 | 60 | 20 | 20 | 20 | 100 | 240 | 260 | 140 | 270 | 480 | 5 |
| | S.E.C. (μmhos/cm, 25°C) | 1450 | 1240 | 1550 | 1870 | 1060 | 350 | 1350 | 1020 | 1020 | 950 | 1030 | 1100 |
| | Alkalinity (mg/ℓ $CaCO_3$) | 406 | 377 | 476 | 505 | 254 | 114 | 346 | 317 | 390 | 365 | 335 | 326 |
| I (mouth) | Instantaneous discharge (cfs) | 13 | 26 | 19 | 15[b/]<br>113 | 45 | 247 | 107 | 916 | 195 | 119 | 48 | 31 |
| | Suspended sediment (mg/ℓ) | 1160 | 243 | 114 | 118<br>500 | 35 | 329 | 347 | 7240 | 328 | 1260 | 140 | 140 |
| | Turbidity (JTU) | 800 | 100 | 40 | 30<br>300 | 20 | 200 | 140 | 2500 | 150 | 600 | 52 | 5 |
| | S.E.C. (μmhos/cm, 25°C) | 1550 | 1320 | 1560 | 2060<br>850 | 960 | 330 | 1340 | 580 | 1040 | 960 | 1040 | 1230 |
| | Alkalinity (mg/ℓ $CaCO_3$) | 385 | 386 | 462 | 522<br>243 | 236 | 109 | 339 | 153 | 383 | 352 | 345 | 365 |

[a/] Abstracted from U.S. Geological Survey (1976).

[b/] Station I measured twice during January.

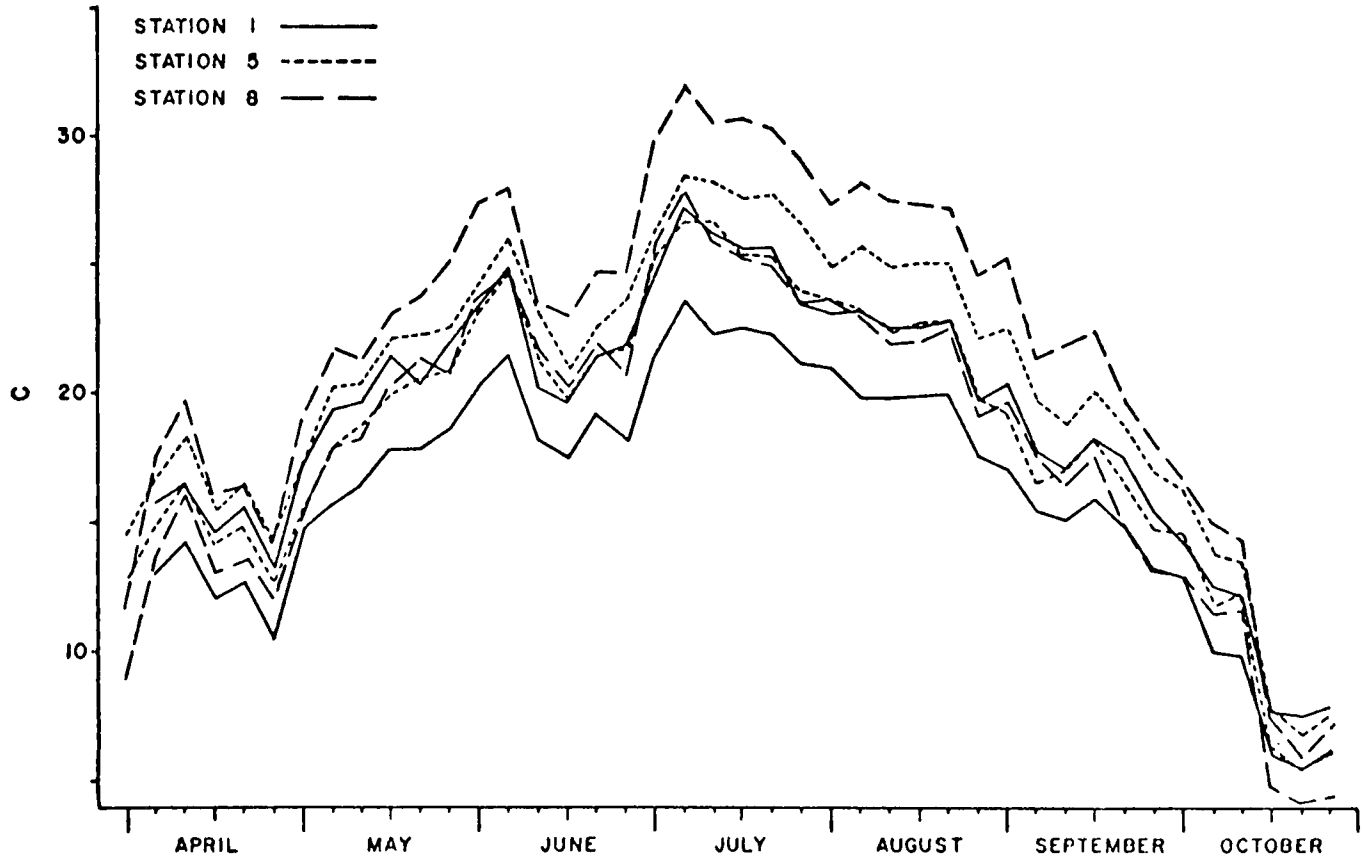


Figure 5. Maximum and minimum water temperatures (5-day averages) at Rosebud Creek; Sections 1, 5, and 8, April-October 1976.

Pool-riffle periodicity (spacing of successive riffles) was determined for Sections 1, 5, and 8 (Table 1). Gradient is steeper in the upper reaches and this is reflected by a lower pool-riffle periodicity. Riffle spacing increased from 4.2 widths near the headwaters to 6.7 widths at the mouth.

Bottom materials found in Rosebud Creek varied in different locations. Headwater areas were characterized by riffles of washed rubble and gravel, and by pools with sandy substrata. Mid-Rosebud Creek substrata consisted mainly of sand, gravel, and silt. The lowest portion of the creek was unique, having a substrate of rubble and boulder from Yellowstone alluvium caused by an increase in gradient as the creek enters the Yellowstone River valley.

## SPECIES COMPOSITION AND DISTRIBUTION

Twenty-one species of fishes representing nine families were collected from Rosebud Creek in the fall of 1975, and in the spring and fall of 1976 (Table 3). Of these, goldeye, emerald shiner, river carpsucker, black bullhead, white crappie, and walleye were collected only near the mouth.

Longitudinal distribution of the fishes is shown in Figure 6. Although grouping by sections obscures some variations, it illustrates general fish distribution. The headwater species, except brook trout, generally ranged throughout the entire stream. Fathead minnows were collected in the headwaters and at the mouth, while brook trout were collected only in the headwaters. Lake chub, longnose dace, and white sucker were present throughout. Mountain suckers were taken in all sections except Section 2, but probably range throughout the entire creek. Northern pike and shorthead redhorse were found in all sections except the headwaters.

A concrete irrigation diversion dam (2 m high) located about 6.4 km upstream from the mouth may influence fish distribution in the lower Rosebud. Ten species were found only in the area downstream from this dam. Since these fishes were collected at times other than spawning season, they were probably year-round residents of Rosebud Creek.

The five main tributaries of Rosebud Creek were sampled to evaluate fish species distribution. The flows of these streams average less than 0.054 $m^3$ per second during normal low-flow periods. Six species were found (Table 4) and their distribution was similar to that of Rosebud Creek proper. White suckers were present in all tributaries while longnose dace and lake chubs were found in all but one. Fathead minnows and brook trout were restricted to Lame Deer Creek and Cache Creek, respectively.

## RELATIVE ABUNDANCE

A summary of fall electrofishing samples for 1975 and 1976 is shown in Table 5. Flathead chubs dominated the samples in Section 1 while white suckers were slightly dominant in Sections 3, 4, and 6, and markedly dominant in Sections 8 and 9. In 1975 white suckers constituted nearly 85% of the total catch at Sections 8 and 9. Spring 1976 sample composition (Table 6)

TABLE 3. FISHES COLLECTED FROM ROSEBUD CREEK, 1975-1976

| Family | Generic name | Common name |
|---|---|---|
| Hiodontidae | *Hiodon alosoides* | Goldeye |
| Salmonidae | *Salvelinus fontinalis* | Brook trout |
| Esocidae | *Esox lucius* | Northern pike |
| Cyprinidae | *Cyprinus carpio* | Carp |
| | *Hybopsis gracilis* | Flathead chub |
| | *Couesius plumbeus* | Lake chub |
| | *Notropis atherinoides* | Emerald shiner |
| | *Pimephales promelas* | Fathead minnow |
| | *Rhinichthys cataractae* | Longnose dace |
| Castostomidae | *Carpoides carpio* | River carpsucker |
| | *Moxostoma macrolepidotum* | Shorthead redhorse |
| | *Catostomus catostomus* | Longnose sucker |
| | *Catostomus commersoni* | White sucker |
| | *Catostomus platyrhynchus* | Mountain sucker |
| Ictaluridae | *Ictalurus melas* | Black bullhead |
| | *Ictalurus punctatus* | Channel catfish |
| | *Noturus flavus* | Stonecat |
| Gadidae | *Lota lota* | Burbot |
| Centrarchidae | *Pomoxis annularis* | White crappie |
| Percidae | *Stizostedion vitreum* | Walleye |
| | *Stizostedion canadense* | Sauger |

Figure 6. Longitudinal distribution of fishes in Rosebud Creek, 1975-1976.

| Species | Sampling sections[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3,4 | 5 | 6 | 7 | 8 | 9 |
| Brook trout | | | | | | | – | |
| Fathead minnow | – | | | | | | – | |
| Mountain sucker | – | – | – | – | – | – | – | – |
| Lake chub | – | – | – | – | – | – | – | – |
| Longnose dace | – | – | – | – | – | – | – | – |
| White sucker | – | – | – | – | – | – | – | – |
| Northern pike | – | – | – | – | – | – | – | |
| Shorthead redhorse | – | – | – | – | – | – | – | |
| Flathead chub | – | – | – | – | – | – | | |
| Stonecat | – | – | – | – | – | – | | |
| Carp | – | – | – | – | – | – | | |
| Longnose sucker | – | | | | | | | |
| White crappie | – | | | | | | | |
| Emerald shiner | – | | | | | | | |
| River carpsucker | – | | | | | | | |
| Black bullhead | – | | | | | | | |
| Walleye | – | | | | | | | |
| Sauger | – | | | | | | | |
| Channel catfish | – | | | | | | | |
| Goldeye | – | | | | | | | |
| Burbot | – | | | | | | | |

[a] See Figure 1 for location.

TABLE 4. OCCURRENCE OF FISHES IN THE MAJOR TRIBUTARIES OF ROSEBUD CREEK, 1976

| Species | Lame Deer Creek | Muddy Creek | Thompson Creek | Cache Creek | Indian Creek |
|---|---|---|---|---|---|
| White sucker | * | * | * | * | * |
| Longnose dace | * | * | * | | * |
| Lake chub | * | * | * | * | |
| Mountain sucker | * | | | * | * |
| Fathead minnow | * | | | | |
| Brook trout | | | | * | |

* Denotes presence

TABLE 5. SUMMARY OF ELECTROFISHING SAMPLES FROM ROSEBUD CREEK, FALL 1975 AND 1976, EXPRESSED AS NUMBERS OF FISH COLLECTED PER KILOMETER

| | Section[a] | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | |
| Species | 1975 | 1976 | 1975[b] | 1976 | 1975 | 1976 | 1975 | 1976 | 1975 | 1976 | 1975 | 1976 | 1975 | 1976 | 1975 | 1976 | 1975 | 1976[b] |
| Goldeye | 7 | | | | | | | | | | | | | | | | | |
| Brook trout | | | | | | | | | | | | | | | 5 | | | |
| Northern pike | 1 | 3 | | 3 | 3 | 5 | 4 | 1 | 7 | 21 | 5 | 10 | 4 | 10 | 3 | 8 | | |
| Carp | 13 | 1 | | 9 | 5 | 8 | 11 | 29 | | 46 | | | | | | | | |
| Flathead chub | 279 | 17 | | 10 | 12 | 27 | 3 | 49 | 34 | | | 9 | 4 | | | | | |
| Lake chub | | 1 | | 3 | 2 | 3 | 1 | | | | 2 | 4 | | 1 | | 13 | 56 | |
| Fathead minnow | | | | | | | | | | | | | | | | | 52 | |
| Longnose dace | 9 | 1 | | | 2 | 4 | | 3 | | | 1 | 2 | 1 | 2 | | 15 | 19 | |
| Shorthead redhorse | 6 | 1 | | 3 | 7 | 14 | 8 | 25 | 14 | 3 | 15 | 90 | 17 | 2 | 15 | 8 | | |
| Longnose sucker | 3 | | | | | | | | | | | | | | | | | |
| White sucker | 12 | 2 | | 8 | 15 | 45 | 25 | 43 | 24 | 6 | 90 | 181 | 4 | 7 | 313 | 11 | 581 | |
| Mountain sucker | | | | | | | | 1 | 1 | | 6 | 4 | 1 | | 1 | 8 | 14 | |
| Channel catfish | 1 | 1 | | | | | | | | | | | | | | | | |
| Stonecat | 3 | 1 | | 4 | 2 | | | 9 | | 1 | | | | 4 | | | | |
| Burbot | 7 | 2 | | | | | | | | | | | | | | | | |
| Sauger | 10 | 10 | | | | | | | | | | | | | | | | |
| Total | 351 | 40 | | 40 | 48 | 106 | 52 | 160 | 80 | 77 | 119 | 300 | 31 | 26 | 337 | 63 | 722 | |

[a] See Figure 1 for location of sections.

[b] Not sampled.

TABLE 6. SUMMARY OF ELECTROFISHING SAMPLES FROM ROSEBUD CREEK, SPRING 1976, EXPRESSED AS NUMBERS OF FISH COLLECTED PER KILOMETER

| Species | Section | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Goldeye | 3 | | | | | | | | |
| Brook trout | | | | | | | | 3 | |
| Northern pike | 6 | 6 | 2 | 3 | 2 | 1 | 5 | | |
| Carp | 12 | 1 | 2 | | 1 | | | | |
| Flathead chub | 23 | 2 | 2 | 3 | 3 | 1 | | | |
| Lake chub | | | | | 3 | | | 10 | 37 |
| Longnose dace | 3 | | | | | 1 | | 9 | 14 |
| Shorthead redhorse | 18 | 7 | 5 | 5 | 10 | 5 | 6 | 10 | |
| Longnose sucker | 18 | | | | | | | | |
| White sucker | 5 | 11 | 2 | 13 | 15 | 18 | 1 | 262 | 234 |
| Mountain sucker | 1 | | | | 1 | | 1 | 54 | 37 |
| Black bullhead | 1 | | | | | | | | |
| Channel catfish | 3 | | | | | | | | |
| Stonecat | 7 | | | | | | | | |
| Burbot | 3 | | | | | | | | |
| Walleye | 1 | | | | | | | | |
| Sauger | 5 | | | | | | | | |
| Total | 109 | 27 | 13 | 24 | 35 | 26 | 13 | 348 | 322 |

was similar to that of the fall 1975 and 1976. Numbers of fishes collected in the fall ranged from 26 at Section 7 during 1976 to 722 at Section 9 during 1975. During spring 1976 sampling, the number of fishes sampled per section ranged from 13 at Section 3 to 348 at Section 8. Species diversity indices were calculated for the combined samples of fall 1975 and 1976 (Table 7, Figure 7). The diversity index values increased progressively downstream.

## SPORT FISHES

Six species of sport fishes were collected from Rosebud Creek. Of these, only northern pike was found distributed throughout the drainage. Brook trout was limited to the upper reaches and sauger, walleye, channel catfish, and burbot were collected only near the mouth.

These latter four species have been reported to move from the Yellowstone River to both the Powder River (Rehwinkel *et al.*, 1976) and the Tongue River (Elser and McFarland, 1977) during spawning seasons, suggesting that spawning migrations into Rosebud Creek may also occur.

### Northern Pike

Northern pike was the most abundant sport fish found in Rosebud Creek with a total of 172 from Sections 1 through 8. The greatest concentration (71 fish) was found near the mouth (Section 1). The mean lengths and weights of northern pike are shown in Table 8. The larger fish were found near the mouth, the biggest of which was 870 mm long and weighed 5.00 kg. Fish taken in Sections 3 through 6 were similar in size, as were those taken in the upper and lower reaches. Fish collected from the upper and lower sections were considerably larger than those taken from mid-sections. The best northern pike habitat generally occurred in areas where slow water was associated with brushy vegetation.

### Brook Trout

Brook trout were collected in the upper reaches of Rosebud Creek, centering around Cache Creek, a tributary near Kirby. Eight specimens were collected, with an average length of 276.6 mm (range 229 to 386 mm) and an average weight of 0.29 kg. The presence of two size groups suggests that brook trout reproduce in Rosebud Creek.

### Sauger and Walleye

A total of 29 sauger were collected. Spawning sauger were not found but two spent fish were collected during May. Only five walleye were taken, three of which were sexually mature. Walleye were larger than sauger, averaging 531.6 mm and 1.45 kg compared to 356.7 mm and 0.40 kg for sauger. Sauger ranged in age from 3 to 6 years (41.3% age 3) while walleye were 5 to

TABLE 7. FISH SPECIES DIVERSITY[a] IN ROSEBUD CREEK, 1975-1976

| Station | $\bar{d}$ [b] | d min[c] | d max[d] | R[e] | Em[f] | SR[g] |
|---|---|---|---|---|---|---|
| 1 | 3.04 | 0.69 | 4.32 | 0.308 | 0.293 | 2.75 |
| 2 | 2.76 | 0.75 | 2.99 | 0.105 | 0.451 | 2.31 |
| 3 | 2.38 | 0.51 | 2.99 | 0.250 | 0.348 | 2.03 |
| 4 | 2.44 | 0.40 | 3.17 | 0.264 | 0.326 | 2.11 |
| 5 | 2.22 | 0.36 | 3.17 | 0.338 | 0.291 | 1.93 |
| 6 | 1.48 | 0.15 | 3.00 | 0.532 | 0.166 | 1.32 |
| 7 | 2.18 | 0.39 | 3.17 | 0.353 | 0.290 | 1.90 |
| 8 | 1.64 | 0.08 | 2.81 | 0.429 | 0.167 | 1.47 |
| 9 | 1.44 | 0.13 | 2.32 | 0.400 | 0.177 | 1.27 |

[a] Wilhm and Dorris (1968)

[b] $\bar{d}$ (mean diversity) = $-\Sigma\ (N_i/N)\ \log_2\ (N_i/N)$; where $N_i$ = number of individuals in the $i^{th}$ species, and N = total number of species

[c] d min (minimum diversity) = $(1/N)\ \{\log_2 N! - \log_2[N-(S-1)]!\}$; where S = number of species

[d] d max (maximum diversity) = $(1/N)\ [\log_2 N! - S\ \log_2(N/S)!]$

[e] $R\ (\text{redundancy}) = \dfrac{d\ max - \bar{d}}{d\ max - d\ min}$

[f] $Em\ (\text{equitability}) = \bar{d}/\log_2 S$

[g] $SR\ (\text{species richness}) = \bar{d} - \bar{d}/\log_2 N$

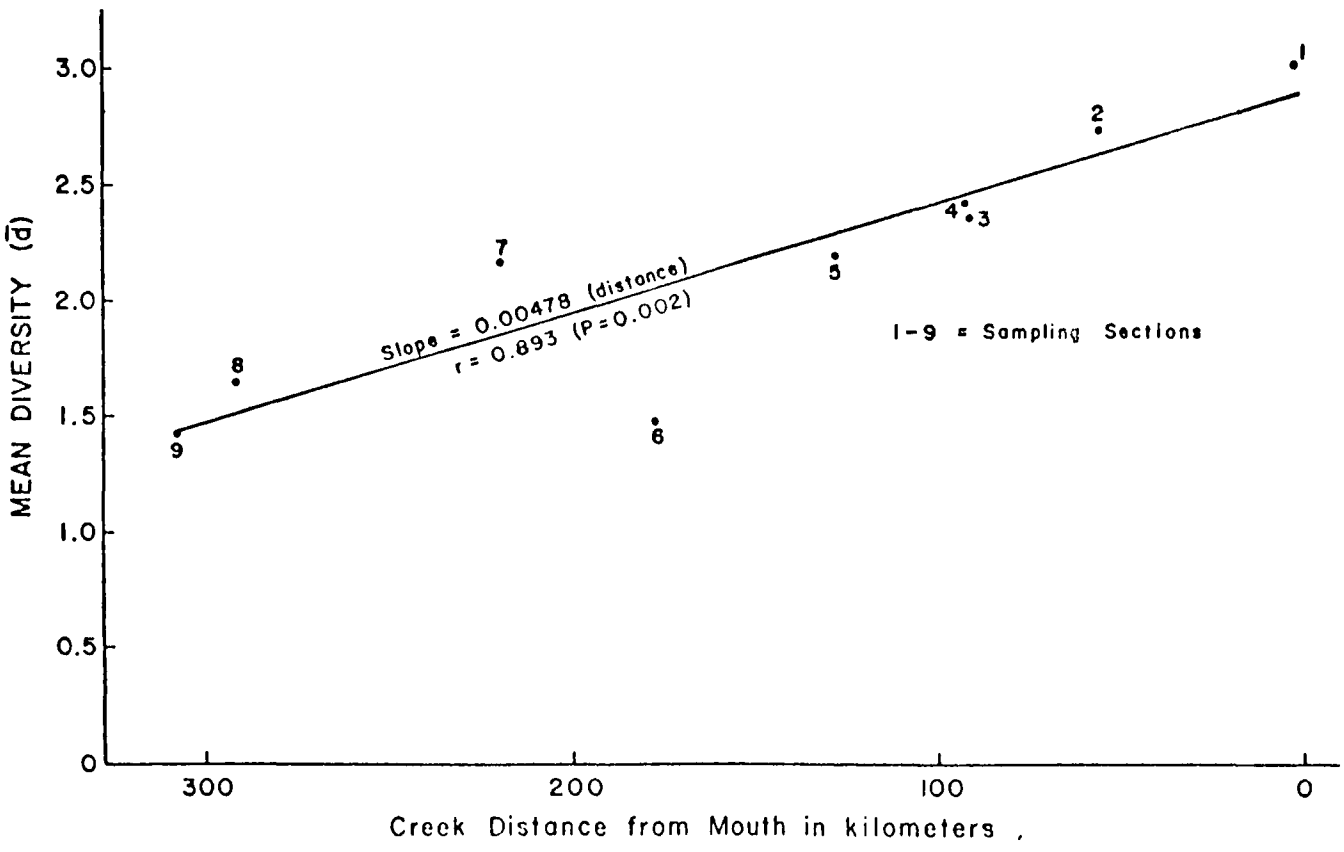


Figure 7. Fish species diversity in Rosebud Creek, fall 1975 and 1976.

TABLE 8. AVERAGE LENGTHS, WEIGHTS, AND RANGES OF NORTHERN PIKE CAPTURED IN ROSEBUD CREEK, 1975-1976

| | | Length (mm) | | Weight (kg) | |
|---|---|---|---|---|---|
| Section | No. fish | Average | Range | Average | Range |
| 1 | 71 | 444.2 | 204-870 | 1.00 | 0.04-5.00 |
| 2 | 8 | 449.7 | 222-709 | 0.83 | 0.05-2.36 |
| 3 | 6 | 271.8 | 230-305 | 0.15 | 0.06-0.27 |
| 4 | 6 | 327.9 | 241-602 | 0.27 | 0.08-1.00 |
| 5 | 27 | 253.3 | 220-410 | 0.14 | 0.06-0.46 |
| 6 | 18 | 314.6 | 193-530 | 0.25 | 0.04-0.90 |
| 7 | 28 | 441.1 | 170-832 | 0.69 | 0.03-2.80 |
| 8 | 8 | 497.7 | 423-580 | 0.91 | 0.54-1.40 |

9 years old. The lack of young fishes in the sample suggests that sauger and walleye move into Rosebud Creek from the Yellowstone River for spawning.

### Channel Catfish

A total of 60 channel catfish were collected, all in the lower portion. Channel catfish move into other tributaries of the lower Yellowstone River apparently to spawn as water temperatures approach 21°C (Rehwinkel *et al.*, 1976; Elser and McFarland, 1977). The catfish collected in the lower Rosebud were mostly large, averaging 606.7 mm. However, some small fish (181 mm) were also collected. The average weight of catfish was 2.87 kg with a range of 0.04 to 6.50 kg.

Ninety-eight percent of 51 catfish examined were older than 4 years, with a maximum of 14 years (Table 9). One fish was found to be a yearling. The predominant age group was 12 years, contributing 23.5% of the total. A majority of the fish sampled were old, with 72.5% older than 10 years. In comparison, catfish from the lower Tongue River ranged in age from 1 to 19 years, and had a more uniform age distribution. Only 43.3% were older than 10 years (Elser *et al.*, in press).

### Burbot

Burbot are common in the lower Yellowstone River drainage. Spawning is reported to occur in the winter, probably in January and February. A total of 42 burbot were collected from lower Rosebud Creek, during spring and summer 1976. These ranged from 291 to 640 mm in length, averaging 371 mm. Five male burbot were also captured in January and February 1976. Specimens collected in winter showed evidence of having recently spawned. Burbot therefore inhabit lower Rosebud Creek during all seasons.

The size classes of the 42 burbot collected in spring and summer 1976 were very similar to burbot found in the Yellowstone River. These fish probably ranged in age from 5 to 11 years (Peterman and Haddix, 1975).

## FISH TAGGING

A total of 252 game fishes were tagged in Rosebud Creek during this study (Table 10). Northern pike showed the largest number of returns, and all northern pike electrofishing returns were from the same section where originally captured. One northern pike and one sauger were caught by anglers in the Yellowstone. The northern pike was caught about 1.6 km downstream from the mouth of Rosebud Creek. It was tagged on April 7, 1976 and reported to be caught four months later on August 14. The sauger was caught upstream in the Yellowstone River below the Cartersville Diversion near Forsyth, 20.9 km from the mouth of Rosebud Creek. It was tagged on July 13, 1976 and reported to be caught 10 days later. The movement of these two fishes indicates that there is most probably passage by these two species between the Yellowstone River and lower Rosebud Creek.

TABLE 9. AVERAGE LENGTH AND RANGE PER AGE GROUP OF 51 CHANNEL CATFISH FROM ROSEBUD CREEK, 1976

| Age group | Number | Average length at capture (mm) | Range in length at capture (mm) |
|---|---|---|---|
| 1 | 1 | 109 | -- |
| 2 | -- | -- | -- |
| 3 | -- | -- | -- |
| 4 | 2 | 183 | 181-185 |
| 5 | 1 | 433 | -- |
| 6 | 2 | 484 | 432-535 |
| 7 | 3 | 503 | 425-560 |
| 8 | 2 | 570 | 540-600 |
| 9 | 5 | 603 | 546-670 |
| 10 | 9 | 571 | 490-735 |
| 11 | 7 | 638 | 530-745 |
| 12 | 12 | 654 | 628-730 |
| 13 | 7 | 680 | 540-750 |
| 14 | 2 | 738 | 730-745 |

TABLE 10. SUMMARY OF FISH TAGGING IN ROSEBUD CREEK, 1975-1976

| Species | Number tagged | Number returned | |
|---|---|---|---|
| | | Sampling | Angler |
| Northern pike | 115 | 6 | 1 |
| Channel catfish | 57 | 1 | 0 |
| Burbot | 42 | 0 | 0 |
| Sauger | 29 | 0 | 1 |
| Walleye | 5 | 1 | 0 |
| Brook trout | 4 | 1 | 0 |
| Total | 252 | 9 | 2 |

MIGRANT FISHES

A weir-trap with a lead constructed across the entire stream was installed in Section 1 to monitor fish movement between Rosebud Creek and the Yellowstone River. The trap was installed on April 6, 1976 and was fished through April 23, 1976 (excluding April 10). High water prevented use of the trap after April 23. A total of 303 fishes were captured (average 20.2 fishes per day; range 2-125). Nine species were taken in the trap and five showed signs of sexual maturity. Ripe or nearly ripe fishes made up about 90% of the total catch. A comparison of lengths, weights, and sex ratios is shown in Table 11.

Longnose suckers, which migrate in schools, were taken April 7-13, comprising 47.2% of the total trap catch. Two migration peaks were evident (Figure 8). Shorthead redhorse contributed 21.5%, and white suckers 18.8%. Catch rates for these species were similar throughout the trapping period. The vivid red color and tubercules on the caudal and anal fins of shorthead redhorse are evidence of the spawning period (Meyer, 1962).

Northern pike were sampled by electrofishing in Section 1 beginning on March 31, 1976. This species spawns in the early spring, moving into shallow weedy areas where they lay their eggs. Spawning migrations by northern pike into tributaries of lakes and streams are well known and the availability of suitable wetlands bordering these streams determines the degree of successful spawning. Nineteen northern pike were taken in the trap and 33 were collected in this reach by other techniques. The catch rate was highest during the early part of the trapping period (Figure 8). Walleye pike made up only 1.0% (3 fish) of the number of sport species taken.

Migration of fishes into Rosebud Creek appears to be temperature related. The maximum water temperature recorded was 10.6°C at the time the trap was installed. The maximum temperature recorded had increased to 13.9°C when the maximum number of fishes were captured in the trap. Spawning temperatures were similar to those reported elsewhere ranging from 12.2 to 15.0°C. Over 76% of the total catch was taken from April 6-12, 1976.

Eggs were collected in drift nets on April 11 and 14, and fry were collected in drift nets on June 8, 1976. Eggs were put into aquaria for hatching, and resulting fry were found to be suckers. It is apparent that suckers migrating out of the Yellowstone River successfully spawn in Rosebud Creek.

TABLE 11. COMPARISON OF LENGTHS, WEIGHTS, AND SEX OF FISHES CAPTURED IN A TRAP ON ROSEBUD CREEK, SECTION 1, 1976

| Species | Number | Percent | Length (mm) | | Weight (kg) | | Male | Female | Undetermined |
|---|---|---|---|---|---|---|---|---|---|
| | | | Average | Range | Average | Range | | | |
| Northern pike | 19 | 6.3 | 592 | 262-859 | 1.86 | 0.10-4.85 | 9 | 6 | 4 |
| Walleye | 3 | 1.0 | 527 | 470-622 | 1.50 | 0.95-2.62 | 1 | 2 | 0 |
| Longnose sucker | 143 | 47.2 | 403 | 328-480 | 0.83 | 0.46-1.51 | 75 | 61 | 7 |
| Shorthead redhorse | 65 | 21.5 | 435 | 330-570 | 0.98 | 0.47-1.42 | 20 | 32 | 13 |
| White sucker | 57 | 18.8 | 381 | 280-430 | 0.73 | 0.25-1.15 | 17 | 35 | 5 |
| Channel catfish | 2 | 0.6 | 611 | 546-676 | 2.34 | 1.67-3.02 | | | 2 |
| Goldeye | 3 | 0.9 | 316 | 295-330 | 0.25 | 0.19-0.30 | | | 3 |
| Carp | 2 | 0.6 | 497 | 493-500 | 1.32 | 1.29-1.34 | | | 2 |
| Flathead chub | 9 | 3.1 | 208 | 180-246 | 0.08 | 0.05-0.12 | | | 9 |
| Total | 303 | | | | | | 122 | 136 | 45 |

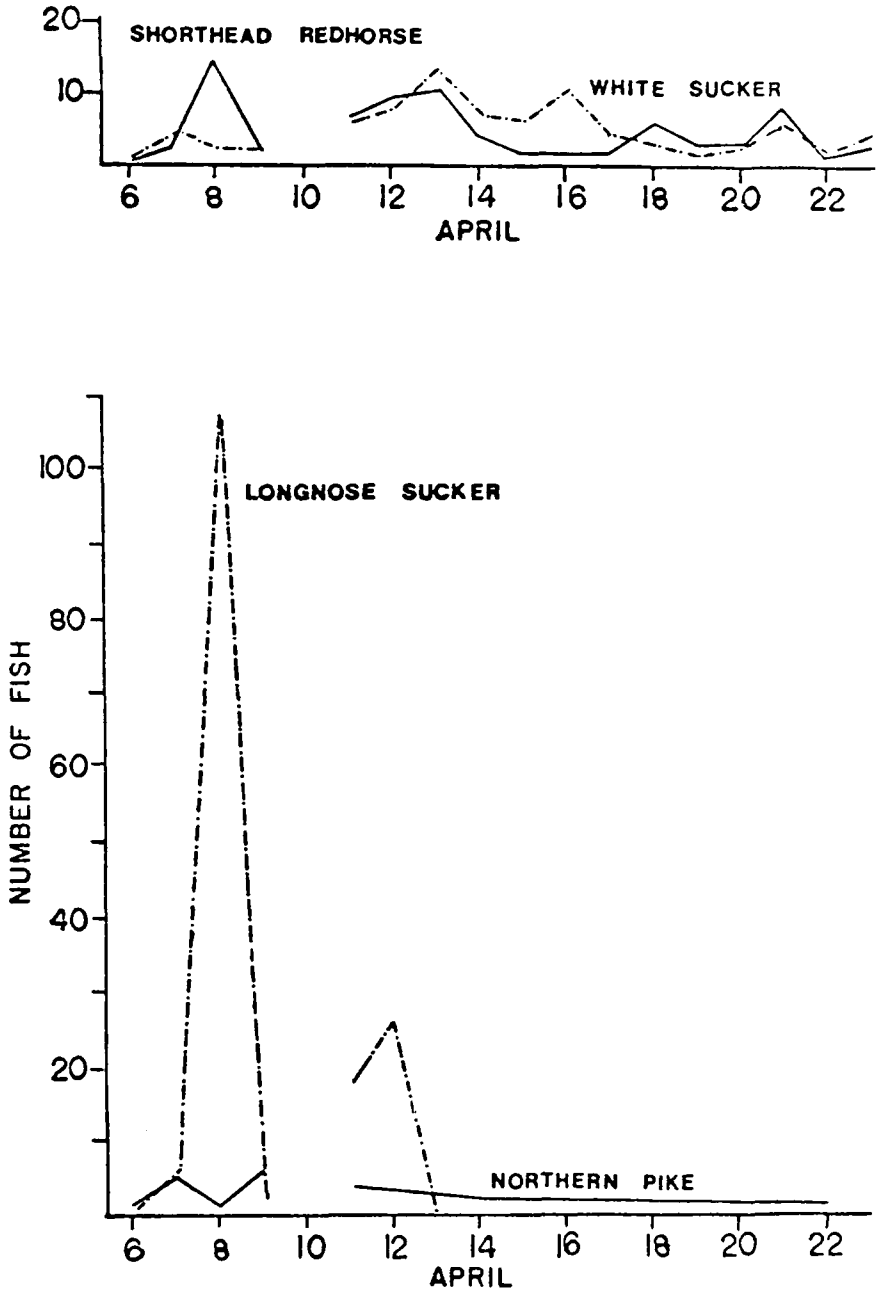


Figure 8. Daily catch of northern pike, white sucker, shorthead redhorse, and longnose suckers taken in the Rosebud Creek trap at Section 1, April 6-22, 1976.

## SECTION VII

## DISCUSSION

Flow regime, physical characteristics, chemical parameters, and stream morphology of Rosebud Creek were found to be similar to other southeastern Montana prairie streams. Runoff in Rosebud Creek is usually characterized by two high-water periods. The first occurs during late winter or early spring and represents lowland snowmelt runoff, while the second occurs in later spring and coincides with snowmelt at higher elevations. Flows for 1975 indicate a high-water year, while 1976 is considered about average.

The fishes found in Rosebud Creek and its tributaries are similar to those found in other eastern Montana streams (Elser and McFarland, 1977). In general, most species were distributed in one of three ways: i.e., found only near the mouth, present only in the headwaters, or distributed throughout. The combination of cooler water and adequate spawning substrate probably accounts for brook trout inhabiting only the headwaters. Those fishes found only in the lower Rosebud (white crappie, river carpsucker, channel catfish, etc.) were likely migrants from the Yellowstone River. Their upstream movement is most probably limited by a concrete irrigation diversion dam near the mouth of Rosebud Creek. Other species existing throughout the creek are obviously tolerant of the entire range of conditions and habitats existing there.

Diversity index values in Rosebud Creek increased in a downstream direction, a direct result of increasing numbers of fish species in the lower reaches. This trend is similar to that reported for the Tongue River (Elser *et al.*, in press).

Interstation comparisons of fish numbers were difficult to make because sampling conditions between stations varied greatly. However, for a given station, the numbers of each species sampled probably indicate their relative densities. In addition, the abundance or scarcity of certain species at a given station probably reflects the suitability of habitat for those species involved. However, samples were not taken frequently enough nor were they of adequate size to allow a completely quantitative assessment.

The low rate of angler return during the mark and recapture study indicates an under-utilized resource. This is not unexpected because human population density is very low in this area and Rosebud Creek, for the most part, flows through privately owned land.

Although observations suggest that Rosebud Creek was utilized for spawning by some fishes from the Yellowstone River, only the eggs of suckers

were actually collected. This leaves unanswered the overall importance of Rosebud Creek to the Yellowstone River fishery.

Among the primary concerns about energy development are the influences of water withdrawal, and the effects of coal mining and coal combustion processes on water quality. The data from this study show no current adverse effects on Rosebud Creek resulting from these processes; however, it should be pointed out that this study was conducted during a pre- and early-operational stage of the coal combustion facilities at Colstrip.

Information on the current fish species composition, distribution, and abundance in Rosebud Creek is important and necessary in order to detect any future changes in fish populations resulting from coal mining and energy conversion. Although no effects on Rosebud Creek of coal-energy development are apparent at the time of this study, additional studies should be planned so that any future effects can be detected, and remedial action can be taken if and where necessary to ensure the continued use of Rosebud Creek for its historic uses.

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16. ABSTRACT

Fish populations have been studied during 1975 and 1976 in Rosebud Creek, a prairie stream which flows through the Fort Union Coal Basin in southeastern Montana. The objective of this study was to collect fish population data to determine any immediate effects, and to act as a yardstick for assessing possible future effects of accelerated activities of coal mining and coal combustion in this region.

Fishes were inventoried at nine stations and included 21 species representing nine families. The species composition and fish distribution were representative of other streams in this region. Game fishes included northern pike found throughout the stream, brook trout which occurred in the headwater areas, and sauger, walleye, channel catfish, and burbot which were found near the confluence with the Yellowstone River. The most abundant nongame species were white sucker and shorthead redhorse. Fish species diversity increased in a downstream direction, and tributaries contained many of the same fish species as in Rosebud Creek. The seasonal occurrence of reproductively mature game fishes in the lower region of Rosebud Creek suggests that it is used for spawning by fishes from the Yellowstone River.

During the study, there was no apparent effect of either coal mining or coal combustion activities on the distribution of fishes in Rosebud Creek.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|
| Biological surveys | Energy development<br>Fish populations<br>Effects pollution<br>Effects of mining | 57H<br>68D |

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