CLARK FORK BASIN PROJECT

DRAFT STATUS REPORT

AND

ACTION PLAN

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LIST OF ACRONYMS

AF	Acre-feet
AMC	Anaconda Minerals Company
ARARS	Applicable and Relevant or Appropriate Requirements
ASCS	Agricultural Stabilization and Conservation Service
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
BOR	Bureau of Reclamation
BPA	Bonneville Power Administration
CDC	Centers for Disease Control
CDD	Conservation Districts Division
CDM	Camp, Dresser and McKee
CERCLA	Comprehensive Environmental Response Compensation and Liability Act of 1980
CFR	Clark Fork River
cfs	Cubic feet per second
DFWP	Montana Department of Fish, Wildlife and Parks
DHES	Montana Department of Health and Environmental Sciences
DNRC	Montana Department of Natural Resources and Conservation
DO	Dissolved Oxygen
DSL	Montana Department of State Lands
EC	Electrical Conductivity
ECC	Energy Content Curve
EE/CA	Engineering Evaluation/Cost Analysis
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EQC	Environmental Quality Council
ERA	Expedited Response Action
EWI	Equality Width Increment
FERC	Federal Energy Regulatory Commission
FIIP	Flathead Indian Irrigation Project

LIST OF ACRONYMS (CON'T)

FLCC	Firm Load Carrying Capacity
FS	Feasibility Study
GIS	Geographic Information System
gpd	Gallons per day
gpm	Gallons per minute
HRJ	House Joint Resolution
HLA	Harding Lawson Associates
IPC	Institute of Paper Chemistry
kwh	Kilowatt hour
LOEL	Lowest Observable Effect Level
MAPA	Montana Administrative Procedures Act
MBMG	Montana Bureau of Mines and Geology
MCCHD	Missoula City-County Health Department
MDA	Montana Department of Agriculture
MEPA	Montana Environmental Policy Act
MGD	Million Gallons Per Day
mg/kg	Milligrams per kilogram
mg/l	Milligrams per liter
MGWPCS	Montana Ground Water Pollution Control System
MMTC	Montana Mining and Timber Company
MOU	Memorandum of Understanding
MPC	Montana Power Company
MPDES	Montana Pollutant Discharge Elimination System
MRI	Montana Resources, Inc.
MSD	Metro Storm Drain
MSU	Montana State University
MW	Megawatt
NBMI	New Butte Mining Company
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	Nonpoint Source
NRIS	Natural Resource Information System
NWPPC	Northwest Power Planning Council

LIST OF ACRONYMS (CON'T)

O&M	Operation and Maintenance
OSM	Office of Surface Mining
PCB	Polychlorinated Biphenyl
PCP	Pentachlorophenol
PER	Preliminary Environmental Review
ppb	Parts per billion
ppm	Parts per million
PRP	Potentially Responsible Party
RC&D	Resource Conservation and Development
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RIT	Resource Indemnity Trust
RM	River Mile
ROD	Record of Decision
RP	Responsible Party
SBC	Silver Bow Creek
SCS	Soil Conservation Service
SHWB	Solid and Hazardous Waste Bureau
STARS	Streambank Tailings and Revegetation Study
SWCB	State Water Conservation Board
TSS	Total Suspended Sediment
ug/g	Micrograms per gram
ug/l	Micrograms per liter
UM	University of Montana
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VSS	Volatile Suspended Sediment
WFTS	Western Fish Toxicology Station
WQB	Water Quality Bureau
WWP	Washington Water Power Company
WWTP	Wastewater Treatment Plant

INTRODUCTION

The Clark Fork of the Columbia River had been seriously polluted even before Montana achieved statehood. Historical accounts of the early mining camps indicate the upper Clark Fork and many of its tributaries were used as sewers for mining and smelting byproducts and domestic waste. Because of its poor condition, few efforts were made to protect the river. In the 1950s, new federal water pollution control legislation required wastewater treatment. Wastewater settling ponds were installed at the headwaters, reducing the river's pollution load, and the river began its slow recovery. Now, as Montana approaches its first centennial, the Clark Fork no longer runs red with mining wastes, and trout thrive at the headwaters, but its recovery is far from complete.

New attention was focused on the basin in March 1984, when the Department of Health and Environmental Sciences (DHES) Water Quality Bureau (WQB) proposed to issue a modified wastewater discharge permit for the Champion International pulp mill located west of Missoula. In the controversy surrounding the WQB's decision, deficiencies in water quality and fisheries data were recognized.

The data deficiencies magnified the need for a basin-wide study of the Clark Fork. Diverse sources, including environmental groups, private citizens, the Montana Environmental Quality Council, and members of industry, encouraged state government to conduct a comprehensive investigation of water quality in the Clark Fork drainage. These groups urged that a study be developed to identify major water quality-related issues and problems and to provide government and local leaders with a broad range of choices for making future resource management decisions.

In April 1984, Governor Schwinden announced the initiation of a long-range comprehensive study of the Clark Fork Basin. He said, "Montanans must make responsible decisions affecting the Clark Fork Basin in the future. We need a solid base of information upon which we can act, and it is imperative we pull together the fragmented studies now underway." The Governor encouraged all groups and individuals with interests in the Clark Fork Basin to help fund and define the nature of the study. Funding for the Clark Fork Basin Project was initially provided with a grant of $200,000 from the Anaconda Minerals Company and later with funds from the state Resource Indemnity Trust Fund. Additional funds for the many individual investigations have come from a variety of public and private sources.

PROJECT ORGANIZATION AND GOALS

The Clark Fork Basin Project is a special program in the Governor's Office in Helena. The project coordinator, assisted by an environmental specialist, has worked with an Interagency Task Force to develop the goals and scope of the project. The Task Force is composed of scientists from federal and state agencies, the Montana State University System, the State of Idaho, and Regions VIII and X of the Environmental Protection Agency (EPA). A Citizens Advisory Council appointed by the Governor in 1984 has also provided assistance in identifying issues and priorities.

The Clark Fork Basin Project has provided administrative continuity to existing or planned Clark Fork studies, has identified what additional information is most urgently needed to understand the water quality and fishery problems facing the basin and--most important--has developed an action plan for the resolution of water-related resource problems within the Clark Fork Basin.

Although there are four Superfund sites in the upper Clark Fork Basin, the focus of the project has been on non-Superfund activities including many that are unrelated to hazardous wastes. However, Superfund and non-Superfund issues often overlap and must be considered jointly in water quality management and land reclamation. Important data and basic information collected by investigators throughout the basin are useful for Superfund purposes. Through coordination with all agencies, the Clark Fork Basin Project has provided a link between Superfund and non-Superfund activities and has provided technical assistance on some issues. Many of the interrelated issues are discussed in this report.

As part of the federal-state coordination effort, the Clark Fork Data Management System has been adopted to manage the vast amount of technical data that has been collected in the basin. The system is implemented through a cooperative agreement between EPA and the DHES and managed by the DHES with coordination support provided by the Clark Fork Basin Project. A Geographic Information System (GIS) component is managed by the Montana Natural Resource Information System (NRIS) located in the Montana State Library.

The data management system uses an IBM PS/2 Model 80 Personal Computer dedicated exclusively to the project. The facilities are located in the DHES office in Helena where a full-time operator is available to perform retrievals and analyses upon request of agencies and organizations associated directly with the Clark Fork Superfund sites. The system is also accessible through a PC LAN network serving the DHES-Solid and Hazardous Waste Bureau. Telecommunications equipment effects rapid data transfer and remote access.

It is intended that all data relevant to Clark Fork Superfund sites eventually will be incorporated into the data base or referenced in the data base and maintained on site in hard copy. Data will be recorded in a standard format compatible with the system. Contractors working directly with EPA and DHES on Clark Fork Superfund Projects, and who elect to adopt the Environmental Information System or a compatible system for data management, may receive routine updates of the data.

The goals of the Clark Fork Basin Project were identified and listed in a project work plan prepared in June 1985 (Johnson and Knudson 1985). The plan provided a general description of the basin's aquatic resources, a summary of environmental issues and a description of information needs. The specific objectives of the project were to 1) conduct an analysis of the quality of the Clark Fork's aquatic resources, 2) determine feasible alternatives to maintain and enhance the Clark Fork's aquatic resources, and 3) develop an action plan to maintain and enhance the quality of the Clark Fork Basin's aquatic resources.

REPORT CONTENT AND ORGANIZATION

This report describes the present status of the Clark Fork Basin and outlines actions needed to restore and maintain water resources for future needs. The report has been developed by the Clark Fork Basin Project with the assistance of ten work groups and an interagency task force.

Chapter 1 provides a brief history of the basin's development including events and activities that led to existing environmental conditions.

Chapter 2 describes current water uses in the basin including some indication of how these uses cost and benefit Montana.

Chapter 3 addresses the many environmental issues affecting the basin's water resources. Historical actions have seriously affected the Clark Fork headwaters. Emphasis is given to recent investigations and monitoring efforts designed to identify specific problems and solutions.

Chapter 4 focuses on future water uses in the basin. Special emphasis is given to water rights, water reservations and water availability questions. The chapter recognizes the conflict between water quantity and water quality and the ultimate conflicts that must be resolved.

Chapter 5 provides a distillation of the specific issues and proposes alternative actions to address these issues. The specific strategies and actions are intended to guide future management efforts.

CHAPTER 1

HISTORY AND DESCRIPTION OF THE CLARK FORK BASIN

This chapter describes the Clark Fork Basin and provides a chronology of the major activities and events that have led to current environmental conditions in the drainage.

INTRODUCTION

The Clark Fork originates at the confluence of Silver Bow and Warm Springs creeks in the Deer Lodge Valley of west central Montana (Figure 1-1). The river drains over 22,000 square miles, including nearly all of Montana west of the Continental Divide and a small part of northern Idaho. The Clark Fork flows north and west from its headwaters for about 490 river miles through a variety of terrain, including broad, semi-arid valleys, high mountain ranges, and steep-sided valleys. It terminates at Lake Pend Oreille in northern Idaho, approximately seven miles west of the Montana-Idaho border.

The drainage can be divided into 13 subbasins (Figure 1-2). With the exception of water quantity issues, the six subbasins forming the Flathead Basin above Kerr Dam are not covered in this report because Flathead Lake and its drainage basin form a distinct aquatic ecosystem. This area has been studied extensively, and the Flathead Basin Commission was established in 1983 to coordinate water quality management programs in that basin.

SURFACE WATER

The Clark Fork is often described in terms of upper, middle, and lower river segments because the character of the river and the nature of the problems differ substantially from one area to another. The upper river segment extends about 125 river miles from the headwaters to below Milltown Dam. Major tributaries that feed the river in this segment include Warm Springs Creek, Gold Creek, the Little Blackfoot River, Flint Creek, Rock Creek, and the Blackfoot River. Below the Milltown Reservoir, the average annual discharge of the Clark Fork is approximately 3,000 cubic feet per second (cfs). Streamflows in this segment are determined by weather conditions, geology, and irrigation. Most of the annual flow occurs during spring runoff, which is quite variable both in timing and volume (Casne et al. 1975).

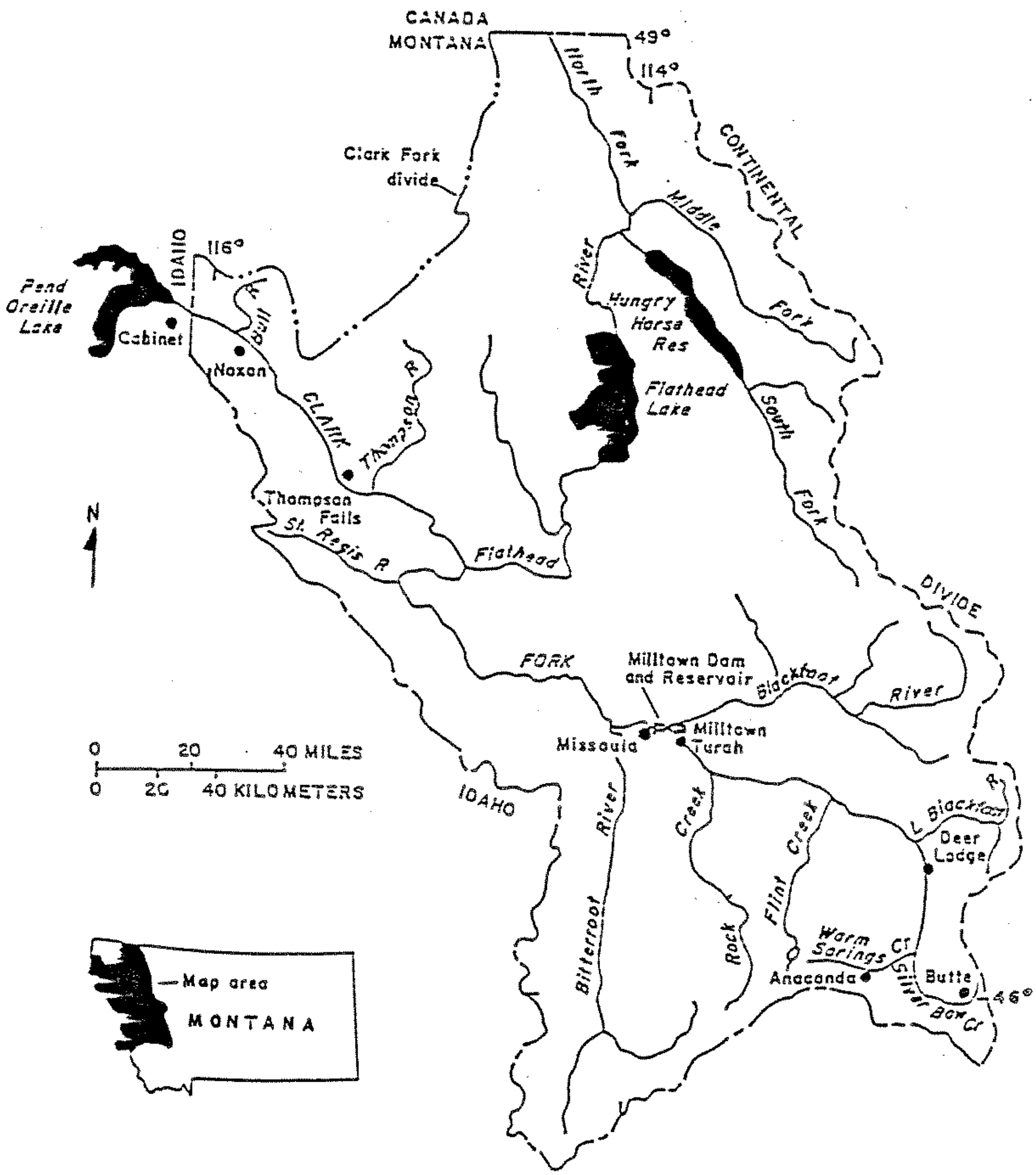

FIGURE 1-1. MAP OF THE CLARK FORK BASIN

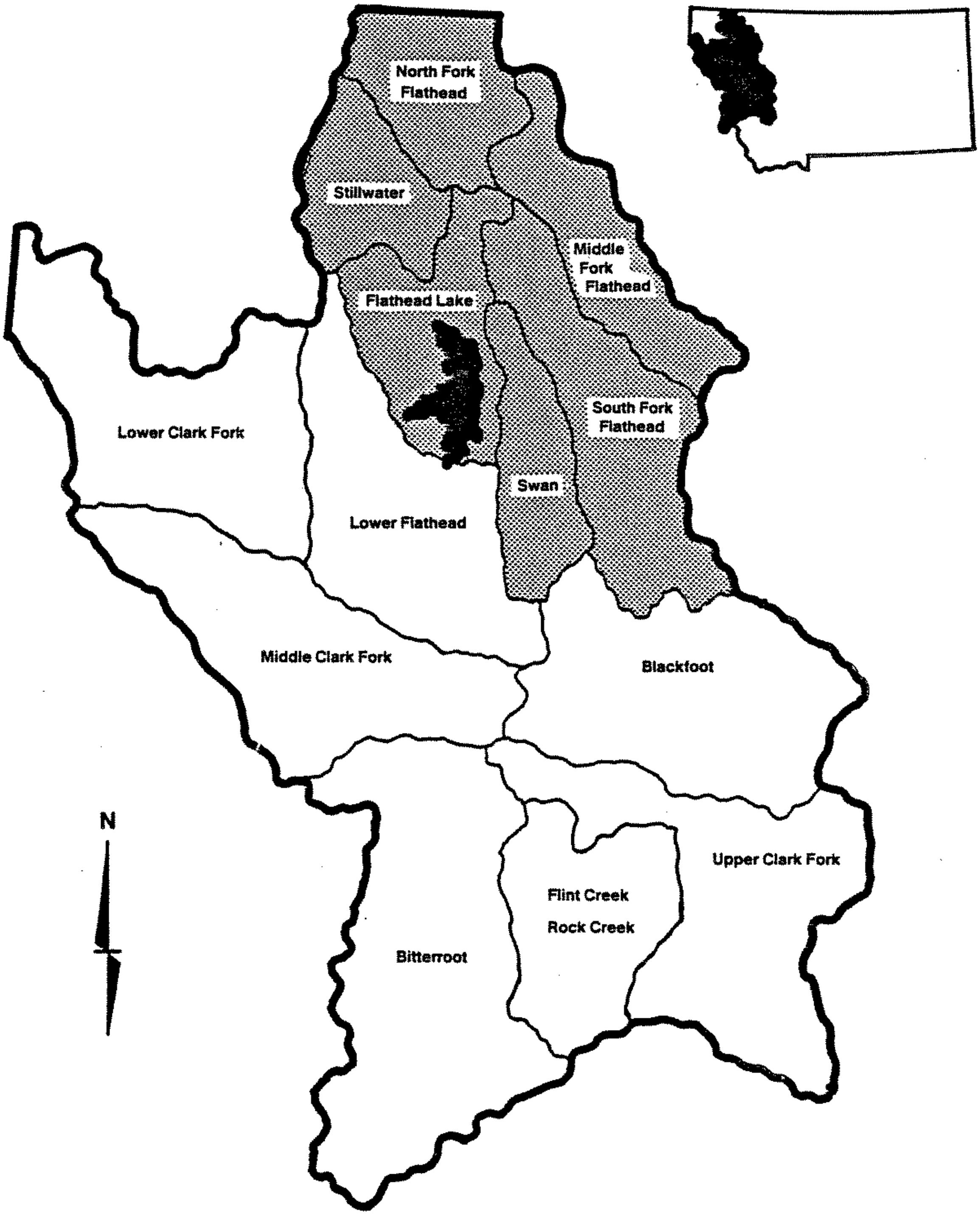

FIGURE 1-2. SUBBASINS OF THE CLARK FORK

NOTE: THE SHADED SUBBASINS WITHIN THE FLATHEAD SYSTEM ARE NOT DISCUSSED IN DETAIL IN THIS REPORT.

The Clark Fork's surface water quality classification varies within the upper river segment. From Warm Springs Creek to Cottonwood Creek (near Deer Lodge) the river is classified C-2, which means water "suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply" (DHES 1984). From Cottonwood Creek to the Little Blackfoot River, the water is classified C-1, which is similar to C-2 with the word "marginal" removed. From the Little Blackfoot River to the Milltown Dam, its classification improves to B-1, which is water suitable for C-1 uses plus drinking, culinary, and food processing purposes after conventional treatment.

Heavy metals from waste sites associated with former mining and smelting operations in the headwaters are the major water quality problem in the upper river. Although water quality has improved greatly in the past 30 years due to installation of settling ponds and treatment systems, water quality criteria for protection of aquatic life are still exceeded fairly frequently.

The middle portion of the Clark Fork extends about 115 river miles from below Milltown Dam to the confluence with the Flathead River. Major tributaries in this section include the Bitterroot, St. Regis, and Flathead rivers. Just below the confluence of the Flathead River, the Clark Fork becomes a very large river with an average annual discharge of about 20,000 cfs. Like the upper river, streamflow in the middle river is determined by weather, geology, irrigation, and to some degree the operation of Kerr Dam on the Flathead River.

The entire mainstem middle river has a water use classification of B-1. The major water quality problem in this segment is the addition of excessive nutrients from various sources.

The lower river extends from below the confluence with the Flathead to Lake Pend Oreille in Idaho. Major tributaries in this section include the Thompson, Bull, and Vermilion rivers and Rock and Prospect creeks. This segment differs greatly in that 60 of the approximately 100 miles of river are impounded by the Thompson Falls, Noxon Rapids, and Cabinet Gorge dams. When the Clark Fork reaches the Idaho border, it is Montana's largest river, with an average annual discharge of 22,380 cfs (Johnson and Knudson 1985). Streamflows in this segment are governed by weather, geology and irrigation, and to a great degree by reservoir and dam operation.

reservoirs

Waters in the lower segment are also classified B-1. Many of the water quality problems of the lower river segment stem from the flow regime of the reservoirs.

Water quality problems in all sections of the Clark Fork and in the tributaries are discussed in detail in Chapter 3.

GROUND WATER

Information on ground water is limited in some parts of the Clark Fork Basin. However, in many areas, it is widely available and represents a valuable resource. Ground water is used mainly for domestic purposes and to a lesser extent for livestock, irrigation, public, and municipal and industrial purposes (Casne et al. 1975).

In the Deer Lodge Valley (headwaters to Garrison), the majority of ground water occurs in pore spaces between grains of Quaternary and Tertiary sediments, with a smaller amount occurring in fractured bedrock. Generally, water in the Quaternary rocks is unconfined, while water in Tertiary sediments is confined. The water table is only about 5-10 feet below the surface in the floodplain alluvium adjacent to the Clark Fork, whereas it may be from 10-150 feet below the surface in alluvial fans and terraces (Konizeski et al. 1968).

The ground water resources in the Deer Lodge Valley are recharged by precipitation and snowmelt runoff, infiltrating irrigation water, and influent tributary streams. Normally, the Clark Fork is an effluent stream, although during runoff, it usually rises high enough to provide some temporary recharge to the ground water system. Ground water discharge from the Deer Lodge Valley occurs via evapotranspiration; effluent seepage into streams, springs, seeps, and drains; and pumping from wells (Konizeski et al. 1968).

In the Missoula Valley (Missoula to Huson), the geology generally consists of a bottommost layer of Precambrian metasediments; a middle, thick (about 2,000 feet) layer of Tertiary sediments; and a thin (less than 200 feet) layer of Tertiary to Quaternary coarse sand and gravel that is exposed at the surface on the valley floor.

Although all three are water-bearing formations, the upper layer (called the Missoula Aquifer) is by far the most productive and is the major source of ground water in the valley (Missoula City-County Health Department 1987).

The Missoula area depends heavily on the Missoula Aquifer for its water. The sole source of drinking water for Missoula Valley residents, the aquifer also supplies two

refers to what

municipal water systems, many small community water systems, several large industrial users, and private well owners. Stone Container Corporation's pulp mill is the largest individual water user in the area, with a pumping rate of 24.5 million gallons per day from 12 large wells. Other sources of discharge from the aquifer include evapotranspiration and base flow to the stream (Missoula City-County Health Department 1987).

Sources of recharge to the Missoula Aquifer calculated by the Missoula City County Health Department are: 50 percent from influent streams (of which the Clark Fork provides 46 percent), 24 percent from lateral flow from adjacent sediments, and smaller amounts from precipitation, urban storm water runoff, and septic system drain fields. The Clark Fork is influent for approximately three miles of the aquifer.

MINING

Gold was discovered in the upper Clark Fork drainage in the early 1850s, although it was not developed until the early 1860s. The most successful diggings were located at Gold Creek, Butte, the Little Blackfoot River, and Bearmouth. Although placer operations in the upper Clark Fork were never major producers, these activities led to the discovery of the silver and copper veins that shaped the later history of this region (Horstman 1984).

As placer operations expanded, the demand for water to work the diggings increased, leading to the organization of independent water companies. Flumes and ditch systems were constructed, and a water rights system was established. Eventually, gold miners turned to hydraulic mining, washing away entire stream banks and beds with high pressure hoses (Horstman 1984). Although this method was quite effective, it had the unfortunate consequences of destroying the structural integrity of the streams and placing large amounts of tailings into circulation. Invariably, these tailings were drained into the nearest major watercourse, which, in many cases, was Silver Bow Creek or the Clark Fork. Thus began over a century of environmental degradation from which the drainage is still struggling to recover.

The easily mined placer deposits in the upper Clark Fork were depleted by the 1870s. Some attempts were made to develop silver deposits in the area, but with limited success. However, with the advent of rail service in Montana in the early 1880s, silver mining boomed, particularly in the Philipsburg district and in Butte. The boom peaked in 1890 but suddenly crashed in 1892 when the Sherman Silver Purchase Act was repealed. Mine tailings and smelter slag were left behind along the streams of the upper Clark Fork (Horstman 1984).

In nearby Butte, copper had become the commodity of interest. The Butte silver mines had yielded rich copper deposits, but copper did not become valuable until electric lights and the telephone were invented and rail service was available. By 1882, copper mining was booming in Butte, and the industry soon outgrew the available water supply. In 1884, Marcus Daly built a smelter and reduction facility (Upper Old Works) along Warm Springs Creek near present day Anaconda, adding an additional smelter (Lower Old Works) in 1887. William Clark constructed a reduction works on Silver Bow Creek in 1886 (Horstman 1984). And so the volume of waste reaching the Clark Fork escalated, consisting of not only mine and smelter by-products, but also wastes from timber treatment plants, meat packing plants, and raw sewage from the towns that grew with the industry.

In Anaconda, copper ore processing activities quickly outstripped the capacity of the Old Works smelting facilities. The Washoe Smelter was built across the valley and became operational in 1902, and the Old Works were shut down in 1903. In the following years, smelter activities expanded, including the construction of a 585-foot stack (1919); operation of an arsenic recovery plant, a sulfuric acid plant, a beryllium processing plant, and an arbiter plant (a short-lived plant that utilized a hydrometallurgical refining process); and various improvements to reduce fugitive gas and particulate emissions. Operations at the Washoe Smelter ceased in 1980, and the complex was demolished between 1982 and 1985. A multitude of wastes, including slag piles, flue dust piles, tailings, and the Anaconda and Opportunity tailings pond systems which cover nearly 4,000 acres, were left behind. In 1983, the Anaconda Smelter site was placed on the EPA's National Priority List, and Superfund remedial investigations began in late 1984. These activities are on-going and are addressed in more detail in Chapter 3.

In Butte, milling and smelting activities continued until about 1910, by which time the Anaconda Copper Mining Co. had purchased and shut down all the major concentrators and smelters in the area except the Pittsmont Smelter (which operated until 1930) (MultiTech 1987a). Thereafter, nearly all the ore was shipped to Anaconda for milling and processing, and Butte became known mainly as a mining center (Tetra Tech 1986a). The numerous underground mines in the Butte area (estimates range from about 50 to over 400) were either closed down or purchased by the Anaconda Copper Mining Co. (which became the Anaconda Company in 1955) between 1917 and the mid 1970s. The company started the Berkeley open-pit copper mine in 1955, and they built the Weed Concentrator in

1964 to mill and concentrate ore from the Berkeley Pit and the underground mines still operating in the area. These concentrates were then shipped to Anaconda for smelting. The company shut down all underground operations in 1976, and production at the Berkeley Pit ceased in 1982. Operations ceased entirely in 1983 when the East Berkeley Extension Pit was closed. Some of the company's (re-named Anaconda Minerals Company [AMC] in 1977) Butte properties were purchased by Montana Resources, Inc. (MRI), in 1985, and MRI resumed mining and milling in 1986 (MultiTech 1987a).

In 1983, the EPA placed Silver Bow Creek and contiguous portions of the upper Clark Fork on the National Priorities List as a high-priority Superfund site. Remedial investigation studies for the site were initiated in late 1984 and are on-going. In 1986, the Silver Bow Creek Superfund site boundary was officially extended to include the stretch of river between the Warm Springs Ponds and Milltown Dam and the city of Butte. Superfund activities in the basin are discussed in more detail in Chapter 3.

FORESTRY

The mines and smelters at Butte, Anaconda, and Philipsburg, and the Northern Pacific Railroad created a large demand for lumber. In the upper Clark Fork region, much of the activity took place on the Blackfoot River, where logs were floated down to sawmills on the Clark Fork. By the late 1880s, the timber stands closest to the mills were depleted, and logging operations were extended farther upstream. Eventually, the Anaconda Company entered the lumber industry directly to satisfy its timber needs. Most of the Anaconda Company's logging took place in the Bitterroot, Blackfoot, Little Blackfoot, and Mill Creek drainages (Horstman 1984).

Since the early lumbering days, the forest and wood products industry has expanded to become the economic backbone of western Montana. Major lumber companies, such as Champion International and Plum Creek Timber, have extensive private land holdings in the Clark Fork Basin and also utilize timber from state and national forest lands. Plywood manufacturing plants, pole plants, and pulp and paper mills are important employers in the basin.

The wood products industry has experienced extremes in market conditions during the past decade. Major fluctuations have occurred due to changes in the housing and construction industries, foreign market prices, mechanization, and timber supplies (Keegan and Polzin 1987). Despite the changes, the forest and wood products industry remains strong with near-record production and sales in 1986.

AGRICULTURE AND RANCHING

The first permanent white settlement in Montana was in the Bitterroot Valley in 1840 (USDA 1977). In the upper Clark Fork region, gold boom days of the early 1860s created a market for agricultural products. By 1879, hay and grain crops were well established in the Deer Lodge and Flint Creek valleys. The potatoes and other vegetables that grew there supplemented produce from the Bitterroot Valley. Although farmers in the 1870s and early 1880s were geared toward local markets, commercial agriculture arrived in the Deer Lodge Valley in the later 1880s. By the 1890s, this area was quite progressive in its farming practices. Irrigation played an important role in agriculture beginning in the late 19th century, and mechanized farming appeared in the 1930s (Horstman 1984).

The U.S. Dept. of Commerce (1982) reported 1,828,350 acres of rangeland and pastureland (excluding pastured woodland) for Silver Bow, Deer Lodge, Powell, Granite, Missoula, Sanders, Mineral, Lake and Ravalli counties in 1982. Precise figures for current irrigated acreage in the Clark Fork Basin are not available. The Montana Department of Agriculture (1987) reported that agricultural land use in those same counties in 1986 consisted of 226,910 acres of irrigated cropland and 52,800 acres of nonirrigated cropland. However, the irrigated cropland figure does not include irrigated pasture, therefore, it is probably on the low side. The Montana Department of Natural Resources and Conservation (DNRC) (1986) estimated that approximately 411,000 acres were irrigated in 1980 in the seven Clark Fork subbasins. However, this figure reflects conditions during the peak of irrigation development in the early and middle 1970s, and likely overestimates current conditions.

Cattle ranching in the upper Clark Fork drainage started in the late 1850s when several enterprising men began rounding up stray animals that were abandoned by settlers on the Oregon Trail. They wintered the trail-worn cattle in the Beaverhead and Deer Lodge valleys, then herded them back to the Oregon Trail in the spring, where they traded one fresh animal for two trail-weary ones. Sizeable herds were built up in this manner, and other stockmen moved into the area in the late 1850s. Hundreds of cows grazed in the upper Clark Fork valleys by the mid-1860s. By the early 1870s, the mountain valley ranges became overcrowded and overgrazed, and there was increasing competition from dairymen and farmers. Although the Deer Lodge Valley continued to support substantial herds, many stockmen began moving their herds north and east onto the plains (Horstman 1984).

In subsequent years, the cattle industry endured various setbacks, including loss of livestock attributed to pasturelands contaminated by Anaconda Smelter emissions, severe droughts, hard winters, overgrazing, and depressed markets. However, cattle production is still the major focus of agriculture in the basin today. Although the number of ranches and number of persons employed in agriculture have steadily declined in the last few decades, the size of farms and ranches and their productivity have generally increased.

A sheep industry was also present in the upper Clark Fork region, beginning in the early days of the mining camps. There were more than 5,000 sheep in Deer Lodge County by 1875. Operations expanded in the 1890s, and by the 1950s, Deer Lodge was the Rambouillet sheep capital of the world. However, large scale sheep operations ceased after the mid-1950s when Australian wool producers began to dominate the markets (Horstman 1984).

HYDROPOWER

The first hydropower development in the basin was at the Blackfoot Milling and Manufacturing sawmill at Bonner. Built in 1885, the low timber dam provided power for electric lighting at the mill and later provided additional electricity to the Missoula power system around 1890-95. The Milltown Dam, or Bonner Development, completed in 1906-07, was an outgrowth of this earlier power system (Horstman 1984).

When the Milltown Dam was completed, its generating capacity was 2,400 kilowatts. In 1926, a fifth unit of 640-kilowatt capacity was added to make a total plant capacity of 3,040 kilowatts. Repairs were made to the dam system following a major flood in 1908, and additional modifications were made in 1920. The Montana Power Company (MPC) purchased the dam, power plant, and water rights in 1929 (Horstman 1984).

The original Flint Creek development on Flint Creek, eight miles south of Philipsburg, was started in 1890 by the Flint Creek Electric Power Company but was never completed. In 1899, the Granite-Bimetallic Consolidated, a local silver mining company, established a subsidiary, the Montana Water, Electric Power and Mining Company, which completed construction of the dam, flume, and powerhouse in 1890. The plant began full-time operation in 1901. Around 1906, the Amalgamated Copper Company took over the Flint Creek dam and power plant. The Anaconda Copper Mining Company (successor to the Amalgamated Copper Company, which disbanded in 1915) eventually carried out some major alterations at Flint Creek. They raised the dam five feet in 1919 by constructing a concrete cap along the crest of the masonry dam. The added height allowed the structure to impound floodwaters in Georgetown Lake that were usually lost over the spillway. This additional water was piped to the smelter in Anaconda.

The Montana Power Company acquired the Flint Creek project in 1935. The dam has a generating capacity of 1,100 kilowatts and Georgetown Lake has a capacity of 31,000 acre-feet.

MPC currently owns Kerr Dam, located on the lower Flathead River about four miles southwest of Polson. The dam, built in 1938, is a "peaking power" facility, which results in wide fluctuations in discharge rates. Total generating capacity is 168,000 kilowatts.

The Thompson Falls, Noxon Rapids, and Cabinet Gorge dams impound the lower 60 miles of the Clark Fork in Montana. The Thompson Falls Dam was built between 1913 and 1917 and is currently owned and operated by MPC. Its total generating capacity is 30,000 kilowatts. The Cabinet Gorge Dam, built in 1952, and the Noxon Rapids Dam, built in 1959, are owned and operated by the Washington Water Power Company (WWP). Maximum net generating capabilities are 554 megawatts and 230 megawatts, respectively. The Thompson Falls and Cabinet Gorge reservoirs are run-of-the-river impoundments, while Noxon Rapids has limited storage capacity.

WATER RIGHTS

Congress perceived that the west could only be settled if its water resources were developed. Water management in the 19th and early 20th centuries was guided by the goal of reclaiming the west. Without irrigation, few crops could be grown to provide the food necessary to support extensive settlements. In addition to being a mode of transport, water was also central to the mining activities that first drew large numbers of people to the region.

Water diverted for placer mining activities in the early 1860s was initially governed by the regulations of individual mining districts. The ditch companies in the Gold Creek area were among the first to hold water rights. Water use in Montana is generally guided by two legal principles. First, the water user is entitled to divert only as much water as he can beneficially use. The second principle is known as the prior appropriation doctrine, "first in time is first in right." A user's right to a specific quantity of water depends on when the use began. The first person to use water from a source established the first right, the second person is free to use what is left, and so on.

The doctrine of prior appropriation was formalized into

Montana territorial law in 1865-66. In 1865, the use of water for irrigation was authorized by the territorial legislature, and by 1884, water for irrigation purposes had been deemed a public use that could not be obstructed by private landowners (Horstman 1984).

A water right had to be conveyed by deed, and a defective conveyance of a water right was considered abandonment of that right. However, in the early days of settlement, land was transferred by simply giving possession or with a bill of sale, and there was no law requiring a record of water appropriated. The territorial courts were, therefore, quite busy with water rights litigation between 1871 and 1889 (Horstman 1984).

Until 1973, Montana water law did not require the centralized recording and administration of water rights. Water rights were use rights (established by diverting and putting the water to beneficial use), filed rights (established by posting notice, filing at the County Clerk and Recorder's Office, then diverting the water to put it to beneficial use), or decreed rights (resulting from court adjudication).

The Water Use Act, passed by the Montana legislature in 1973, created a centralized records system for water rights and set up a permitting system for future appropriations. Under the permitting system, a person has to apply for and receive a permit from the DNRC to appropriate water. There are exceptions to the law for stock water purposes and small ground water flows. DNRC must evaluate the proposed appropriation against several criteria, including whether there were unappropriated waters in the source of supply and whether the proposed appropriation would adversely affect prior right-holders. The act also established a system by which the state, any political subdivision of the state or the U.S., or any agency of the U.S. could receive a reservation of water. The reservation could be for future or existing beneficial uses or to maintain a minimum flow or quality of water. The reservations were to be approved by the Board of Natural Resources.

Another important phase of Montana water law began with the Water Use Act's mandate to recognize and confirm all water rights that originated prior to July 1, 1973. The current process, known as the statewide adjudication, was mandated by Senate Bill 76 in 1979 and required anyone who held a water right prior to July 1, 1973, to file a claim with DNRC by April 1982. The water courts are overseeing the investigation of claims, including providing opportunities for appeals and objections and issuing preliminary and final decrees.

RECREATION AND TOURISM

The Clark Fork Basin is a valuable local and regional resource for outdoor enthusiasts. The area offers many recreation opportunities with its mountains, clear lakes and tributary streams, and abundant wildlife. For these reasons, recreation, tourism, and outfitting for fishing and big game hunting are increasingly important industries in the basin. Much of the activity and growth in the recreation industry has occurred on the Clark Fork's major tributaries. Fishing and other water-related recreation are well below their potential on the mainstem, largely due to water quality degradation that limits the fishery in many segments of the river.

Three tributaries to the Clark Fork are classified as Class 1 streams (highest fishery resource value). These include Rock Creek, the Blackfoot River, and Fish Creek.

Rock Creek is one of the most highly valued and popular trout streams in Montana. The subbasin is nationally renowned and supports heavy angling pressure during the summer season. Because of this pressure, special restrictions have been enforced in recent years.

The Blackfoot River drainage is extensively used for fishing, floating, and camping. Many Missoula County residents use the Blackfoot for recreation, accounting for 60 percent of the total use. Fishing is the primary activity of more than 80 percent of those using the river (Walker 1977). A recreation corridor was established on the river in 1975 (Blackfoot River State Recreation Area) whereby local government and landowners cooperate in managing the river for recreation. The Blackfoot River is the most frequently floated river in west central Montana.

Fish Creek is a small tributary with high-quality trout habitat that drains directly into the mainstem Clark Fork about 20 miles downstream from Missoula. The stream supports self-sustaining populations of rainbow and cutthroat trout and migratory runs of rainbow and bull (Dolly Varden) trout from the Clark Fork. The stream is heavily used by regional fishermen.

A significant fishery also exists in the 2,768-acre Georgetown Lake on Flint Creek. Georgetown Lake receives extremely heavy angling pressure both summer and winter. Fishermen's catch rates are among the highest in the state.

Other important tributaries of the Clark Fork that support a trout fishery, but may be somewhat less productive because of altered habitat, poor stream flow, or other factors, include the Bitterroot, St. Regis, and Thompson rivers. These streams are all rated as Class II (high-priority fishery resource value).

The mainstem of the Clark Fork throughout most of its length is rated as a Class II stream because of its fishery resource value. The river provides significant recreational opportunities consisting primarily of fishing and boating or rafting.

FISH AND WILDLIFE RESOURCES

Historically, the Clark Fork was a major corridor and spawning ground for fish migrating out of Lake Pend Oreille, Idaho. The lake supports a fishery of national renown, including westslope cutthroat trout, bull trout, rainbow trout, lake whitefish, and kokanee salmon. All of these species once had spawning migrations into the Clark Fork drainage (U.S. Fish and Wildlife Service 1966; Vanek 1972).

Residents who fished the lower Clark Fork in Montana prior to construction of Cabinet Gorge Dam indicated that it was generally unproductive except during the seasonal spawning migrations out of Lake Pend Oreille. Of particular importance was the snag fishery for kokanee salmon at Thompson Falls and Heron Rapids, 68 and 15 miles upstream from Lake Pend Oreille, respectively. Mature bull and cutthroat trout were readily caught in many of the tributary streams and in the mainstem near the mouths of these tributaries (Montana Department of Fish, Wildlife and Parks 1981). The fall kokanee salmon migration probably lasted six to eight weeks (Graham et al. 1980; McMullin and Graham 1981; Vanek 1972). Lake whitefish were captured migrating up the Clark Fork during autumn (Vanek 1972), and mountain whitefish also provided an autumn fishery (Gaffney 1956; Malouf 1975).

Indian historians referred to the significance of trout migrations in the Clark Fork. Salish Indians used weirs to catch migrating fish in side streams of the Clark Fork such as Graves Creek, Deep Creek, Beaver Creek, and others (Malouf 1975). Fish made up as much as 30 percent of the Salish diet with bull and cutthroat trout the most favored (Malouf 1979). The Salish also fished for migratory bull trout near Missoula. In fact, the Salish name for Missoula, Milltown, and Butte areas refers to "bull trout" which were caught there. The construction of Thompson Falls Dam at river mile 70 blocked the ascent of bull trout up the Clark Fork (Malouf 1974).

A sport fishery was virtually nonexistent in the upper

Clark Fork until pollution abatement programs were implemented in the headwaters in the early 1970s. Since then, a significant trout fishery has developed, but its quality is quite variable.

Although some progress has clearly been made in addressing the fisheries' problems, the Clark Fork is still well below its potential. Today, rainbow and brown trout probably rank as the most abundant and sought after trout species in the basin. Cutthroat and brook trout are locally abundant in tributary streams. Mountain whitefish are abundant throughout the drainage and provide a winter fishery. Bull trout are found throughout the drainage in small numbers. Kokanee salmon and rainbow trout provide a large portion of the fishery in Georgetown Lake. Lake whitefish are common in the lower two reservoirs. Warm water species such as yellow perch and largemouth bass are found locally throughout the drainage. Northern pike are found in the lower three reservoirs.

The basin is widely known for its big game hunting. Elk, mule deer white-tailed deer, moose, mountain goat, bighorn sheep, black bear, grizzly bear, and mountain lion are the big game species currently hunted in the basin. Numerous species of upland game birds are also hunted. Most important among these are blue, ruffed, and spruce grouse; Hungarian partridge; and pheasant. Several species of mammals classified as furbearing and/or predatory are hunted or trapped for their pelts. Notable among these are mink, muskrat, marten, beaver, otter, wolverine, bobcat, lynx, coyote, and weasel. Many species of waterfowl inhabit the basin or stop there during migration and provide substantial hunting recreation. In addition, a large number of nongame animals inhabit the basin, including some classified as rare or endangered, such as northern Rocky Mountain wolf, bald eagle, and peregrine falcon.

CHAPTER 2

CURRENT WATER USES AND ACTIVITIES IN THE BASIN

The Clark Fork flows through diverse terrain that supports a variety of land uses. Many of these land uses depend heavily on the river system, utilizing surface and ground water for consumptive and nonconsumptive uses. This chapter provides a description of current land and water uses along the mainstem Clark Fork and its major tributaries. The relative benefits and costs of some activities are discussed, although there are limitations on quantifying these benefits and costs. The amount of water in acre-feet (AF) used for different purposes varies considerably among the seven Clark Fork subbasins covered in this report, as illustrated in Table 2-1.

MINING

From the late 1800s until the early 1980s, mining and metal processing industries were the mainstay of the economy in the upper Clark Fork Basin. The largest employer, the Anaconda Minerals Company shut down its smelter operations in Anaconda in 1980 and its mining operations in Butte in 1983.

The closure of these facilities marked the end of an era, but the recent rise in prices of copper and precious metals has spurred renewed interest in mining throughout the basin. Several companies are now in the exploratory phase, and others have submitted conceptual plans or permit applications to regulatory agencies (see Chapter 4). A few companies are currently operating in the basin, the largest of which is Montana Resources, Inc. in Butte.

Montana Resources, Inc.

MRI purchased most of the Anaconda Minerals Company's Butte holdings in December 1985 and assumed their permits and liabilities for the permitted mine area. MRI began open pit mining of copper and molybdenum in June 1986. It currently employs about 320 people in Butte, and the expected life of the mine is 13.5 years. In the course of the operation, approximately 200 million tons of ore will be processed and 80 million tons of low-grade waste rock will be removed from the top of the ore body and placed on permitted waste rock dumps.

TABLE 2-1. 1980 SURFACE AND GROUND WATER USE IN CLARK FORK SUBBASINS

Water Use	Upper Clark Fork (AF)	Flint-Rock (AF)	Blackfoot (AF)	Middle Clark Fork (AF)	Bitterroot (AF)	Lower Flathead (AF)	Lower Clark Fork (AF)
IRRIGATION							
Ground water withdrawn	689	598	1,488	2,104	2,212	13,188	1,159
Surface Water withdrawn	287,524	124,486	104,692	81,862	481,502	610,575	51,973
Ground water consumed	510	442	1,101	1,557	1,637	9,759	858
Surface water consumed	63,255	31,077	25,126	27,833	134,821	170,961	11,954
MUNICIPAL							
Ground water withdrawn	5,947	0	49	11,738	5,868	812	586
Surface water withdrawn	129	53	340	11,756	1,398	177	154
Water consumed (all sources)	2,248	20	144	8,693	2,688	366	273
RURAL DOMESTIC							
Ground water withdrawn and consumed	411	170	687	390	1,573	549	335
Surface water withdrawn and consumed	2	3	45	20	6	37	36
SELF-SUPPLIED INDUSTRY							
Ground water withdrawn	2,440	0	361	22,112	100	1	200
Surface water withdrawn	0	0	2,931	485	0	0	1
Water consumed (all sources)	366	0	494	3,390	15	0	30
LIVESTOCK							
Ground water withdrawn and consumed	18	234	4	3	115	60	98
Surface water withdrawn and consumed	287	23	276	33	368	342	58
HYDROELECTRIC POWER							
Water used	0	14,586	832,524	0	0	5,884,890	19,197,420

±25% —

Source: DNRC 1986.

Trucks transport ore from the Continental Pit to the Weed Concentrator, where the metals are separated from the ore. Possible waste disposal sites include the Hillcrest Dumps, the Yankee Doodle tailings pond, the Berkeley Pit and the Pittsmont dump--all areas formerly used by AMC for disposal of waste rock removed from the Continental and East Berkeley Pits. Reclamation after mining will follow the methods described for specific areas in the mining permits.

Mill tailings are currently disposed of in the Yankee Doodle tailings pond, located near the confluence of Yankee Doodle Creek and upper Silver Bow Creek. The pond will be expanded from 10 acres to 16 acres over the course of mining operations. MRI has also submitted a proposal to dispose of their tailings in the Berkeley Pit. This proposal is under review by state and federal regulatory agencies.

MRI is currently operating the leach-precipitation process on a much smaller scale than AMC. This process removes soluble copper from waste dumps that were generated when AMC mined the Berkeley Pit.

MRI acquired large water rights when it purchased AMC's holdings. Although the open pit mining operations require minimal water use, MRI uses a portion of the water acquired from AMC to operate the Weed Concentrator. This water flows by gravity from Warm Springs Creek below Silver Lake in Deer Lodge County to Ramsay, where it is pumped to the Weed Concentrator. There is currently more water available than is being used for the Butte operations, and studies are being conducted to make this excess water available to other users.

MRI uses approximately one to three million gallons of water per day, most of which is recycled. Although MRI holds a permit to discharge water to Silver Bow Creek, it is not currently discharging to any surface water body. The DHES classifies Silver Bow Creek as a Class E stream (suitable for agricultural and industrial water uses other than food processing), which enables MRI to discharge untreated operational wastes directly into the creek. However, the classification of Silver Bow Creek is currently under review by various agencies, and should the classification be upgraded, a modification of MRI's permit may be required.

In 1987, Montana Mining Properties, Inc., purchased extensive holdings on Butte Hill from MRI. Future activities on the hill are discussed in Chapter 4.

Other Mining Operations

A number of smaller mines, recovering a variety of minerals, are currently operating in the basin. They generally employ fewer than 75 people, and their operations are permitted by the Montana Department of State Lands (DSL). Most of these mines do not consume surface water or discharge mining wastes to surface waters. A list of these mines is provided in Table 2-2.

Table 2-2. PERMITTED MINING OPERATIONS IN THE CLARK FORK BASIN

COMPANY NAME	MINE NAME	TYPE OF MINE/MILL	MINERAL	COUNTY
Anaconda Minerals Co.	Anaconda	Quarry	Limestone	Deer Lodge
Anaconda Minerals Co.	Anaconda	Silica quarry	Silica	Deer Lodge
Black Pine Mining Co.	Black Pine	Underground	Silver, copper	Granite
Wolverine Mining	Wolverine Mine	Placer	Gold	Granite
Giguere Industries	Giguere Industries	Placer	Gold	Powell
Skalkako Sapphire	Skalkako Sapphire	Placer/open pit	Sapphires	Granite
Cominco American, Inc.	Cominco American	Underground	Phosphate	Powell
Big Horn Calcium	Drummond Quarry	Open pit	Limestone	Granite
Westmont Development	Deep Creek	Placer	Gold	Granite
Montana Barite	Coloma Mine	Open pit	Barite	Granite/Missoula
Montana Barite	Elk Creek	Open pit	Barite	Missoula
WS Mining Co.	Elk Creek Mine	Placer	Gold	Missoula
Clay Lewis	Ninemile	Placer	Gold	Missoula
US Antimony	US Antimony (Kennedy C)	Placer/custom mill	Gold/antimony	Missoula/Sanders
US Antimony	US Antimony	Underground	Antimony	Sanders

Source: DSL 1988.

In addition to these operations, there are numerous "small miner" metal mines in the basin. These operations disturb less than five acres and mine less than 36,500 tons of material per year. These mines generally do not involve consumptive uses of water or discharges of waste into surface waters, although they are required to comply with Montana's Air and Water Quality Acts.

There are also hundreds of inactive metal mines in the Clark Fork Basin, and many hold senior water rights for consumptive uses. These rights are still valid, but the non-use of water by inactive operations makes more water available for junior water right holders (such as irrigators) and contributes to instream water flows.

FOREST PRODUCTS

The forest products industry has played a major role in the economy of the Clark Fork Basin. Nearly 77 percent of the basin is forested and about three-fourths of that area is capable of producing industrial-quality wood (USDA 1977). More than half of the forested area is federal land controlled by the U.S. Forest Service; the remainder is divided between state and private ownership (Table 2-3). Most private lands are held by just a few owners, such as Champion International and Plum Creek Timber.

TABLE 2-3. FOREST LAND OWNERSHIP IN THE CLARK FORK BASIN

Area	Federal Forest (acres)	State & Private Forest (acres)	Total Land Area (acres)
Upper Clark Fork(a)	1,713,640	606,180	3,525,600
Lower Clark Fork(b)	3,384,680	420,049	5,736,130
Total(c)	5,098,320	1,026,229	9,261,730

(a) Upper Clark Fork: Deer Lodge, Granite, Powell, Silver Bow counties.
(b) Lower Clark Fork: Mineral, Missoula, Ravalli, Sanders counties.
(c) Does not include Flathead and Lake counties.

Source: USDA 1977

Since the early logging days when most timber was supplied to mining camps, the industry has diversified to include several large lumber mills, plywood manufacturers, pulp and paper mills, log home manufacturers, post and pole mills, miscellaneous building products manufacturers, and fuel producers. The industry is concentrated in the six western counties: Lincoln, Sanders, Lake, Mineral, Missoula, and Ravalli. Between 80 and 85 percent of industry activity occurs in these counties (Johnson 1983).

The forest products industry experienced unprecedented growth in the late 1970s. Excellent markets and high prices from 1976 to 1979 boosted economic prosperity in western Montana. The growth rate followed major increases in U.S. housing starts, but the industry stalled when housing starts slowed down in 1979. From 1979 to 1982, the market declined with a resultant economic loss in western Montana. In 1983, the industry rebounded, but growth such as that experienced in the 1970s is unlikely to occur again (Keegan and Polzin 1987).

The sales value of wood and paper products produced in Montana west of the Continental Divide was estimated to be $745 million in 1986. This represents 90 percent of the sales value of wood and paper products by all Montana producers. Lumber accounted for 40 to 50 percent of the sales west of the divide; pulp, paper, particle board, and fiberboard together provided 35 percent; and all other producers (house logs, posts, poles, and cedar products) about 5 percent (Charles E. Keegan, Bureau of Business & Economics Research, University of Montana, January 1988, personal communication).

The forest products industry, with the exception of pulp and paper producers, does not use or affect large amounts of water. Forest harvest and forest management, however, does have a significant influence on the quantity and quality of water resources. Timber harvest and associated activities, such as road construction, can affect water quality through increased sedimentation, and elevated water temperatures. Extensive areas of clear-cut forest land can dramatically modify the hydrology of a subbasin with resultant changes in stream flows. Many of these topics are addressed in the section in Chapter 3 on nonpoint source pollution.

The Stone Container Corporation linerboard mill west of Missoula is the largest water user in the Clark Fork Basin. Stone Container pumps approximately 24 million gallons per day from the ground for use in various parts of the mill. A small percentage of the water is lost to the atmosphere as steam, while the remainder is treated and discharged to the Clark Fork.

Hoener —

The mill has expanded in production and product types since 1957, when it was known as the Waldorf Paper Company. At present, the mill employs more than 700 people and has the capacity to produce nearly 2,000 tons per day of linerboard. In its early days, the mill was responsible for fish kills and other water quality problems, but the mill's wastewater treatment facilities have been expanded as the complexity and quantity of waste have increased. Most recently, the mill has added a color-removal system that will remove much of the organic waste, including color and many other pollutants. Although the system will be used for only a portion of the total waste flow, it will improve the overall quality of wastewater discharged to the river. The discharge permit granted to Stone Container in 1986 requires it to reduce the nutrient content of its waste to approximately 1982 levels. Stone Container has made progress in nutrient reduction, and the color-removal process should aid it in meeting its goals.

OTHER INDUSTRIES

Stauffer Chemical Company

The Stauffer Chemical Company operates an elemental phosphorus plant near Ramsay, about eight miles west of Butte. The facility was built in 1950 by the Victor Chemical Company and was purchased by Stauffer in 1959.

Phosphate rock ore is shipped by rail from Idaho to the plant. The ore, along with other additional constituents, is charged to two large rotary kilns that change the material into nodules. Various types of dust and fluoride pollutants are emitted in this process. The nodulized material, along with coke and silica rock, is cooled and stored in silos. Following storage, the nodulized material is fed to two electric furnaces that vaporize the phosphorus from the nodules. The vaporized phosphorus is cleaned of contaminating dust in electrostatic precipitators and then condensed in water. It is filtered, stored under water and shipped out in tank cars. Elemental phosphorus must be stored under water at all times. When exposed to air, it burns to phosphorus pentaoxide. The reaction is immediate and forms dense white clouds of a particulate that is very visible.

Sources of visible emissions, in addition to the slag tapping operation at the furnaces, are the kiln stacks and sometimes the roaster area, although there are also other fugitive-type emissions within the Stauffer facility.

Stauffer has installed, as a result of a 1976 Board of Health and Environmental Sciences order, abatement equipment on the nodulizing kilns, furnace taphole scrubber, phosphorus handling system, and the roaster. Prior to that order, Stauffer had also installed turbalaire scrubbers on various transfer and handling facilities to control dust. Some of the equipment, notably the furnace taphole scrubber, has not lived up to expectations and the DHES Air Quality Bureau was forced to issue a departmental order on the facility in February 1987. Stauffer has not yet brought the taphole scrubber stack into visual compliance with state emission standards.

Until 1972, untreated process wastewater from the plant was discharged directly into Silver Bow Creek. At that time, Stauffer began construction of a closed system to recycle process wastewater. The system was completed in 1975, and further improvements made in 1979 and 1982 have reduced the risk of contaminant discharge to Silver Bow Creek (CH_2M Hill 1983).

IRRIGATED AGRICULTURE

Introduction

Irrigated agriculture in the seven Clark Fork subbasins consists of approximately 400,000 acres of cropland supplied with water from projects operated or managed by private water users and state and federal government agencies (DNRC 1986). According to figures published by the DNRC in 1986, these projects withdraw approximately 1,764,000 AF of ground water and surface water, which amounts to about 4.4 AF withdrawn for each irrigated acre. Table 2-4 gives figures for irrigated acreage served by ground water and surface water in seven Clark Fork subbasins.

The Agricultural Statistics Service of the Montana Department of Agriculture (MDA) has compiled crop statistics by county for irrigated agriculture (MDA 1987). Using the MDA's 1986 figures for Clark Fork Basin counties, the percentages of irrigated acreage for eight major crops were calculated. These percentages were applied to the total irrigated acreage figure given in Table 2-4, to estimate the irrigated acreage, by crop, for the Clark Fork Basin (Table 2-5).

The estimates in Table 2-5 indicate that more than 75 percent of the irrigated land in the Clark Fork produces hay crops, with alfalfa alone accounting for nearly one half. Just over 20 percent of irrigated lands are used for small grain production. Potato and corn silage production together account for 2 percent.

Federal Water Projects

There are five federal water projects in the Clark Fork Basin. Information on these projects is summarized in Table 2-6.

The largest is the Flathead Indian Irrigation Project (FIIP), an irrigation and power project located on the Flathead Indian Reservation. The FIIP has been operated by the Bureau of Indian Affairs (BIA) since 1910. A number of problems has been associated with the project and in 1984, the Bureau of Reclamation (BOR) and the BIA were requested by Secretary of the Interior William Clark "to conduct a comprehensive examination of the Flathead Irrigation Project, to document outstanding problems and to recommend corrective measures." According to the BOR and BIA (1985), water-use conflicts between Indian and non-Indian exists on the Flathead Indian Reservation. The Confederated Salish-Kootenai tribes feel that they have the legal authority to assume management and operation of the FIIP; that the

TABLE 2-4. ACRES IRRIGATED BY GROUND WATER AND SURFACE WATER IN CLARK FORK SUBBASINS

Subbasin	Ground Water	Surface Water	All Sources
Upper Clark Fork*	531	58,487	59,018
Flint Creek-Rock Creek*	480	30,487	30,635
Blackfoot	1,210	27,611	28,821
Middle Clark Fork	1,162	20,771	21,933
Bitterroot	1,353	111,422	112,775
Lower Flathead	7,393	129,516	136,909
Lower Clark Fork	650	9,056	9,706
TOTALS	12,779	387,350	399,797

* DNRC figures adjusted according to Elliott 1986.
Source: DNRC 1986.

The Agricultural Statistics Service of the Montana Department of Agriculture (MDA) has compiled crop statistics by county for irrigated agriculture (MDA 1987). Using the MDA's 1986 figures for Clark Fork Basin counties, the percentages of irrigated acreage for eight major crops were calculated. These percentages applied to the total irrigated acreage figure given in Table 2-4, to estimate the irrigated acreage, by crop, for the Clark Fork Basin (Table 2-5).

TABLE 2-5. IRRIGATED ACREAGE ESTIMATES AND PERCENTAGES FOR THE EIGHT MAJOR CROPS OF THE CLARK FORK BASIN

Crop	Acreage Estimate	Percent of Total[1]
Alfalfa	118,704	47.2
Other hay	116,341	29.1
Barley	57,971	14.5
Spring wheat[2]	13,193	3.3
Winter wheat	9,595	2.4
Oats	5,997	1.5
Potatoes	5,597	1.4
Corn silage	2,399	0.6
TOTALS	399,797	100.0

[1] Estimated from Department of Agriculture data (MDA 1987).
[2] Figures are for spring wheat other than durum.

TABLE 2-6. SUMMARY OF FFDERAL IRRIGATION PROJECTS IN THE BASIN

Name, Location, and Operation History	Project Specifications	Operation and Maintenance
LOWER WILLOW CREEK PROJECT		
• Located on Willow Creek 6 miles west of Hall, Montana. • Constructed in 1962 by the Soil Conservation Service.	• This is a 174-acre project with a capacity of about 5,100 AF. • It provides water to lands in lower Willow Creek and the lower Flint Creek Valley.	• The project is owned and operated by the Lower Willow Creek Drainage District.
MISSOULA VALLEY PROJECT		
• Located southwest of Missoula, Montana. • Construction was completed in 1949 with assistance from the BOR.	• The project consists of the Big Flat canal and distribution system. • Water is diverted from the Bitterroot River and is used to irrigate about 780 acres 7 miles west of Missoula. • Principal crops are hay, grain, and pasture.	• The project is operated and maintained by the Big Flat Irrigation District.
FRENCHTOWN PROJECT		
• Located near Frenchtown, Montana. • Construction was completed in 1937 with assistance from the BOR.	• The project consists of a diversion dam on a side channel of the Clark Fork and a gravity-flow distribution system that includes 17 miles of main canal and 21 miles of laterals. • The system irrigates about 4,600 acres between Grass Valley and Huson; principal crops are hay, grain, and pasture.	• The project has been operated and maintained by the Frenchtown Irrigation District since 1938.

TABLE 2-6 (CON'T). SUMMARY OF FEDERAL IRRIGATION PROJECTS IN THE BASIN

Name, Location, and Operation History	Project Specifications	Operation and Maintenance
BITTERROOT PROJECT		
• Located on Rock Creek, a westside tributary of the Bitterroot River, near Darby, Montana. • Initially authorized in 1930, additional federal funds requested in 1936, 1948, 1954, and 1956 for continued rehabilitation and repair. Constructed with assistance from the BOR.	• Water is stored in Lake Como, which has a total capacity of 36,900 AF. • The Rock Creek Diversion Dam about one mile below Lake Como diverts water into a 60-mile long canal. A feeder canal from Lost Horse Creek enters the district's canal about one mile below the diversion dam. • The system irrigates about 16,668 acres. Principal crops are grain, hay, and pasture.	• The project is operated and maintained by the Bitterroot Irrigation District.
FLATHEAD INDIAN IRRIGATION PROJECT		
• A large irrigation and power project located within the boundaries of the Flathead Indian Reservation. • Construction of irrigation facilities by the BOR began in 1907. Additional construction was performed by BIA after 1922; nearly all of the irrigation facilities were completed before 1940.	• Water storage and regulation is provided by 16 reservoirs that have storage capacities ranging from 95 to 27,100 AF. • Approximately 127,000 acres are currently assessed water delivery charges. About 90-95 percent of that acreage is irrigated each year. Sprinkler irrigation is used on approximately 70,000 acres.	• The project has been operated by the BIA since 1910.

Sources: U.S. Department of Interior 1981; BOR and BIA 1985.

project must comply with established tribal law and procedures; and that the project remain under the management of BIA. Conversely, the non-Indian water users represented by the Flathead Joint Board have indicated a strong desire to manage and operate the project themselves.

The BOR and BIA concluded that the FIIP and non-Indian water users will be affected by the quantification of Indian reserved water rights, on and off the reservation. The impact may significantly alter the existing operations of the project and there may be insufficient water to maintain the existing level of irrigation.

The project also faces a basic financial problem. The water users cannot adequately fund the operation and maintenance of the storage and distribution system. This situation exists in spite of the fact that power revenues are used to repay the original irrigation construction. Any increases in water user assessments need to be applied to improve the operation and maintenance of the irrigation system. However, additional fee assessments to fund desperately needed rehabilitation work are beyond the financial capability of the water users. The deterioration of the irrigation facilities is such that, without rehabilitation, portions of the system will soon stop functioning (BOR and BIA 1985).

State-owned Irrigation Projects

The State of Montana owns several water conservation projects in the basin. Many of these were built by the State Water Conservation Board (SWCB), which was formed in 1935 during the Depression and serious drought. Most of the projects are administered by the Water Resources Division of the DNRC through a contractual agreement with local water users associations. The water marketing contracts require the associations to pay the state its investment in the project plus an operation and maintenance (O&M) fee in exchange for delivery of the water. Many of the local water associations operate the projects themselves, with DNRC maintaining a supervisory capacity.

Information on each of the five state-owned irrigation projects is summarized in Table 2-7. Additional information can be obtained from the publication "State Water Conservation Projects" (DNRC 1977). Although most of the water stored by these projects is used for irrigation, there is also recreational use on some of the reservoirs. In addition, various organizations have purchased water from the Painted Rocks project to augment streamflows in the Bitterroot River for protection of fisheries. In 1958, the Western Montana Fish and Game Association in Missoula, the Ravalli

TABLE 2-7. SUMMARY OF STATE-OWNED IRRIGATION PROJECTS IN THE BASIN

Name, Location, and Construction History	Project Specifications	Irrigation and Other Uses	Contract Costs	Repairs Made/ Current Problems
PAINTED ROCKS				
• West Fork of Bitterroot River, 30 miles south of Darby, Montana. • Constructed in 1940 with federal financing from Public Works Administration (PWA) and state funding through the SWCB for a total cost of $991,270.	• Storage Capacity: 32,362 AF • Reservoir Pool Area: 655 acres • Dam Height: 143 feet • Dam Length: 800 feet	• Irrigation water conveyed downstream in the Bitterroot River channel serves a portion of the Daly Ditch Project upstream from Hamilton, Montana. • Also used for recreation. • There are no long-term irrigation contracts for the project.	• One year contracts are available to irrigators at a cost of $1.40/AF plus an O&M fee of $0.60/AF.	• Repairs to the outlet tunnel were made in 1977. • Slide gate is difficult to operate and requires frequent maintenance. • Spillway joint and wall top repairs were made in 1987.
FRED BURR				
• Fred Burr Creek, 8 miles west of Victor, Montana. • Constructed in 1948 with funding from SWCB and loans from local individuals for a total cost of $117,839.	• Storage Capacity: 512 AF • Reservoir Pool Area: 28 acres • Dam Height: 50 feet • Dam Length: 275 feet	• Irrigation water is diverted in private ditches to seven water users, providing supplemental irrigation for approximately 900 acres near Victor.	• Costs are $2.50/AF plus O&M fees of $0.45/AF.	• Damage to outlet tunnel pipe joints was repaired in 1975 and 1987.
GREEN MOUNTAIN				
• Diversion structure on Swamp Creek, 13 miles southeast of Noxon, Montana. • Constructed in 1940 with financing from Works Progress Administration (WPA) and SWCB for total cost of $58,232. • Project was originally designed to include storage reservoir at Worless Lake, but was never completely developed.	• Dam Height: 18 feet • Dam Length: 150 feet • Project consists of diversion headworks, main canal, and associated laterals.	• Irrigation water is diverted by 27 water users to irrigate 375 acres of a potentially irrigable 4100 acres within the project service area.	• Operation and maintenance fees vary from year to year.	• Diversion headgate was replaced in 1974. • Project operation is hampered by canal leakage problems and water shortages caused by low flows. • Green Mountain Water Users Association is attempting to become better organized and conduct an active O&M program.

TABLE 2-7 (Con't). SUMMARY OF STATE-OWNED IRRIGATION PROJECTS IN THE BASIN

Name, Location, and Construction History	Project Specifications	Irrigation and Other Uses	Contract Costs	Repairs Made/ Current Problems
NEVADA CREEK				
• Nevada Creek, 10 miles southeast of Helmville, Montana. • Constructed in 1940 with funding from PWA, WPA and SWCB for total cost of $445,594.	• Storage Capacity: 12,640 AF • Reservoir Pool Area: 375 acres • Dam Height: 83 feet • Dam Length: 1,195 feet	• Irrigation water is supplied under 39 water purchase contracts to irrigate 13,000 acres with 9,161 AF. • Limited recreational use of reservoir (fishing).	• Annual charges for water use are $1.05/AF plus an O&M fee of $1.20/AF.	• Tunnel outlet butterfly valve was replaced and emergency gate was epoxied in 1974. • SCS identified problems such as erosion, leaky canals and spillway deterioration. • A new 3-inch concrete slab was placed on top of the existing spillway in 1980.
FLINT CREEK				
• East Fork of Rock Creek, 20 miles SW of Philipsburg, Montana. • Constructed in 1938 with funding from PWA and SWCB for total cost of $916,672.	• Storage Capacity: 16,040 AF • Reservoir Pool Area: 400 acres • Dam Height: 87 feet • Dam Length: 1,075 fee	• Irrigation water is supplied under 80 contracts to irrigate 18,700 acres with 14,745 AF • A main diversion canal crosses the divide from Rock Creek into Flint Creek, and there are four distribution canals in the Flint Creek valley. • Moderate recreational use of the reservoir.	• Annual charges are $0.80/AF plus an O&M fee of $2.50/AF.	• Past maintenance has included rebuilding of Flint Creek Canal, bentonite lining of the main canal, and repairs to Marshall Creek and Allendale canals. • Water shortages, due partly to leaky canals and canal failures, are persistent problems for water users. • The emergency gate stem was straightened in 1985.

Source: DNRC 1977.

County Fish and Wildlife Association and the Montana Fish and Game Department (now the Department of Fish, Wildlife and Parks or DFWP) purchased 5,000 AF per year, at a cost of $110,400 for the life of the Painted Rocks project. They also agreed to pay $500 per year for operation and maintenance costs. In 1985, 1986, and 1987, the DFWP purchased an additional 10,000 AF per year. The department is currently negotiating for the long-term purchase of 10,000 AF per year; recently, the Montana Power Company contributed $250,000 to a trust fund to purchase this water from the reservoir as fisheries mitigation for its Thompson Falls hydropower project under the Northwest Power Planning Act. Very recent local efforts have been initiated by Trout Unlimited and others to acquire the remaining 17,000 AF for instream flow purposes.

Benefits and Costs of Irrigation to Western Montana's Economy

Irrigation benefits agricultural production, and agricultural production is an important factor in western Montana's economy. Approximately two-thirds of all crops produced in the region are irrigated, and 83 percent of the irrigated land produces hay. The high percentage of irrigated hay corresponds to the dominance of livestock production in the agricultural sector. Livestock production accounts for approximately $83 million annually, or 73 percent of total marketing receipts for agricultural production in the region. The agricultural sector, in turn, accounts for approximately 1 percent of total income in the region and employs about 5 percent of the work force. In some counties, however, agriculture accounts for as much as 9 percent of county income and 19 percent of employment. Irrigation not only increases average production, but also stabilizes production during drought periods. Thus, irrigation has had a stabilizing effect on the livestock industry and agriculture in western Montana.

The value of irrigation to each operation depends on many site-specific factors and is estimated to range between $5 and $60 dollars per acre-foot. Based on low end estimate of 230,000 irrigated acres and a crop requirement of two AF of water per acre, the total value of irrigation to western Montana lies between $2 million and $28 million per year.

The cost of irrigation to western Montana cannot easily be quantified. The direct costs associated with irrigation and crop production are not costs to the region, because most of the needed labor, equipment, and material can be purchased in western Montana. Irrigation depletions affect other beneficial uses such as fish and wildlife habitat, water quality, and recreational opportunities. Each new depletion can also further reduce hydroelectric generating capabilit-

Consumed by crop?

ies. These impacts represent the primary costs of irrigation to the region. Approximately 1.5 to 2.0 AF per year are depleted for every acre irrigated. In most of western Montana, depletions should tend to be on the lower end of this range given high elevations and relatively high rainfall, which reduces net irrigation requirements. However, in some areas such as the Flint Creek and Rock Creek drainages, the soils are quite porous and require more water to derive an irrigation benefit. Based on a range of 230,000 to 400,000 acres of irrigated cropland in the seven Clark Fork subbasins, total depletion is estimated to range from 345,000 to 800,000 AF per year.

The cumulative impacts of water quality degradation in the Clark Fork Basin associated with irrigation are not quantified and will be difficult to quantify in the future. However, general water quality impacts are known to include: increased sedimentation associated with overland runoff; increased water temperature related to decreased stream flows; increased nutrient levels that occur as a result of a combination of both irrigation and fertilization of crop land; and a potential for decreased dissolved oxygen levels associated with an increase in algae growth.

The tradeoff between instream uses, such as power generation, and irrigation uses has become an important issue, as power demand has exceeded hydropower system capacity even when system capacity has increased. The lands currently under irrigation will probably be maintained, given the large capital investment associated with irrigation development. However, in addition to any other development costs, future irrigation developments may only be justified if the net benefits exceed the lost value of power generation and other interests associated with depletions. For the Columbia River Basin this would mean that the net benefits of irrigation are greater than $40 per acre-foot depleted (see next section).

HYDROPOWER

As a headwater state, Montana is an important contributor to the regional hydropower system of the Columbia River basin. The average quantity of water flowing from Montana at the Montana-Idaho state line is about 26 million AF per year, of which about 16 million AF per year flow in the Clark Fork. The Montana water contribution (total flow minus 8.3 million AF entering from Canada) is about 57 percent of the upper Columbia River flow and 11 percent of the average annual stream flow at the mouth of the Columbia River (Wright Water Engineers and DNRC 1982).

There are four hydropower dams on the Clark Fork mainstem and three hydropower facilities located on major tributaries in Montana. The mainstem dams contain very little storage capacity and have little influence on seasonal discharge patterns. Two major storage projects on the Flathead River system, Kerr and Hungry Horse dams, do have potential to alter seasonal flows in the Clark Fork. A description of the basin's major hydropower facilities and their operations is provided in Table 2-8.

System Operation

The organizational structure of the Columbia River hydroelectric power system has evolved over a period of 40 years. Although utilities in many parts of the United States have formed interconnected power pools on a regional basis, the degree of integration among major producers and consumers in the Northwest is unusual.

Columbia River Treaty

The "Treaty between Canada and the United States Relating to Cooperative Development of the Water Resources of the Columbia River Basin," was signed in 1964, and it will end in 2003. This agreement, a keystone in the development of the vast hydropower system of the Pacific Northwest, provides for both flood control and power benefits. Some key provisions of the treaty that affect water management in the Columbia River basin are summarized below:

- Canada is required to develop 15.5 million AF of storage in British Columbia available for power in the U.S. and for downstream flood control.

- Approved construction of Libby Dam on the Kootenai River in the U.S. and allowed some inundation upstream in Canada.

- The U.S. is required to operate downstream projects on the Columbia River in such a manner to make effective use of the added stream flow resulting from Canadian storage.

- The two nations are required to divide the resultant downstream power benefits equally. Canada's share of the downstream benefits for the first thirty years were sold by Canada to a group of Pacific Northwest utilities.

- The U.S. is required to pay Canada for the flood control provided by Canadian storage. The payment reflects the flood damage prevented in the U.S. and compensates Canada for the economic loss arising

TABLE 2-8. SUMMARY OF MAJOR HYDROPOWER FACILITIES IN THE BASIN

Name, Location, and History	Engineering Specifications and Generating Capacity	Operating Criteria and Water Rights Claimed	Current and Future Activities	Other Uses
FLINT CREEK				
• Located on Flint Creek about 18 miles west of Anaconda, Montana. • Constructed by Montana Water, Electrical Power and Mining Company in 1900; purchased by Amalgamated Copper Co. in 1906; purchased by MPC in 1935. • Current license expired July 1, 1988.	• Storage Capacity: 31,000 AF • Dam Height: 39 feet • Dam Length: 250 feet • Two generators with total installed capacity of 1.1 MW through a gross head of 718 feet. • Georgetown Lake is used as the forebay.	• The project has the potential to draw Georgetown Lake down 10-15 feet; however, drawdown is usually limited to 3 feet. • Drafting of the lake usually occurs during the winter. • Under an old decreed water right, a minimum of 30 cfs must be released for irrigation in the Flint Creek Valley from May 1 to October 1.	• In July 1987, MPC filed an application with FERC to surrender its license for the Flint Creek Project with with the intent of transferring the project to another party. • In April 1988, MPC and Granite County jointly filed an application with FERC to transfer the MPC license to Granite County. If FERC grants the transfer, MPC will withdraw its surrender application. If it is not granted, FERC will process the surrender application and MPC will seek an acceptable party to take over the project. • If neither application is resolved by July 1, 1988, MPC will either cease generating and mothball the project facilities or FERC will grant MPC an annual license to operate the plant until one of the applications is resolved.	• Georgetown Lake is a very important recreational lake and is one of the most heavily fished lakes in the state.

TABLE 2-8 (Con't). SUMMARY OF MAJOR HYDROPOWER FACILITIES IN THE BASIN

Name, Location, and History	Engineering Specifications and Generating Capacity	Operating Criteria and Water Rights Claimed	Current and Future Activities	Other Uses
MILLTOWN DAM				
• Located on the Clark Fork River about 5 miles east of Missoula, Montana. • Constructed in 1906-07; purchased by MPC in 1929. • License issued in 1965 is effective until 1993. • Run-of-the river development.	• Storage Capacity: 820 AF (usable storage 300 AF) • Dam Height: 64 feet • Dam Length: 668 feet • Five generators have a total nameplate capacity of 3.0 MW and a rated capacity of 3.4 MW.	• Current drawdowns of up to 22 feet. • Once rehabilitation is complete, reservoir level will be controlled more efficiently. Annual drawdowns will be unnecessary and will be limited to 2 feet. • MPC has a water right claim of 2,000 cfs.	• The spillway was rehabilitated in 1986-87 under an emergency directive from FERC. The spillway deck and flashboards were removed and replaced by a concrete skin and a system of wheel gates. • Phase II of the rehabilitation to repair the dam will begin in summer 1988. Rehabilitation of the powerhouse and generation equipment will follow at a later date.	• Wetlands provide important wildlife habitat.
KERR DAM				
• Located on the Flathead River about 4.5 miles downstream from the outlet of Flathead Lake; on the Confederated Salish and Kootenai Indian Reservation. • Construction completed in 1938; license transferred from Rocky Mountain Power Company to MPC in 1938. • License expired in 1980; both MPC and the Tribe filed with FERC for relicensing. • In July 1985, FERC issued a 50-year license. MPC retains control until 2010; ownership will than be transferred to the Tribe.	• Storage Capacity: 1,217,000 AF • Dam Height: 200 feet • Dam Length: 381 feet • Three generators have a total nameplate capacity of 168 MW and a rated capacity of 180 MW.	• Drafting of storage from Flathead Lake usually begins in mid-September and reaches maximum drawdown in late March or early April. • Maximum rate of discharge through the outlet channel is 55,500 cfs when Flathead Lake is full at elevation 2,893 feet. Maximum rate of outflow at drawdown is 5,200 cfs. • Operational planning is based on a minimum daily average release of 1,500 cfs. • MPC has a water right claim of 14,540 cfs.	• MPC has no immediate plans for expansion of the project. However, several options to increase energy output have been considered by MPC and government agencies. These include raising the dam and elevation of the reservoir, enlarging the lake outlet to increase maximum flow rates (at drawdown), rewinding the present generators, and installing an additional generator.	• Flathead Lake is heavily used for recreation, and there are a large number of summer and year-round homes around the lake.

TABLE 2-8 (Con't). SUMMARY OF MAJOR HYDROPOWER FACILITIES IN THE BASIN

Name, Location, and History	Engineering Specifications and Generating Capacity	Operating Criteria and Water Rights Claimed	Current and Future Activities	Other Uses
THOMPSON FALLS				
• Located on the Clark Fork near Thompson Falls, Montana. • Constructed 1913-17; MPC acquired the project from Thompson Falls Power Co. in 1929. • Relicensed by FERC in 1979. • Run-of-the river development. • Taintor gates were installed in 1983.	• Storage Capacity: 15,000 AF, but not normally utilized. • Dam Height: 54 feet • Dam Length: 1,016 feet • Auxiliary Dam Height: 45 feet • Auxiliary Dam Length: 449 feet • Six generators have a total nameplate capacity of 30 MW and a rated capacity of 40 MW.	• Reservoir level and spill are controlled by flash-boards and wheel panels at the main and dry channel dams and two taintor gates on the main dam. • Present hydraulic capacity of the plant is 11,000 cfs. • Current operation maintains a full reservoir except for drawdowns for maintenance. • MPC has a water right claim of 11,120 cfs.	• MPC is considering the addition of a 50 megawatt (MW) generating plant. • MPC is also considering converting to peaking or load shaping operations.	• The reservoir is used for fishing and other recreation.
NOXON RAPIDS				
• Located on the Clark Fork near Noxon, Montana. • Constructed in 1959, owned and operated by the Washington Water Power Company (WWP).	• Total Storage Capacity: 497,700 AF • Active Storage Capacity: 230,700 AF (seasonal) • Dam Height: 260 feet • Dam Length: 5,840 feet • Five generators have a total nameplate capacity of 467 MW and a maximum net capability of 554 MW.	• Maximum allowed drawdown is 36 feet. However, drawdown is generally limited to 4 feet from May 15 to October 1 each year to protect fish spawning and recreational access. The rest of the year, drawdown is usually limited to 10 feet to help maintain benthic populations for fish. • Hydraulic capacity of the plant is 50,000 cfs. • WWP has a water right claim of 35,000 cfs and a use permit for 15,000 cfs.	• WWP has no plans for changes to the project.	• The reservoir is increasingly used for fishing and other recreation.

TABLE 2-8 (Con't). SUMMARY OF MAJOR HYDROPOWER FACILITIES IN THE BASIN

Name, Location, and History	Engineering Specifications and Generating Capacity	Operating Criteria and Water Rights Claimed	Current and Future Activities	Other Uses
CABINET GORGE				
• Located on the Clark Fork just outside the Montana border in Idaho. • Constructed in 1952, owned and operated by WWP. • Run-of-the river development.	• Total Storage Capacity: 104,500 AF • Active Storage Capacity: 42,780 AF • Dam Height: 140 feet • Dam Length: 600 feet • Eight vertical lift spillway gates increase height an additional 68 feet. • Four generators have a total nameplate capacity of 200 MW and a maximum net capability of 230 MW.	• Maximum possible drawdown is 15 feet; however, typical operations seldom exceed 6-8 feet of drawdown and these are of short duration. • The project operates as a satellite plant of the Noxon Rapids project. Daily and weekly fluctuations are generally the result of upstream operation and are about 2 and 3 feet, respectively. • WWP provides a voluntary minimum flow of 3,000 cfs through the project.	• WWP has no plans for changes to the project.	• The reservoir is used for fishing and other recreation.
HUNGRY HORSE				
• Located on the South Fork of the Flathead River, 20 miles northeast of Kalispell, Montana. • Authorized by Congress in 1944; constructed by BOR between 1948 and 1953. • A federal project operated by the BOR.	• Total Storage Capacity: 3,468,000 AF • Active Storage Capacity: 2,982,000 AF • Dam Height: 564 feet • Dam Length: 2,115 feet • Four generating units have a total nameplate capacity of 285 MW and a peak capacity of 328 MW.	• NWPPC's Fish and Wildlife Program directs the BOR to provide a minimum year-round flow of 3,500 cfs in the Flathead River at Columbia Falls from the Hungry Horse Project. A maximum flow of 4,500 cfs from October 15 to December 15 is also stipulated. • Maximum flow capacity of 55,000 cfs.	• The BOR has no plans to enlarge the project at this time.	• The project provides flood control and recreation benefits.

Sources: FWP 1981; BOR 1988; Northwest Power Planning Council 1986; Simons and Rorabaugh 1971.

from foregoing alternative uses of storage used to provide for flood control.

Pacific Northwest Coordination Agreement

The Pacific Northwest Coordination Agreement is a contract for planned operation among the 16 major operating utilities. The agreement became effective in 1964 and it is scheduled to end in 2003. The agreement provides operational guarantees that insure usability of the Columbia River Treaty storage to downstream generating plants and specifies the restoration of pre-treaty capabilities to certain plants under certain conditions.

A fundamental concept of the coordination agreement is "Firm Load Carrying Capability," commonly abbreviated as FLCC. For the coordinated system of all 16 parties, the FLCC is the aggregate firm load that the system could carry under coordinated operation with critical period streamflow conditions and with the use of all reservoir storage.

To accomplish such coordinated operations, the combined power facilities of the parties are operated to produce optimum firm load-carrying ability. Prior to the start of a contract year, a reservoir operating and storage schedule is set up to provide the optimum FLCC of the coordinated system. An energy content curve (ECC) is derived for each storage reservoir from the same critical period operation study that was used to derive FLCC. This curve represents the schedule of levels that the reservoir should follow in order to assure FLCC for the system. If, as may frequently happen, the good of the system requires a utility to cut back on releases and to hold storage for later use, thereby reducing its present generation below its FLCC, and perhaps below its load requirements, it has the right to call for and receive interchange energy from a party with excess capability. Later, when the first party's storage is scheduled for release, it will be able to return the energy. Provision is made to pay for any imbalances in such interchange energy exchange accounts that may remain at the end of a contract year.

The Coordination Agreement provides that, upon request, a project is entitled to the energy that it could generate at its plants if upstream reservoirs released all water above their energy content curves. The upstream party can either release the water, or, if it has surplus energy and wishes to conserve its storage for later use, it may deliver energy in lieu of the water. An intent of coordinating the system is to maximize use of the water resource, minimize waste, and consequently defer the need for new generating resources.

Northwest Power Pool

The Northwest Power Pool is another institutional arrangement governing the operation of the regional power system. The Northwest Power Pool was created in 1942 as a result of the War Production Board order directing utilities throughout the U.S. to cooperate to increase electric capacity. After the war, the utilities continued the coordinated operation on a voluntary basis.

The Northwest Power Pool is a strictly voluntary organization, a confederacy of autonomous electrical systems. It is not a formal operating pool managed by a separate group of officers. The operating organization of the pool consists of an operating committee and a coordinating group.

Major functions of the Northwest Power Pool are: electrical coordination to insure that each member can meet its requirements; scheduling maintenance outages to the extent possible so that the region's needs can be met at all times; to control the whole system and ensure that proper voltages and frequency are maintained; coordination of communication between members; to represent the Northwest as a group on the national level, and to collect data for future planning on a regional basis. It is important to both the region and the members of the pool that these functions be carried out to insure an efficient and smooth operating system.

Headwater Payments

A third component of the operational organization is the provision for headwater payments. Downstream dams are required to make payments to owners of upstream storage facilities based on the benefits received from the release of upstream storage.

For each reservoir, a computation is made to determine the cost of storage, which includes the capital costs of the dam, operation and maintenance costs, taxes, interest, depreciation, insurance, interim replacements, and joint use costs. The cost of storage does not include any costs associated with power production at site. The computed cost may be bound by a predetermined cost limit adjusted each year for every reservoir. The headwater payments are determined by the smaller of the computed storage costs or the cost limit.

The portion of the costs payable by a downstream dam depend on the portion of the benefits received. An assessment is made to determine the total energy available from the storage at the upstream reservoir. This calculation includes the power generation produced at site and the generation produced at all the downstream dams. Each downstream dam's portion of the cost is the ratio of its benefits to the total benefits multiplied by the storage cost (or the cost limit).

Benefits and Costs to Western Montana and Northwest Region

"For more than a half century, electrical power has been the cornerstone of the Pacific Northwest economy" (Northwest Power Planning Council [NWPPC] 1986). The extensive hydropower system of the Columbia River Basin--the largest in the nation--supplies about 70 percent of the electricity in the Northwest.

Hydroelectric development in the Clark Fork Basin provides a significant part of the electrical energy generated by the WWP, MPC, and the BOR. The five major hydropower facilities in the Clark Fork Basin have a total maximum generating capacity of approximately 1,290 MW (Table 2-9). On average, however, these five plants generate approximately 600 MW of power. In comparison, hydropower facilities in the Northwest have the capacity to generate approximately 20,000 MW, and on average generate 16,400 MW (NWPPC 1986). Thus, these five facilities account for approximately 4 percent of the average hydropower generation in the region. In addition to power generation, Hungry Horse Reservoir provides substantial headwater benefits associated with its large storage capacity, 3,468,000 AF, and its location in the basin. This storage is released to augment stream flows which are then used to generate power by the downstream facilities.

TABLE 2-9. GENERATING CAPACITY AND MAXIMUM FLOW CAPACITY OF THE FIVE MAJOR HYDROPOWER FACILITIES

Facility	Owner	Generating Capacity Max (MW)	Generating Capacity Avg (MW)	Maximum Flow Capacity (cfs)
Hungry Horse	BOR	328	107	55,000
Kerr	MPC	180	128	14,540
Thompson Falls	MPC	40	34	11,120
Noxon Rapids	WWP	554	199	50,000
Cabinet Gorge	WWP	230	130	36,000

Source: NWPPC 1986

The facility owners listed in Table 2-9, as members of the Pacific Northwest Coordination Agreement, operate their hydropower facilities in concert with others in the Northwest to maximize the utilization of water discharges for optimum energy production and minimum wastage, thereby deferring the need for new energy resources.

Hydropower plants provide benefits to the local area through employment and dollars spent in the operation and maintenance of the facilities. In addition, the non-federal facility owners pay generation-based taxes on the production output of the plants and property taxes, which contribute significantly to the local tax base. In addition to revenues gained from hydropower production, damming of the Northwest's rivers provides additional benefits associated with irrigation, navigation, flood control, and diverse recreation.

The power production from hydropower plants is used by the utility owners to meet the requirements of their customers. Undeniably, the people of the region have come to expect the availability of electrical energy when they require it. The dependability of hydropower generation contributes greatly to the reliability of the region's power supply. Hydropower plants such as Noxon Rapids and Kerr Dam are also important for load control, which is necessary to insure that the generating system responds to instantaneous changes in the customer's demand for electrical power.

The Northwest currently is capable of generating more power, on average, than there is demand. This surplus may not continue into the next century, however. In the 1986 Northwest Conservation and Electric Power Plan, the Northwest Power Planning Council estimated that between 1990 and 1996, the demand for power will exceed the region's generating capacity, on average, and new generation capacity will be required.

Residential uses of power in the Northwest accounts for approximately 36 percent of current regional power demand. Industrial uses account for 39 percent of regional power demand. Commercial uses demand 20 percent, and irrigation power requirements account for most of the remaining 4 percent (NWPPC 1986). In western Montana, industrial demand for power accounts for 64 percent, residential 21 percent, commercial 13 percent, and irrigation 2 percent (Bonneville Power Administration [BPA] 1985).

Water for power production has contributed greatly to the economic well-being of the region, as cheap hydroelectricity has been a significant factor in encouraging industry to locate in the Northwest. Low energy costs help businesses that provide much needed jobs to local areas, which in turn allows the people who work and live here to enjoy the many other qualities of the region. The existing hydroelectric base contributes greatly to the comparatively low electrical prices that exist in the Northwest. The capital cost to replace the hydropower facilities of today with new thermal plants could be 8 to 10 times more than the original construction cost. Because the "fuel" for hydropower generation is water, and the cost has not been subject to price fluctuations, the region has enjoyed a large measure of rate stability. This situation should continue in the future to the extent these hydropower developments are maintained.

The economic value of Clark Fork water used for power production is difficult to measure because many factors are involved. One measure of the value of hydropower is to estimate the cost of replacing hydropower generation with the next best alternative. Based on work conducted by the Northwest Power Planning Council, the current replacement cost (excluding construction) for hydropower is approximately 2.5 to 3.5 cents per kilowatt hour (NWPPC 1986). Replacement power provided by new thermal power plants may be three to four times higher than these rates, however. Using site-specific power factors that relate power generation to flow and converting this flow to a volume of water, the value of an acre-foot of water passing through the hydropower facilities in Montana and the Columbia River Basin can be estimated. Table 2-10 shows that every acre-foot of water depleted in Montana will cost the region approximately $50, excluding hydropower facilities in Montana.

TABLE 2-10. VALUE OF ONE ACRE-FOOT OF WATER USED FOR HYDROPOWER PRODUCTION

Location	Incremental Value for Montana Facilities ($0.025/kwh to $0.035/kwh)		Cumulative Value for Montana Facilities ($0.025/kwh to $0.035/kwh)		Regional Value ($0.03/kwh to $0.035/kwh)	
Hungry Horse	$7	$9	$15	$21	$50	$70
Kerr Dam	4	5	8	11	43	61
Thompson Falls	1	1	4	6	40	56
Noxon Rapids	3	5	3	5	39	55
MT-ID Border	--	--	--	--	36	50

(Based on at site and HKSUM factors from BPA)

Source: John Tubbs, DNRC, Helena, April 1988, personal communication.

For the Montana hydropower facilities, the location of the depletion is important. For example, if the depletion occurs in the Flathead drainage below Hungry Horse Dam, the value of an acre-foot would be approximately $11/AF, or $61/AF for the entire region.

The BOR recently completed a planning study analyzing the affects of future irrigation development in the Clark Fork Basin and the potential for Hungry Horse Reservoir to mitigate these impacts (BOR 1988). Analyzing the effect of 120,000 new acres of sprinkler irrigation development, the study found that depletions would result in a loss of 261 million kilowatt hours (kwh). This translates into a financial loss of approximately $6.5 million per year, assuming the current rate of 2.49 cents per kwh. The estimates shown in Table 2-10 above compare favorably with the Bureau's more detailed estimates. Using the same assumptions about the location of developments, depletions, and electric rates, there was only a 20 percent difference in the calculation of losses ($7.84 vs. $6.5 million).

The potential for storage at Hungry Horse to mitigate these losses was found to be limited. The study found that, while total generation within Montana could be restored, there was great disparity in gains and losses at each of the hydropower plants. There were substantial generation gains at Kerr Dam (MPC) resulting from releases from Hungry Horse, but the effect at Noxon Rapids (WWP) could not be mitigated. This is because Noxon Rapids has the capacity to use almost the entire annual flow of the Clark Fork. Using storage to reshape the timing of these flows increases generation at Kerr by making flows usable that might otherwise exceed plant capacity and be lost to spill.

Furthermore, the Bureau points out that there would be significant impacts associated with changing the operation of Hungry Horse Reservoir. "An increase in winter releases would increase the risk that Hungry Horse would not refill in the spring. This could affect the reservoir fishery and recreation use. Additional restrictions on Hungry Horse may cause other headwater projects in the Columbia River system to be drafted more heavily in the coordinated system operation, as the Northwest utilities reformulate their system operation to maximize the FLCC based on new depletions and contractual constraints."

MACROINVERTEBRATES

Biological surveys of fishes, macroinvertebrates, and periphyton have been conducted in the Clark Fork Basin by numerous investigators during the past several decades. Aquatic macroinvertebrates have been the most frequently studied as bioindicators of water quality. McGuire (1988) summarized the results of past macroinvertebrate studies on the Clark Fork to identify trends and information needs. The following summary is from McGuire's report.

Silver Bow Creek to Milltown Dam

Macroinvertebrate studies initiated in the late 1950s provide starting points for both long-term trend monitoring in specific river reaches and evaluations of conditions throughout the Clark Fork drainage. The early studies by Spindler (1959) and Averett (1961) allowed gross comparisons of environmental conditions throughout the drainage. They found macroinvertebrates absent from Silver Bow Creek and only sparse insect populations in the upper Clark Fork. Dipterans (presumably midges and/or black flies) predominated throughout the drainage, while caddisflies, may- flies, stoneflies, and beetles were virtually absent above the confluence of the Little Blackfoot River.

No additional information is available for the upper Clark Fork until Shinn's (1970) qualitative study of 12 sites from Silver Bow Creek to below the Frenchtown Mill (now Stone Container Corp.). Shinn documented degradation in much of his study area, and his data indicated that environmental conditions in the Clark Fork had not changed significantly during the 1960s. Like Averett and Spindler, Shinn found no aquatic insects in Silver Bow Creek and few species in the Clark Fork from the Warm Springs Ponds to Deer Lodge. He noted that dilution by the Little Blackfoot River nearly doubled the number of macroinvertebrate species present from Deer Lodge to Garrison. From the confluence of the Little Blackfoot River to Milltown Dam, the assemblage remained constant but was suppressed compared with Warm Springs Creek and stations downstream from Milltown Dam.

More recent investigations have documented improved macroinvertebrate communities in Silver Bow Creek (Chadwick et al. 1986) and in the upper Clark Fork (Canton and Chadwick 1985; McGuire 1987). Macroinvertebrates began colonizing Silver Bow Creek in 1975 when the Anaconda Minerals Company began secondary treatment of the Weed Concentrator effluent and the Butte sewage treatment plant ceased discharging sludge into the stream (MultiTech and OEA Research 1986). By 1981, metal-tolerant midge species were present throughout Silver Bow Creek, and a few other tolerant species were established in the stream's lower reach (Gregson Hot Springs to the Warm Springs Ponds). Since 1981, the composition and abundance of macroinvertebrate assemblages have been more variable, indicating a gradual stabilization of environmental conditions. Although much improved relative to historic conditions, Silver Bow Creek remains severely polluted by heavy metals, which results in an impoverished macroinvertebrate fauna.

Similarly, severe impacts from metals contamination have been less frequent during the past ten years in the upper Clark Fork (MultiTech and OEA Research 1986). However, metal-sensitive species are still precluded from much of the river above Milltown Dam. As heavy metals pollution has become less severe, other environmental conditions have become more apparent. Densities of a few tolerant insect species have increased dramatically in response to nutrient and organic enrichment from municipal sewage treatment plants and nonpoint sources (natural, agricultural, and forest practices). This response, previously suppressed by toxic conditions resulting from metals contamination, is now evident throughout the drainage.

Milltown Dam to the Confluence of the Flathead River

Pollution in the Clark Fork has had a less dramatic effect on the biota downstream from Missoula than in the headwaters. Spindler (1959), Averett (1961), Shinn (1970) and McGuire (1987) have reported more diverse faunas below Missoula than above. Organic wastes from the Missoula Wastewater Treatment Plant (WWTP), Stone Container Corporation's pulp mill, and upstream sources have been the pollutants of historical concern in this river reach (Watson 1985). The Missoula WWTP is the largest point source of nutrients in the drainage and, until secondary treatment was installed in 1978, probably had the greatest potential for creating toxic conditions in the Clark Fork downstream from Milltown Dam. Shinn's study indicated a sharp decline in species richness immediately below the Missoula WWTP outfall compared with stations just upstream and farther downstream, although species richness was still greater than in the headwaters.

The Institute of Paper Chemistry (IPC) began an annual biological assessment of environmental conditions near the Stone Container Corporation's (Frenchtown) mill in 1956 to detect impacts from the mill's effluent and settling ponds seepage. During the mill's first year of operation (1958-59), the untreated effluent had a significant localized impact on the fauna. Spindler and Whitney (1960) documented a fish kill and a shift in the composition of the benthic community, while the IPC (1962) found reduced densities of sensitive insect species and reduced species richness below the mill outfall. The subsequent recovery of the benthic community was documented (IPC 1962) when effluent treatment was initiated a year later. Other than the deleterious effects during the first year of operation, the paper mill has generally has minor impacts on the Clark Fork. During the 1960s, slight reductions in species richness were sometimes noted near the effluent outfall, and organic enrichment was documented immediately downstream. Wastewater treatment at the mill has been improved several times, and since 1975, impacts have been limited to nutrient enrichment (Rades 1985).

While the IPC studies were designed to detect impacts from a single point source, they also provide valuable information for evaluating overall environmental conditions in the river between Missoula and Alberton. Although the IPC annual reports did not usually address environmental stresses, they did show some evidence of stresses throughout the study area. For instance, in 1959, 1963, 1964, 1967, 1974, and 1975, reduced macroinvertebrate densities, species richness, and/or shifts in relative abundance were evident at most stations. Perturbations at IPC control sites appeared greatest during high runoff years and, therefore, may have resulted from elevated heavy metals concentrations during runoff. Conversely, during years when runoff was relatively low (e.g. 1966, 1969, 1973, and 1977), investigators typically noted indications of nutrient enrichment (increased macroinvertebrate densities and biomass) at sites upstream and downstream from the paper mill. These findings suggest that biologically significant heavy metals contamination has occurred in the Clark Fork below the Milltown Dam during high runoff years, and it occasionally has extended downstream at least as far as Alberton.

Impacts attributable to heavy metals have been substantially less downstream from the Milltown Dam than in the upstream reaches where metal pollution has historically been more severe. The magnitude, frequency, and the duration of exposure to elevated metal concentrations downstream from Milltown Dam have been lessened as a result of metal-bearing sediments being trapped in the reservoir (Johns and Moore 1985), and by dilution from the Blackfoot River and Rock Creek. Consequently, the middle reach of the Clark Fork supports a fauna rich in species compared to the impoverished upstream fauna (Shinn 1970; McGuire 1987).

Confluence of the Flathead River to the Idaho Border

Because scant data are available for the Clark Fork downstream of its confluence with the Flathead River, only a few generalizations regarding environmental conditions in the lower river can be made. Heavy metals contamination does not appear to have been a problem in this reach of the Clark Fork in recent years. Hornig and Hornig (1985) and McGuire (1987) reported increased abundances of several mayfly and mollusk species considered intolerant of heavy metals below the confluence of the Flathead River. The benthic communities described in these studies suggest that nutrient enrichment is not a serious problem at this time. Stream regulation, particularly fluctuating flows, appear to be the principle threat to the biological integrity of the lower

Clark Fork.

FISHERIES

Introduction

The fishery in the Clark Fork has passed through many stages in the past 140 years. Beginning as a varied and productive fishery, it was devastated by human activities in the watershed. Now it is a slowly recovering system. Although the Clark Fork fishery today is greatly improved over what it was just a few decades ago, its recovery has been erratic, and the fishery is considered to be far below the carrying capacity of the river.

In recent years, the DFWP has initiated several investigations to determine why the Clark Fork fishery is poor relative to other rivers of comparable size, such as the Blackfoot River. Information that has been obtained includes population estimates, spawning ground surveys, recruitment, bioassays, and fish stocking survival. In 1987, the DFWP intensified its efforts to obtain information needed to guide management decisions.

The following sections provide a summary of the current fishery in the upper, middle, and lower segments of the Clark Fork. Fishing trends in the basin and benefits and costs to the region are also discussed. A list of fish species in the Clark Fork Basin is given in Table 2-11.

Upper Clark Fork Fishery (Headwaters to Milltown Dam)

Fish Species Composition

Brown trout are recreationally significant throughout the upper river, and rainbow trout are abundant in the sections immediately upstream from the mouth of Rock Creek and downstream to Milltown. A few cutthroat, brook, and bull trout occur and are presumably outmigrants from the tributaries. Mountain whitefish and coarsescale suckers are common throughout the segment. Redside shiners, longnose dace, and sculpins are distributed in suitable habitats within the segment. Squawfish are found from Drummond downstream.

For nearly a century, the upper river was barren of trout due to the toxic materials released by mining, milling, and smelting operations. Trout were observed in the river during the 1960s, but populations of brown trout were not established until the 1970s. Development of the uppermost populations of brown trout near Warm Springs began immediately after the installation of Anaconda Minerals' treatment

TABLE 2-11. DISTRIBUTION OF FISH SPECIES IN THE CLARK FORK BASIN EXCLUDING THE FLATHEAD RIVER SYSTEM.

Common Name	Scientific Name	Distribution
Westslope cutthroat trout	*Salmo clarki lewisi*	Tributaries and reservoirs
Rainbow trout	*Salmo gairdneri*	Throughout drainage
Brown trout	*Salmo trutta*	Throughout drainage
Bull trout (Dolly Varden	*Salvelinus confluentus*	Scattered throughout drainage
Brook trout	*Salvelinus fontinalis*	Tributaries
Kokanee salmon	*Oncorhynchus nerka*	Georgetown Lake
Mountain whitefish	*Prosopium williamsoni*	Throughout drainage
Lake whitefish	*Coregonus clupeaformis*	Noxon Rapids, Cabinet Gorge
Artic grayling	*Thymallus arcticus*	Heart Lake, Fuse Lake
Northern pike	*Esox lucius*	Lower drainage
Yellow perch	*Perca flavescers*	Throughout drainage
Largemouth bass	*Micropterus salmoides*	Throughout drainage
Black bullhead	*Ictalurus melas*	Lower drainage
Pumpkinseed	*Lepomis gibbosus*	Throughout drainage
Northern squawfish	*Ptychocheilus oregonensis*	Throughout drainage
Peamouth	*Mylocheilus caurinus*	Throughout drainage
Redside shiner	*Richardsonius balteatus*	Throughout drainage
Longnose dace	*Rhinichthys cataractae*	Throughout drainage
Longnose sucker	*Catostomus catostomus*	Throughout drainage
Coarsescale sucker	*Catostomus macrocheilus*	Throughout drainage
Slimy sculpin	*Cottus cognatus*	Throughout drainage
Mottled sculpin	*Cottus bairdi*	Throughout drainage
Burbot	*Lota lota*	Planted in Noxon Rapids Reservoir in 1971
Smallmouth bass	*Micropterus dolomieu*	Planted in Noxon Rapids Reservoir in 1982

Sources: DFWP 1981.

pond No. 3 in the late 1950s. Populations of brown trout throughout the upper river seem to have been relatively stable over the 1970-88 period with the exception of the Warm Springs area. The population of brown trout in the Warm Springs river section (known as the pH shack section) has increased rather steadily to the present level.

Trout Population Estimates

In 1987, the Clark Fork, from its origin at Warm Springs to Milltown, was divided into segments and the population of trout in each was estimated. Some 6,000 trout were tagged. During the fall of 1987, spawning data on Clark Fork brown trout were collected by electrofishing in potential spawning tributaries. A fish trap was placed above the mouth of the Little Blackfoot to monitor upstream movements of spawning fish from the Clark Fork. These efforts produced a plethora of information that has not yet been fully analyzed.

The most useful data of the 1987 study were the fish population estimates for the spring-early summer period. Figure 2-1 displays estimates of the numbers of rainbow and brown trout 7.5 inches or more in total length in 31 sections comprising 135 river miles (RM). Exact comparison with estimates generated in previous years is not possible because section lengths vary due to the improved mapping and measuring techniques in 1987. Older estimates were based on numbers of trout 6 inches or more in most cases. Despite these computational differences, estimates from 1987 are very similar to those from previous years.

Data presented in Figure 2-1 show that fish population distribution varies considerably from the headwaters to Milltown. In the uppermost sections from the Warm Springs Pond 2 outflow to the end of the pH shack section (RM 501-498), brown trout densities were between 1,500-2,000 fish per mile. A precipitous drop in trout numbers to a level of about 500 per mile, occurred between the end of the pH shack section and the Galen Bridge (RM 498-491). From the Galen Bridge to below Drummond (RM 491-409) populations slowly declined in density from about 250 per mile to 150 per mile. A more abrupt change occurred from about Bear Creek to Beavertail (RM 409-385) where populations of trout were about 50 per mile. Rainbow trout numbers became significant in this section, presumably reflecting the influence of recruitment from Rock Creek. Trout population numbers increased substantially to about 250 per mile in the segment from about the mouth of Rock Creek to Milltown Dam (RM 385-366). Rainbows were the most abundant trout, with brown trout comprising the other dominant species in this segment.

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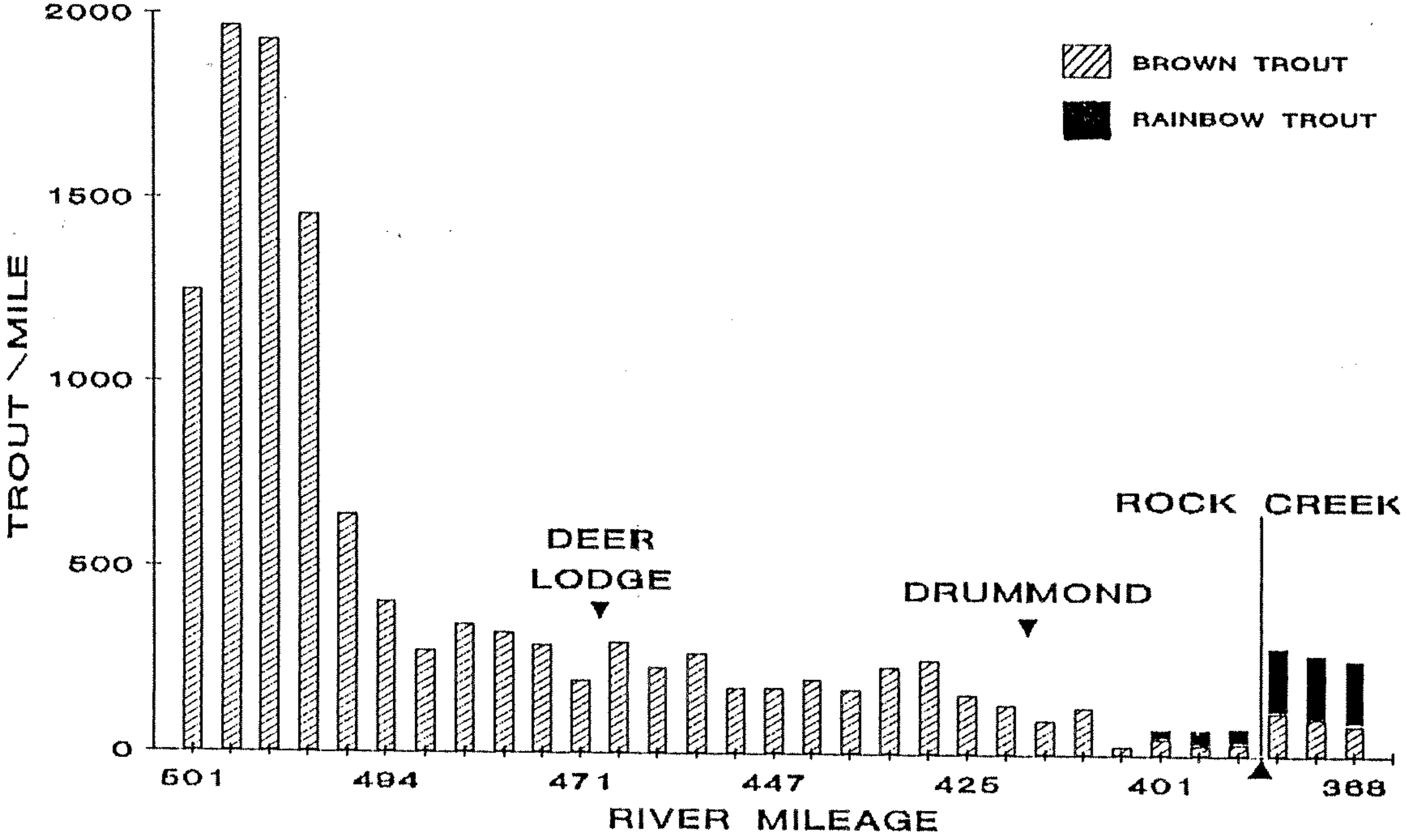

FIGURE 2-1. TOTAL TROUT PER MILE IN 31 RIVER SEGMENTS OF THE UPPER CLARK FORK SPRING 1987. SOURCE: DEPARTMENT OF FISH, WILDLIFE AND PARKS 1988

Trout Spawning and Rearing Habitat

Throughout the Clark Fork above Milltown, with the exception of the Warm Springs section, trout populations appear to be of lower density than the habitat might support. The factors that determine trout abundance over much of the upper river are not well known nor easily discernable. If physical habitat in the most basic sense is present in excess of population levels, then some other factor(s) must be limiting population density. Either the number of trout available from reproductive efforts is inadequate to fill the available habitat, or something kills a significant fraction of the population on a regular or, at least, frequent basis.

Conditions for trout reproduction in the river are poor. Most of the upper river seems unsuitable for trout reproduction due to siltation and other substrate deficiencies. Successful reproduction may occur in the uppermost reaches of the river near Warm Springs, at least in some years. The 1987 survey data collected did not estimate numbers of juvenile brown trout due to the unsuitability of the gear used, but numbers of brown trout smaller than 7.5 inches, ages 0 and 1, were recorded. In general, those numbers vary in concert with adult population estimates. Highest numbers of small (young) fish were observed in the Warm Springs area. Numbers declined generally to a low near Bearmouth and increased immediately upstream and downstream from the mouth of Rock Creek. Except in the Warm Springs area, the numbers of young trout were generally very low.

During the summer of 1987, marked juvenile hatchery rainbows were released in the low population areas below Drummond. If these fish persist in the river, then it may suggest that reproduction and juvenile survival is indeed a major limitation on population levels. A few of those stocked fish were recaptured by electrofishing in the fall of 1987.

Eggs were taken from brown trout spawners in the Warm Springs area in 1987 and placed in the hatchery for rearing. Fish reared from these eggs will be marked and released in the summer of 1988, and their survival monitored in future years. Assessment of timing and estimates of numbers of outmigrating juvenile brown trout from spawning tributaries will begin in 1988 and continue in following years.

Tributary Trout Spawning Migrations

Tributary spawning habitats appear to be limited in the upper river segment. Warm Springs Creek has been shown to have a run of hundreds of brown trout during the spawning season, and limited numbers of browns also enter Lost and

Racetrack creeks. The 1987 trapping of brown trout entering the Little Blackfoot River yielded fewer than 400 trout; far fewer than the Little Blackfoot appears capable of supporting. A similar number of river migrants was shocked in Gold Creek where access to trout is limited to only 300 yards of stream due to an artificial barrier. The importance of Flint Creek for spawning trout is unknown, but spawning substrates there are of poor quality. Rock Creek is no doubt a significant contributor to recruitment in the Clark Fork, particularly for rainbow trout.

In summary, available data are presently equivocal on the questions of recruitment, available habitat, and rates of trout mortality in river environments. However, the catch from the Little Blackfoot spawning migration trap in fall 1987 may offer some clues regarding fish population dynamics in the upper Clark Fork. Water quality and substrate conditions in the Little Blackfoot seem to be well suited to brown trout reproduction, and upstream migrants should have access to more than 30 miles of stream. The available spawning habitat would appear to easily accommodate several thousand fish. This suggests that factors controlling fish populations in the mainstem are limiting available spawners to numbers below the available spawning habitat capacity.

Middle Clark Fork Fishery (Milltown Dam to Flathead River)

Fish Species Composition

The bulk of the sport fishery in this 119.4 mile reach of the river is provided by rainbow trout along with a few brown, bull and westslope cutthroat trout. Mountain whitefish provide an important winter sport fishery. Common nongame fish species found in the reach include squawfish, redside shiners, longnose dace, coarsescale suckers and slimy sculpins.

Trout Population Estimates

Trout populations have been estimated by electrofishing and mark/recapture procedures in four study sections on the middle Clark Fork. The study sections are located in the vicinities of Milltown Dam, Missoula, Huson, and Superior (Table 2-12). Estimates in the four study sections indicate the river supports from 175 to 402 catchable rainbow trout per mile (Table 2-13). Rainbow constituted more than 90 percent of the catchable trout population in all of the study sections. Catchable brown, westslope cutthroat, and bull trout were present in the river, but their numbers were usually too low to estimate. In September 1986, estimates of 16 catchable brown and 22 catchable westslope cutthroat trout per mile were obtained in the Missoula study section.

TABLE 2-12. LOCATION, LENGTH, AND RIVER MILE INDEX BOUNDARIES OF FISH POPULATION STUDY SECTIONS ON THE CLARK FORK.

Section Name	Description of Location	Section Length (mi)	River Mile Index Boundaries
Milltown	Milltown Dam to 2.8 miles upstream from confluence of Rattlesnake Cr.	3.4	364.4 to 361.0
Missoula	Confluence of Bitterroot R. to 0.5 mile upstream from Harper Bridge	8.6	350.5 to 341.9
Huson	Confluence of Sixmile Cr. to 4.0 miles upstream from confluence of Petty Cr.	4.5	328.2 to 323.7
Superior	Confluence of Cedar Cr. to confluence of Dry Cr.	6.3	286.6 to 280.3

Source: Berg 1986a.

TABLE 2-13. TROUT POPULATION ESTIMATES IN FOUR STUDY SECTIONS OF THE CLARK FORK.

Study Section	Date of Estimate	Fish Species	Section Length (mi)	Catchable[1] Trout/Section	Catchable[1] Trout/Mile
Missoula	Sept., 1984	Rainbow	8.6	1,506	175
Missoula	June, 1985	Rainbow	8.6	1,804	210
Milltown	June, 1985	Rainbow	3.4	1,035	288
Superior	July, 1985	Rainbow	6.3	1,382	219
Huson	Sept., 1985	Rainbow	4.5	1,749	389
Missoula	Sept., 1986	Rainbow	8.6	3,461	402
		Brown	8.6	137	16
		W.S. Cutthroat	8.6	187	22
Huson	Sept., 1986	Rainbow	4.5	1,504	334
			All Section-Rainbow Mean (X)		288

1 Catchable trout 7 inches total length and larger.
Source: Berg 1986a.

The density of catchable trout is less than expected for comparable trout streams the size of the Clark Fork. While the Clark Fork supports an average of 200 to 400 catchable trout per mile, other large trout rivers in Montana often support 2,000 to 3,000 or more catchable trout per mile (Berg 1984).

Major tributaries to the Clark Fork support larger populations of catchable trout than the mainstem of the river. The mean number of catchable rainbow trout per mile in the Blackfoot River over a three-year period from 1983 to 1985 was 445 percent larger than the mean number of catchable rainbow trout per mile in the Clark Fork during a three-year period from 1984 to 1986 (Tables 2-13 and 2-14). The comparison of the Blackfoot River with the Clark Fork is appropriate because both rivers have similar physical habitat characteristics. Higher water quality in the Blackfoot River appears to be the major difference between the two rivers.

TABLE 2-14. TROUT POPULATION ESTIMATES IN THE JOHNSRUD SECTION OF THE BLACKFOOT RIVER, APPROXIMATELY 13 MILES UPSTREAM FROM BONNER.

Date of Estimate	Fish Species	Section Length (mi)	Catchable[1] Trout/Section	Catchable[1] Trout/Mile
June, 1985	Rainbow	3.6	5,225	1,451
June, 1984	Rainbow	3.6	3,186	885
June, 1983	Rainbow	3.6	5,445	1,512
		Mean (X)	4,618	1,282

[1] Catchable trout 7 inches total length and larger.

Source: Berg 1986a.

Scales were collected from trout during population sampling to determine growth rates and age structure of the trout populations. Preliminary findings indicate growth rates of trout in the Clark Fork are relatively high when compared with trout streams of similar size. This indicates that food supply is probably not a limiting factor for trout populations in the Clark Fork. Furthermore, it suggests that the Clark Fork may be "under seeded" and that recruitment may be a limiting factor.

Trout Spawning and Rearing Habitat

Visual surveys have been made in the Milltown, Missoula, Huson, and Superior study sections during the rainbow and brown trout spawning periods in an attempt to locate trout redds. To date, only brown trout redds have been located, in the Milltown and Missoula sections. Because a very limited amount of time has been spent on visual surveys, additional observations must be made to evaluate the extent of trout spawning in the river.

The search for trout redds in the middle Clark Fork is hindered during both rainbow and brown trout spawning periods by poor visibility in deep water areas where spawning could occur. Visibility is sometimes precluded even in shallow water during the rainbow trout spawning period due to highly turbid spring runoff conditions. For this reason, use of the Clark Fork for trout spawning is also being evaluated by electrofishing during the spawning periods in an attempt to locate concentrations of mature fish in spawning condition.

Suitable rainbow, westslope cutthroat, and brown trout rearing habitat is found primarily along the edge of the Clark Fork's channel. Limited electrofishing surveys of this habitat indicated young-of-the-year trout were relatively more abundant in the Milltown and Superior study section than in the Missoula and Huson sections during late summer of 1985 (Table 2-15). Young-of-the-year trout were relatively scarce in all four study areas. In the Missouri River below Holter Dam, a stream comparable in size to the Clark Fork below Milltown Dam, young-of-the-year trout were at least ten times more abundant than in the Clark Fork (Berg 1983).

TABLE 2-15. AVERAGE SIZE AND RELATIVE ABUNDANCE OF YOUNG-OF-THE-YEAR TROUT SAMPLED BY ELECTROFISHING.

Study Section	Date	Trout Species	Average Length (mm)	Juvenile Trout Electrofished/Hour
Milltown	8-26-85	Rainbow	57	7.1
		Brown	90	10.1
Missoula (side channel)	8-28-85	Rainbow	76	1.7
		Brown	94	10.0
Missoula (main river)	8-28-85	Rainbow	63	1.4
		Brown	--	0.0
Huson	8-30 & 9-4-85	Rainbow	60	3.6
		Brown	77	0.3
Superior	9-5-85	Rainbow	58	14.6
		Brown	81	1.1

Source: Berg 1986a.

Tributary Trout Spawning Migrations

In an effort to evaluate spawning periodicity and sources of trout recruitment in the middle Clark Fork, the lower reaches of several tributaries were electrofished or trapped during trout spawning periods to locate spawning migrants from the Clark Fork.

Most members of the trout family migrate during the spawning season in search of suitable spawning sites (Hubbs and Lagler 1970). Spawning movements of lake dwelling salmonid populations into inlet or outlet streams have been extensively documented for rainbow (Rayner 1942; Hartman et al. 1962; Calhoun 1966; Scott and Crossman 1973) and brown trout (Fenderson 1958; Stuart 1957) and mountain whitefish (Snyder 1918; Calhoun 1966).

Less information is available on spawning movements of river-dwelling salmonid populations into feeder streams. Calhoun (1966) reports resident rainbow trout populations in streams tend to move upstream, and if possible into tributaries to spawn. River-dwelling brown trout in Ontario normally seek tributary streams for spawning purposes (MacKay 1963). Spawning movements of mountain whitefish from larger streams into some tributaries have been observed in Montana (Liebelt 1970; Brown 1971).

Electrofishing and fish trapping surveys indicate considerable numbers of rainbow, brown, and westslope cutthroat trout migrate from the Clark Fork into tributaries to spawn (Berg 1986a). Significant trout fry outmigrations from several tributaries, monitored with fry traps, indicated tributaries provide considerable recruitment of juvenile trout to the Clark Fork (Table 2-16).

Lower Clark Fork Fishery (Flathead River to Lake Pend Oreille)

Fish species composition in the lower Clark Fork has been significantly altered by habitat changes and the introduction of new species. Of the ten game species found in the lower Clark Fork, only the westslope cutthroat, bull trout, and mountain whitefish are endemic. Five game species introduced since the impoundment of the reservoirs are northern pike, burbot or ling, kokanee salmon, silver salmon, and smallmouth bass. Northern pike resulted from an illegal introduction while the other four species were planned introductions by DFWP. Of the ten nongame fish species, only the bullhead, pumpkinseed, and perch were introduced by man.

Attempts to establish a viable sport fishery in the Noxon Rapids and Cabinet Gorge reservoirs have been mostly unsuccessful. However, a shift in management emphasis in 1982 away from cold water fish species, such as rainbow trout to cool water species such as smallmouth bass, has shown great promise for future fisheries. Efforts on each reservoir have differed due to different reservoir conditions.

Cabinet Gorge Reservoir, 1953-85

The Cabinet Gorge water exchange rate or flushing time, during spring high water is about one to three days and during the remainder of the year about one week. Reservoir fluctuations from 1953-85 were slightly different since Cabinet Gorge was used as a reregulation reservoir for Noxon Rapids Reservoir, which came on line in 1959. Typically, daily and weekly fluctuations during that period often were two to four feet respectively; annual maximum fluctuations

TABLE 2-16. TROUT FRY OUTMIGRATION RATES MONITORED IN FIVE TRIBUTARIES OF THE CLARK FORK DURING 1985.

		Rainbow Trout		W.S. Cutthroat Trout		Brown Trout		Bull Trout	
Stream	Total Trap Nights	Total Number Captured	Average Catch/ Trap Night	Total Number Captured	Average Catch/ Trap Night	Total Number Captured	Average Catch/ Trap Night	Total Number Captured	Average Catch/ Trap Night
Fish Cr.	57	626	11.00	25	0.44	3	0.05	1	0.02
Ninemile Cr.	46	493	10.72	0	0.00	14	0.30	0	0.00
Petty Cr.	49	346	7.06	7	0.14	0	0.00	0	0.00
Rattlesnake Cr.	31	65	2.10	1	0.03	1	0.03	0	0.00
Sixmile Cr.	5	4	0.80	0	0.00	0	0.00	0	0.00

Source: Berg 1986b.

seldom exceeded ten feet.

Attempts to establish a sport fishery at Cabinet Gorge Reservoir during the period of 1953 through 1963 included planting large numbers of hatchery-reared salmonids. During these years, a total of about 1.7 million kokanee salmon, 1.2 million Yellowstone cutthroat, 0.1 million silver salmon, and 0.5 million rainbow trout were released into the reservoir. These planted fish provided a very limited sport fishery and did not establish self-sustaining populations within the reservoir.

Since 1963 to the present, fish planting has been limited to planting catchable-size rainbow trout near the Bull River campground and eyed brown trout eggs near the mouth of Elk Creek in an attempt to establish a spawning run. The emphasis for fishery management has been shifted to Noxon Rapids Reservoir because the fishery that develops there will probably determine the fishery in Cabinet Gorge Reservoir.

Noxon Rapids Reservoir, 1958-79

This reservoir has rapid water exchange rates of about one exchange per week during a normal spring high water period and one exchange per three weeks during the remainder of the year. During maximum drawdown of 54 feet, the surface area is reduced from 8,600 acres at full pool to 5,500 acres.

Reservoir operation during the 1958-79 period followed two distinct patterns. From 1958-60, maximum annual drawdown was limited to ten feet, and from 1961-79 maximum annual drawdown ranged from 26 to 54 feet and averaged 35 feet. In 1961, Noxon Rapids Reservoir was integrated into the Northwest Power Pool under terms of the Northwest Power Coordination Agreement. Deep, spring season drawdowns were in response to calls for power from the Bonneville Power Administration or other utilities. The spring drawdowns also created up to 230,000 AF of storage space for flood control.

Initial fisheries management efforts to establish a viable fishery in Noxon Rapids Reservoir were mostly unsuccessful. Chemical treatment to remove unwanted rough fish followed by planting rainbow trout fingerlings produced an excellent fishery for a brief period when the stream was first impounded. Subsequent fish plantings have included brown trout (690,000 fry), kokanee salmon (1,000,000 fry), westslope cutthroat trout (926,000 fingerlings), burbot (420 adults), and rainbow trout (200,000 fingerlings). These plants have been unsuccessful.

Fish populations noticeably increased from 1980 to 1985. During this period, Noxon Rapids Reservoir drawdowns were within a maximum of 12 feet. Increased numbers of game fish and forage fish during this period are believed to be a result of the relatively more stable reservoir conditions. In 1982 and 1983, smallmouth bass were planted in the reservoir, and by 1984, the fish were being caught by anglers. At the same time, the numbers of largemouth bass were also increasing.

A new reservoir operation plan that reduces the extent and frequency of drawdowns was initiated in 1986 following a meeting of the Washington Water Power Company, the Northwest Power Planning Council, and the DFWP. In 1985, the DFWP and WWP began a 3-year pilot fisheries development program. Hundreds of thousands of brown trout eggs and fingerlings and over 2,000 adult burbot have been planted in the reservoirs. The program was recently extended through 1989 and expanded to include enhancements for bass.

The fish populations of both Noxon Rapids and Cabinet Gorge reservoirs have been periodically sampled with gill nets since 1958. The results indicate a shift in species composition, probably as a response to the more stable water levels in the 1980s. Mountain whitefish, rainbow trout, and bull trout have virtually disappeared from Cabinet Gorge, while the numbers of largemouth bass, brown trout, and yellow perch have increased. Surveys also indicate increased numbers of brown trout are spawning in the Bull River, a tributary to Cabinet Gorge Reservoir.

Fish population samples from Noxon Rapids Reservoir indicate fairly stable populations from 1960 through 1982, followed by a marked increase in 1987. Much of the increased catch was made up of yellow perch, squawfish, and coarsescale suckers. Brown trout increased during 1982-87 probably due to improved natural reproduction. Bull trout and rainbow trout numbers have remained relatively stable, while largemouth and smallmouth bass appear to be increasing. The stabilization of reservoir levels appears to have enhanced populations of forage fish species, such as redside shiners, yellow perch, peamouth, and pumpkinseed. Burbot have not been taken in the gill net samples, and special sampling efforts will be required to determine their success.

Growth rates of brown trout and yellow perch have increased during the 1980s. The drawdown restrictions of Noxon reservoir is expected to result in both improved growth rate and greater fish numbers in the future.

Fisherman Use and Benefits

The number of fishermen using a body of water is one measure of its value as a recreational resource. Fisherman use, or "fishing pressure," on Montana waters has been estimated by the DFWP each year since 1982. The Montana Fisheries Survey uses a questionnaire mailed to a sample of fishing license holders to determine where and how often they have fished. The data are compiled for individual lakes and streams and summed to provide a measure of fishing pressure in an entire drainage.

The estimated total fishing pressure on all lakes and streams within the Clark Fork Basin (excluding the upper Flathead River drainage) has ranged from 215,272 to 242,691 angler days per year in the four annual surveys conducted since 1982. The fishing pressure statistics indicate resident fishermen accounted for 83 percent of the total, while 17 percent were nonresidents from various locations in the region (McFarland 1988).

A comparison of fishing pressure between streams and between segments of a stream is an indication of relative recreational importance. Table 2-17 provides a breakdown of the 1985-86 fishing pressure statistics for streams in the Clark Fork Basin and for some selected Montana rivers. The data indicate that all segments of the Clark Fork sustain significant fishing pressure. Fishing pressure on individual segments of the river (upper and middle river) are comparable to pressure on the Blackfoot River and Rock Creek. Much higher fishing pressure occurs on Montana's more famous trout streams such as the Madison and Big Hole rivers.

Although differences in pressure among streams may reflect fishing success, other factors such as access, distance to population centers, aesthetics, fishing regulations, etc., may have an equally important influence on the numbers of fishermen using a stream.

In the past, the primary indicator of the economic value of fish and wildlife in Montana has been dollars spent by sportsmen. Although these expenditures are important to local and state economies, they do not reflect the total recreational value of the resource that includes the personal benefits one receives from hunting and fishing (Montana Department of Fish, Wildlife and Parks 1988).

In 1985, the DFWP in cooperation with the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM), initiated a two-year study to document the recreation value of sport fishing and hunting in Montana (Duffield et al. 1987). Using widely accepted recreation analysis methods

TABLE 2-17. ESTIMATED FISHING PRESSURE ON THE CLARK FORK AND SELECTED MONTANA RIVERS (1985-1986).

River	Fishing Pressure
Lower Clark Fork (including tribs)	21,237
Middle Clark Fork (mainstem)	30,414
Middle Clark Fork Tributaries	6,835
Upper Clark Fork (mainstem)	17,578
Upper Clark Fork Tributaries	24,208
Bitterroot River (mainstem)	56,024
Blackfoot River (mainstem)	28,974
Rock Creek (mainstem)	27,881
Big Hole River	47,910
Madison River	108,712
State Total	1,192,658

Source: Duffield et al. 1987

(U.S. Water Resources Council 1979, 1983), the department was able to develop an estimate of how much additional amount recreationists would be willing to pay over and above their actual travel costs to have access to a particular site for fishing. The study data provides net economic values appropriate for benefit/cost analysis or where economic efficiency decisions are being made.

The data used in the study of fishing values was obtained through questionnaires mailed to approximately 36,000 resident (92 percent) and nonresident (8 percent) fishermen. Fifty-four percent, or 19,271 of the surveys were returned. In addition, a supplemental survey was administered to obtain socio-economic data from approximately 2,000 fishermen. All data were then analyzed to estimate fishing pressure, net economic values (willingness to pay), and actual expenditures by fishermen on the major fishing streams and lakes in Montana.

The net economic value for the Clark Fork and other important Montana rivers is shown in Table 2-18. The value per day multiplied by fishing pressure provides estimated annual site value. The site values for the Clark Fork mainstem indicate the upper Clark Fork is valued at about one-half the middle river. The lower river value is the highest, but data for this segment includes tributary data that undoubtedly influenced the results.

The upper Clark Fork is valued at a fraction of the more popular fishing streams such as the Big Hole, Bitterroot, and Blackfoot. The sum total value of stream fishing in the Clark Fork Basin is estimated to be approximately $8.1 million; lake fishing in the basin was estimated to be worth an additional $2.6 million.

The authors of the economic evaluation consider these values to be highly conservative, but useful measures of the relative economic importance of sport fishing in Montana.

RECREATION AND AESTHETICS

The Clark Fork Basin provides exceptional outdoor recreation opportunities from near its headwaters to Lake Pend Oreille. The region is known for its unusual scenic beauty, pristine mountain lakes and streams, and abundant fish and wildlife. Recreation and tourism are considered valuable economic attributes of the region, but relatively little has been done to measure their actual use, value, or potential.

The recreational value of a river is affected by many factors, including public access, use levels, type of

TABLE 2-18. NET ECONOMIC VALUE OF THE CLARK FORK AND SELECTED MONTANA RIVERS

Stream	Value/Day	Site Value (in thousands of dollars)
Lower Clark Fork (includes tribs.)	$64.51	$ 1,370
Middle Clark Fork (mainstem)	30.27	921
Upper Clark Fork (mainstem)	23.97	421
Bitterroot (mainstem)	$32.41	$ 1,816
Blackfoot (mainstem)	65.30	1,880
Rock Creek (mainstem)	61.82	1,724
Madison	$75.16	$ 8,171
Big Hole	61.82	1,724
State Total		$57,081

Source: Duffield et al. 1987

scenery, rapids, fish and wildlife populations, level of development, and on-site management. Public taste regarding these and other river attributes vary so that measurements of recreation values may differ according to the measurement methods.

The recreational and aesthetic values of the Clark Fork Basin were described and ranked by the Montana River Study (Graham 1986). The study provides an inventory and criteria to assess the significance of the river's fish and wildlife values and recreational, natural, and cultural features. The following has been paraphrased from a summary of the study published by Montana Outdoors (Hilander 1988).

The upper Clark Fork drainage (above Milltown Dam) was ranked high for most resource values. The upper basin contains three sport fisheries ranked as Class I (unique or outstanding), and 30 stream reaches were ranked as Class I for habitat and species value. A total of 740 stream miles in the basin were ranked as Class II fisheries. Scenic quality was ranked as substantial or outstanding on half of the river segments evaluated. Recreational attributes were ranked as moderate on 47 percent, with 34 percent either substantial or outstanding. The three major tributaries of the upper basin--Rock Creek, Blackfoot, and Bitterroot--all have Class I fisheries, wildlife areas, and natural areas.

The lower Clark Fork drainage received lower rankings largely due to the impacts of development. Fisheries values were ranked Class I on only 1 percent of the reaches evaluated, and only four stream reaches were ranked as Class II sport fishery value. Scenic quality was rated Class I or II on only 3 percent of the 1,350 miles of stream assessed for recreation. Three-fourths of the tributary drainages in the lower river basin were ranked Class I or II for wildlife values.

Hagmann (1979) estimated recreational use on the upper Clark Fork and its major tributaries (Little Blackfoot, Flint Creek, and Rock Creek) during 1978-79. Data obtained by direct observation and questionnaires indicated the use on tributaries exceeded use on the mainstem, with Rock Creek receiving the most recreational visits. Summer visits on the upper Clark Fork focused on trout fishing--above Deer Lodge and between Schwartz Creek and Milltown. In the winter period, fishing was again the dominant activity, followed by waterfowl hunting. Camping, picnicking, floating, and other recreational activities were also reported by the visitors. Almost 70 percent of the recreationists interviewed were Montanans, and approximately 25 percent of all recreational visits were by nonresidents. A majority of users rated access and recreation site development along the river as adequate. Four fishing access sites are located along the river, and many private sites are accessible. Stream access along the Clark Fork is likely to be an increasingly important issue as greater numbers of recreationists use the river basin.

A limited survey of recreation use of the Cabinet Gorge and Noxon Rapids reservoirs was conducted in the summer of 1986 (Schwiesow and Burch 1987), and recreation access and facilities were also inventoried (Schwiesow 1987). Sponsored by the Washington Water Power Company, these surveys were conducted to aid recreational planning in the future. The user survey involved a standard interview of individuals participating in various recreational activities along the Clark Fork from two miles west of Thompson Falls to the Cabinet Gorge Dam, 25 miles east of Sandpoint, Idaho. A total of 120 individuals were interviewed during the period of mid-June to early September 1986. The survey results indicated more than half (51 percent) of those interviewed were Montanans, and 55 percent of those were from Sanders County. Forty-nine percent of the total interviewees were from one of 19 states or provinces other than Montana. Most respondents (74 percent) used the reservoirs for fishing, camping, and boating. Easy access attracted most people to the sites surveyed, and 80 percent approved of the facilities available. Many of the respondents preferred recreation sites that offered isolation from other recreationists.

Duffield (1981) estimated the economic value of recreation on the upper Clark Fork and its tributaries. His study used the recreational use survey by Hagmann (1979) and traffic surveys on Rock Creek by the Lolo National Forest. The dollar values of these visits were estimated using the travel cost method. The study results indicated a substantial annual use value for instream uses of upper Clark Fork ranking between a low of $500,000 and a high of $1.4 million per year in 1979.

MUNICIPAL WATER SUPPLIES

Public water supplies in the Clark Fork Basin are derived from a number of sources. The majority of the communities use ground water as their primary source of water, but a few rely heavily on tributary surface water. In the Missoula area, the public water supply is obtained primarily from the Missoula Aquifer, which is partially recharged by the Clark Fork. An inventory of municipal water supplies in the basin is provided in Table 2-19.

The DHES-WQB has full responsibility for administering the Safe Drinking Water Act, and it monitors these public water supplies to insure that bacterial, chemical, and

TABLE 2-19. INVENTORY OF MUNICIPAL WATER SUPPLIES IN THE CLARK FORK BASIN

COMMUNITY	POPULATION SERVED WATER USAGE	SOURCE(S) OF WATER	STORAGE CAPACITY/FACILITIES	DISTRIBUTION FACILITIES	TREATMENT	COMMENTS
Butte	35,000	Surface water from: Big Hole River,* Moulton Reservoir, Butcher Town Reservoir, Basin Creek Reservoir, South Fork Reservoir, West Side Reservoir.	85,000,000 gallons	Pumps, water mains.	Chlorination, alum.	Much of distribution system is obsolete and in bad shape The entire Butte water supply system in under revie
Anaconda	10,000 Summer: 4 million gallons/day (MGD) Winter: 2.75 MGD	Ground water: 3 wells* Surface water from: Meyers Dam, Hearst Lake.	--------	Pumps, pipelines.	Chlorination.	
Warm Springs State Hospital	500 Summer: 900,000 gallons per day(gpd) Winter: 320,000 gpd.	Ground water: 2 wells.	120,000 gallons--storage tank.	Pumps, pipelines, gravity.	Chlorination.	
Galen State Hospital	500 Summer: 120,000 gpd. Winter: 60-80,000 gpd.	Ground water: 2 wells.	50,000 gallons	Pumps, pipelines, gravity.	Chlorination.	
Deer Lodge	4,300	Ground water: 2 wells* Surface water from Tin Cup Creek.	740,000 gallons--storage reservoirs plus buried storage tank.	Pumps, pipelines, gravity.	Chlorination of surface water when in use.	
Drummond	--------	No public water system (use shallow individual wells).				
Bonner	150 Summer: 14,000gpd Winter: 10,000gpd	Ground water: 1 well.	900 gallons--pressure tank.	Pump, pipelines.	None	
Milltown	100	Ground water: 2 wells.	Pressure tank.	Pumps, pipelines.	None	System installed under Superfund program.
Missoula	45,000	Ground water: well network (Missoula aquifer recharge by Clark Fork River and Rattlesnake Creek).	24,338,000 gallons--buried storage tanks.	Pumps, pipelines.	Chlorination of surface water when in use.	

TABLE 2-19 (Con't). INVENTORY OF MUNICIPAL WATER SUPPLIES IN THE CLARK FORK BASIN

COMMUNITY	POPULATION SERVED WATER USAGE	SOURCE(S) OF WATER	STORAGE CAPACITY/FACILITIES	DISTRIBUTION FACILITIES	TREATMENT	COMMENTS
Lolo	1,600-1,800 Summer: 300,000gpd Winter: 150,000gpd	Ground water: 2 wells.	250,000 gallons--storage tank.	Pumps, pipelines, gravity.	None	
Stevensville	1,200	Surface water from: Burnt Fork Creek. Ground water: 3 wells.	500,000 gallons--storage tank.	Pumps, pipelines, gravity.	Chlorination.	Direct filtration plant treats water from infiltration gallery on Burnt Fork Creek.
Hamilton	4,000 Summer: 3 MGD+ Winter: 1.2 MGD	Ground water: 5 wells.	500,000 gallons--storage tank.	Pumps, pipelines, gravity.	Chlorination.	Water rationing in summer when necessary.
Darby	580	Ground water: 4 wells.	100,000 gallons--storage tank.	Pumps, pipelines, gravity.	None	Water rationing in summer when necessary.
Alberton	400 75,000gpd	Ground water: Infiltration gallery plus 1 well.	300,000 gallons	Pumps, pipelines, gravity.	Chlorination.	
Superior	1,500 130 million gallons per year.	Ground water: 2 wells plus 1 mine adit.	40,000 gallons	Pumps, pipelines, gravity.	None	
Plains	1,100 Summer: 350,000gpd Winter 125,000gpd	Ground water: 1 well. Spring: estimated flow 300gpm.	500,000 gallons--storage tank.	Pumps, pipelines, gravity.	Chlorination	Additional well (Balch well) is idle.
Hot Springs	750	Surface water from: Hot Springs Creek Ground water: 3 wells.	200,000 gallons--storage reservoir	Pumps, pipelines.	Chlorination	Turbidity and *Giardia* problems in the past.
Thompson Falls	1,500	Surface water from: Ashley Creek. Ground water: 2 wells.	365,000 gallons--reservoir, 204,000 gallon reservoir.	Pumps, water mains, gravity.	Chlorination	Improvements made to intake diversion dam on Ashley Creek in 1987.
Noxon	240	Ground water: 2 wells.	25,000 gallons--storage tank.	Pumps, wooden water mains.	None.	Storage tank in poor condition, needs to be replaced. Wooden water mains leak.

*Primary water source

Source: DHES 1988a.

radiological contents remain within safe limits. WQB personnel review and approve all construction and modifications to public water systems and conduct annual inspections of each system.

INDUSTRIAL/MUNICIPAL WASTEWATER DISPOSAL

A number of industries and municipalities discharge wastewater to the Clark Fork and its tributaries. These are point source discharges that are permitted by the DHES-WQB under the Montana Pollutant Discharge Elimination System (MPDES). A list of MPDES permittees in the Clark Fork Basin is provided in Table 2-20. These industries and municipalities discharge a variety of substances to the Clark Fork and its tributaries, including nutrients, organic wastes, and sediment.

Nearly all of the cities and towns in the basin have wastewater treatment plants, although a few of the smaller communities such as Gold Creek, Clinton, Bonner, and Noxon are served solely by septic systems. The wastewater treatment plants range from fairly simple lagoon systems to more elaborate secondary treatment facilities in the larger cities such as Butte and Missoula. An inventory of WWTP's in the basin is provided in Table 2-21. All of the operators (except Anaconda, whose system does not currently discharge to state waters) are required to monitor their discharges and report to the DHES-WQB. These monitoring reports are reviewed by WQB personnel to ensure compliance with permit requirements. Regular inspections of the facilities are also conducted by the WQB.

Among the larger dischargers in the basin, the two that have raised the most controversy are the Frenchtown pulp mill (previously owned by Champion International Corporation, now owned by Stone Container Corporation) and the Missoula WWTP. In 1983, Champion International applied for a permit that would allow them to discharge a portion of the wastewater into the Clark Fork year-round, rather than only during spring high flows (as stipulated by their previous permits). Although the WQB was initially inclined to approve the permit, public concern over the lack of scientific data to support such a permit modification resulted in the issuance of an interim two-year permit and the initiation of a number of scientific studies. The WQB analyzed the information gathered during the two-year study period and issued a draft environmental impact statement (EIS) late in 1985, recommending renewal of the permit for five years. Public concerns over the EIS led to the issuance of an addendum to the EIS, wherein some of the disputed issues were clarified. A five-year permit for the pulp mill was finally issued in November 1986. The permit stipulated that wastewater could not be

TABLE 2-20. MONTANA WASTEWATER DISCHARGE PERMITS IN THE CLARK FORK BASIN

Permittee's Name	Permit Expiration Date
Anaconda Company	01-31-88
Montana Resources, Inc.	02-28-88
Butte WWTP	03-31-93
Rocker Water & Sewer District	05-31-88
Montana Warm Springs State Hospital	05-31-93
Montana Galen State Hospital	01-31-91
Montana Fish & Game Washoe Hatchery	08-01-89
City of Deer Lodge	05-31-93
Town of Philipsburg	05-31-93
Town of Drummond	05-31-93
Missoula WWTP	03-31-93
Champion Building Products	03-31-93
Stone Container Corp.	09-30-91
J. R. Daily	03-31-92
Lolo WWTP	10-31-92
Stevensville WWTP	12-31-88
Town of Stevensville	12-31-88
City of Hamilton	06-30-93
Town of Darby	05-31-93
Town of Alberton	05-31-92
Town of Superior	05-31-92
Montana Power Company, Kerr Dam	06-30-89
City of Ronan	09-30-88
City of St. Ignatius	09-30-88
Montana Fish & Game Jocko Hatchery	08-01-89
Charlo Sewer District	06-30-89
Town of Hot Springs	01-31-90
Town of Thompson Falls	11-30-88
Western Materials, Inc.	03-31-90
Nicon Minerals Ventures	06-30-88

Source: DHES 1988a.

TABLE 2-21. INVENTORY OF WASTEWATER TREATMENT PLANTS IN THE CLARK FORK BASIN

FACILITY TYPE HISTORY	DESIGN SPECIFICATIONS RECEIVING WATERS	PARAMETERS MONITORED EFFLUENT LIMITATIONS	SELF MONITORING REQUIREMENTS	PERFORMANCE RECORD	RECENT OR PROPOSED UPGRADES/ FUTURE ACTIVITIES
BUTTE					
• Secondary treatment facility. • Complete mix activated sludge. • Present facility began operation in 1979. • Current discharge permit expires March 1993.	• System serves population of 40,000. • Average design flow is 8.5 MGD. • Receiving waters: Silver Bow Creek.	• Parameters monitored: flow, total residual chlorine, BOD_5, pH, total suspended solids (TSS), oil and grease, fecal coliforms, temp. • Effluent Limitations: <u>30-day period</u> pH 6-9 TSS 30 mg/l BOD_5 30 mg/l Oil & grease 10 mg/l Fecal coliforms 200/100 ml <u>7-day period</u> pH 6-9 TSS 45 mg/l BOD_5 45 mg/l Oil & grease --- Fecal coliforms 400/100 ml • Cl_2 in any grab sample shall not exceed 0.50 mg/l • Effluent loadings: 2,002 lb/day TSS, BOD_5	Discharge: • Continuous flow. • Daily Cl_2, pH, oil and grease. • Once/weekday BOD_5, TSS. • Twice/week fecal coliforms. • Weekly temperature. Influent: • Weekly TSS, BOD_5.	• In compliance with discharge permit.	---------------
ANACONDA					
• Two-cell aerated lagoon facility. • Present facility operational in 1986. • Prior to 1986, raw sewage was conveyed to Opportunity Ponds. • Discharge is still to the Opportunity Ponds. The city has applied for and received a permit with nondegradation-based limits to discharge to either Warm Springs Creek or the Mill-Willow Bypass.	• System serves approximately 8,000 people. • Average design flow 3 MGD.	• Not applicable.	• Not applicable.	• Not applicable.	• The Anaconda Minerals Company has indicated it would like to dry up the tailings ponds that are currently receiving the treated wastewater. The city plans to appeal the nondegradation limits in their discharge permit. Discharge to a wetland site is also under consideration.

TABLE 2-21 (Con't). INVENTORY OF WASTEWATER TREATMENT PLANTS IN THE CLARK FORK BASIN

FACILITY TYPE HISTORY	DESIGN SPECIFICATIONS RECEIVING WATERS	PARAMETERS MONITORED EFFLUENT LIMITATIONS	SELF MONITORING REQUIREMENTS	PERFORMANCE RECORD	RECENT OR PROPOSED UPGRADES/ FUTURE ACTIVITIES
WARM SPRINGS STATE HOSPITAL					
• Facultative Sewage Lagoon. • Present facility began operation in 1960. • Current permit expires March 1993.	• System serves approximately 500 people. • Receiving waters: Clark Fork.	• Parameters monitored: flow, BOD_5, TSS, pH, fecal coliforms. • Effluent limitations: samples). 30-day period pH 6-9 BOD_5 30 mg/l TSS 100 mg/l 7-day period pH 6-9 BOD_5 45 mg/l TSS 135 mg/l	• Monthly instantaneous flow. • Quarterly BOD_5, TSS, pH, fecal coliforms (grab	• In compliance with discharge permit.	• Recent modifications included improvements to dikes and the outfall structure.
GALEN STATE HOSPITAL					
• Extended aeration wastewater treatment facility. • Present facility began operation in 1951. • Current permit expires January 1991.	• System designed to serve population of 1,500. • Currently serves about 300. • Average design flow 0.15 MGD. • Receiving waters: Clark Fork.	• Parameters monitored: flow, BOD_5, TSS, fecal coliforms, pH, Cl_2. • Effluent limitations: 30-day period pH 6-9 BOD_5 30 mg/l TSS 30 mg/l Fecal coliforms 20,000/100 ml (April - October) 7-day period pH 6-9 BOD_5 45 mg/l TSS 45 mg/l Fecal coliforms 40,000/100 ml (April - October) • Cl_2 in any grab sample shall not exceed 0.3 mg/l.	• Continuous flow. • Monthly BOD_5, TSS, fecal coliforms grab samples. • Weekly pH, Cl_2 grab samples.	• Occasional violation of TSS, BOD_5, and fecal coliforms.	• In 1987 the Galen sewage treatment plant was extensively refurbished. The improvements should take care of the occassional permit violations.

TABLE 2-21 (Con't). INVENTORY OF WASTEWATER TREATMENT PLANTS IN THE CLARK FORK BASIN

FACILITY TYPE HISTORY	DESIGN SPECIFICATIONS RECEIVING WATERS	PARAMETERS MONITORED EFFLUENT LIMITATIONS	SELF MONITORING REQUIREMENTSRECORD	PERFORMANCE	RECENT OR PROPOSED UPGRADES/ FUTURE ACTIVITIES
DEER LODGE					
• Aerated lagoon system. • Present plant began operation in January 1985. • Current discharge permit expires March 1993.	• System designed for a population of 5,550, currently serves 4,000. • Average design flows: 1.5 MGD winter, 3.3 MGD summer.	• Parameters monitored: flow, pH, TSS, BOD_5, fecal coliforms. • Effluent limitations: <u>30-day period</u> pH 6-9 BOD_5 30 mg/l TSS 100 mg/l Fecal coliforms 2500/100 ml (April - October) <u>7-day period</u> pH 6-9 BOD_5 45 mg/l TSS 135 mg/l Fecal coliforms 5,000/100 ml (April - October)	• Weekly instantaneous flow measurements. • Monthly grab samples.	• First year winter flows averaged 1.3 MGD • First year summer flows averaged greater than 5 MGD due to nearby irrigation ditches and practices. • In compliance with discharge permit.	---------------
DRUMMOND					
• Facultative sewage lagoon system. • Present system began operation in 1961. • Current permit expires March 1993.	• Serves population of about 500. • Receiving waters: Clark Fork.	• Parameters monitored: flow, BOD_5, TSS, pH, fecal coliforms. • Effluent limitations: <u>30-day period</u> pH 6-9 BOD_5 30 mg/l TSS 100 mg/l <u>7-day period</u> pH 6-9 BOD_5 45 mg/l TSS 135 mg/l	• Monthly instantaneous flow. • Quarterly BOD_5, TSS, pH, fecal coliforms (grab samples).	• In compliance with discharge permit.	---------------

TABLE 2-21 (Con't). INVENTORY OF WASTEWATER TREATMENT PLANTS IN THE CLARK FORK BASIN

FACILITY TYPE HISTORY	DESIGN SPECIFICATIONS RECEIVING WATERS	PARAMETERS MONITORED EFFLUENT LIMITATIONS	SELF MONITORING REQUIREMENTS	PERFORMANCE RECORD	RECENT OR PROPOSED UPGRADES/ FUTURE ACTIVITIES
PHILIPSBURG					
• Facultative sewage lagoon. • Plant operation began in 1955. • Current discharge permit expired March 1993.	• System serves population of approximately 1,100. • Average design flow is 0.11 MGD. • Receiving waters: Flint Creek.	• Parameters monitored: flow, BOD_5, pH, TSS, fecal coliforms. • Effluent limitations: 30-day period pH 6-9 TSS 100 mg/l BOD_5 30 mg/l 7-day period pH 6-9 TSS 100 mg/l BOD_5 45 mg/l	• Monthly instantaneous flow. • Quarterly grab samples of BOD_5, TSS, pH, and fecal coliforms.	• In compliance with discharge permit.	---------------
MISSOULA					
• Conventional activated sludge, secondary treatment facility. • Original primary facility constructed 1963. • Secondary treatment facilities added 1976. • Current discharge permit expires March 1993. • Enforcement actions taken in March 1986 and November 1987 in response to permit violations.	• System currently serves approximately 30,000. • Average design flow is 8.9 MGD. • Receiving waters: Clark Fork.	• Parameters monitored: flow, BOD_5, TSS, pH, fecal coliforms, oil and grease, total residual chlorine, total ammonia, total phosphorus, nitrate and nitrite, Kjeldahl nitrogen. • Effluent limitations: 30-day period BOD_5 30 mg/l TSS 30 mg/l pH 6-9 Oil & grease 10 mg/l Fecal coliforms 10,400/100 ml (June - September). 7-day period BOD_5 45 mg/l TSS 45 mg/l pH 6-9 Oil & grease --- Fecal coliforms 20,800/100ml (June - September) Total Cl_2 in any grab sample 0.37 mg/l (June - September) 0.30 mg/l (October - May)	• Continuous flow. o daily grab samples for pH, Cl_2. • Once/weekday composite BOD_5, TSS. • Twice/week grab sample for fecal coliforms. • Weekly composite sample for total ammonia. • Monthly composite samples for total phosphorus, nitrate and nitrite, Kjeldahl nitrogen.	• Current flows through the system are about 6.1 - 6.3 MGD. • Recurring violations of BOD_5, TSS, Cl_2, and fecal coliforms.	• Plant sludge handling improvements made in 1984. • Improvement to plant headworks in 1986. • Secondary clarifier added in 1986. • Modification to aeration system completed in 1987.

TABLE 2-21 (Con't). INVENTORY OF WASTEWATER TREATMENT PLANTS IN THE CLARK FORK BASIN

FACILITY TYPE HISTORY	DESIGN SPECIFICATIONS RECEIVING WATERS	PARAMETERS MONITORED EFFLUENT LIMITATIONS	SELF MONITORING REQUIREMENTS	PERFORMANCE RECORD	RECENT OR PROPOSED UPGRADES/ FUTURE ACTIVITIES
LOLO					
• Conventional activated sludge. • Facility began operation in 1973. • Discharge permit expires October 1992.	• System designed for 2,500; currently serves about 1,700 people. • Average design flow is 0.25 MGD. • Receiving waters: Bitterroot River.	• Parameters monitored: flow, BOD_5, TSS, pH, fecal coliforms, total residual chlorine. • Effluent limitations: 30-day period BOD_5 30 mg/l TSS 30 mg/l pH 6-9 Fecal coliforms 25,000/100ml (April - October) 7-day period BOD_5 45 mg/l TSS 45 mg/l pH 6-9 Fecal coliforms 50,000/100ml (April - October) • Total residual chlorine in discharge shall not exceed 0.5 mg/l.	• Daily instantaneous flow. • Weekly composite sample of BOD_5, TSS. • Weekly grab samples of pH, fecal coliforms. • Daily grab samples of total residual chlorine.	• In compliance with discharge permit.	• 1987 modifications included an equalization basin, new disinfection facilities, and modifications to the secondary system and sludge storage lagoon.
STEVENSVILLE					
• Oxidation ditch type activated sludge plant. • Facility completed in 1978; operational in 1979. • Current discharge permit expires December 1988.	• System designed for 3,000; currently serves about 1,200 people. • Average design flow is 0.30 MGD. • Receiving waters: Bitterroot River.	• Parameters monitored: flow, BOD_5, TSS, pH, fecal coliforms, total residual chlorine. • Effluent limitations: 30-day period BOD_5 30 mg/l TSS 30 mg/l pH 6-9 Fecal coliforms 50,000/100ml (April - October) 7-day period BOD_5 45 mg/l TSS 45 mg/l pH 6-9 Fecal coliforms 100,000/100ml (April - October) • Total residual Cl_2 0.5mg/l.	• Weekly instantaneous flow. • Monthly grab samples of BOD_5, TSS, pH, fecal coliforms.	• In compliance with discharge permit.	---------------

TABLE 2-21 (Con't). INVENTORY OF WASTEWATER TREATMENT PLANTS IN THE CLARK FORK BASIN

FACILITY TYPE HISTORY	DESIGN SPECIFICATIONS RECEIVING WATERS	PARAMETERS MONITORED EFFLUENT LIMITATIONS	SELF MONITORING REQUIREMENTS	PERFORMANCE RECORD	RECENT OR PROPOSED UPGRADES/ FUTURE ACTIVITIES
HAMILTON					
• Oxidation ditch-type activated sludge plant. • Plant began operation in 1984. • Current discharge permit expires June 1993.	• System designed for 5,200; currently serves 2,700 people. • Average design flow is 3 MGD. • Receiving waters: Bitterroot River.	• Parameters monitored: BOD$_5$, pH, TSS, fecal coliforms, total residual chlorine. • Effluent limitations: 30-day period BOD$_5$ 30 mg/l TSS 30 mg/l pH 6-9 Fecal coliforms 2500/100ml (April - October) 7-day period BOD$_5$ 45mg/l TSS 45 mg/l pH 6-9 Fecal coliforms 5000/100ml (April - October) • Cl$_2$ in any grab sample 0.5 mg/l November - May 0.15 mg/l June - October.	• Continuous flow. • Weekly composite samples of BOD$_5$, TSS. • Weekly grab samples for pH, fecal coliforms. • Daily grab sample for total residual chlorine.	• In compliance with discharge permit.	---------------
ALBERTON					
• Aerated lagoon system. • Present facility began operation in 1969, modified in 1979. • Current discharge permit expires May 1992.	• System designed to serve 700, currently serves about 400. • Average design flow is 0.3 MGD. • Receiving waters: Clark Fork.	• Parameters monitored: flow, total residual chlorine, BOD$_5$, TSS, pH, fecal coliforms, total ammonia, total phosphorus, nitrate and nitrite, Kjeldahl nitrogen. 30-day period BOD$_5$ 30 mg/l TSS 100 mg/l pH 6-9 7-day period BOD$_5$ 45 mg/l TSS 135 mg/l pH 6-9 • Cl$_2$ in any grab sample shall not exceed 0.50 mg/l.	• Monthly instantaneous flow. • Quarterly grab samples of: BOD$_5$, TSS, pH, fecal coliforms, total ammonia, total phosphorus, nitrate and nitrite, Kjeldahl nitrogen.	• Occasional BOD$_5$ violations.	---------------

TABLE 2-21 (Con't). INVENTORY OF WASTEWATER TREATMENT PLANTS IN THE CLARK FORK BASIN

FACILITY TYPE HISTORY	DESIGN SPECIFICATIONS RECEIVING WATERS	PARAMETERS MONITORED EFFLUENT LIMITATIONS	SELF MONITORING REQUIREMENTS	PERFORMANCE RECORD	RECENT OR PROPOSED UPGRADES/ FUTURE ACTIVITIES
SUPERIOR					
• Aerated lagoon system. • Present facility began operation in 1964. • Current discharge permit expires May 1992.	• System designed to serve 1,800; currently serves about 1,500. • Average design flow is 0.18 MGD. • Receiving waters: Clark Fork.	• Parameters monitored: flow, total residual chlorine, BOD_5, TSS, pH, total phosphorus, nitrate and nitrite, Kjeldahl nitrogen. • Effluent limitations: <u>30-day period</u> BOD_5 30 mg/1 TSS 100 mg/1 pH 6-9 <u>7-day period</u> BOD_5 45 mg/1 TSS 135 mg/1 pH 6-9 • Cl_2 in any grab sample shall not exceed 0.50 mg/1.	• Monthly instantaneous flow. • Quarterly grab samples of: BOD_5, TSS, pH, total phosphorus, nitrate and nitrite, Kjeldahl nitrogen.	• In compliance with discharge permit.	---------------
PLAINS					
• Two-cell aerated lagoon system with infiltration ponds. • Present facility was operational in 1983. • There is no discharge to receiving waters (wastewater infiltrates) therefore there is no discharge permit.	• System serves about 1000 people. • Average design flow is 0.16 MGD.	• Not applicable.	• Not applicable.	• Not applicable.	---------------

TABLE 2-21 (Con't). INVENTORY OF WASTEWATER TREATMENT PLANTS IN THE CLARK FORK BASIN

FACILITY TYPE HISTORY	**DESIGN SPECIFICATIONS RECEIVING WATERS**	**PARAMETERS MONITORED EFFLUENT LIMITATIONS**	**SELF MONITORING REQUIREMENTS**	**PERFORMANCE RECORD**	**RECENT OR PROPOSED UPGRADES/ FUTURE ACTIVITIES**
THOMPSON FALLS					
• Aerated lagoon system. • Original facility began operation around 1958. • Current discharge permit expires November 1988. • Present facility began operation in 1986.	• System serves about 520 people. • Average design flow estimated to be 0.088 MGD. Receiving waters: Clark Fork.	• Parameters monitored: flow, BOD_5, TSS, pH, fecal coliforms. • Effluent limitations: <u>30-day period</u> BOD_5 30 mg/l TSS 100 mg/l pH 6-9 <u>7-day period</u> BOD_5 45 mg/l TSS 135 mg/l pH 6-9	• Monthly instantaneous flow. • Quarterly grab samples of: BOD_5, TSS, pH, fecal coliforms.	• In compliance with discharge permit.	• System was upgraded in 1986 to correct seepage problems

Source: DHES 1988a.

discharged to the Clark Fork during low flow periods.

The discharge permit for the Missoula WWTP expired on September 30, 1987, but was administratively extended into 1988. The WQB prepared a preliminary environmental review (PER) in January 1988, and issued a notice in February 1988, of its intent to issue and/or review the permit. The tentative permit drafted by the WQB contained interim (one-year) biochemical oxygen demand (BOD) and total suspended solids (TSS) effluent limitations that were less strict than National Secondary Standards. These interim limits were intended to allow the city to remain in compliance while making changes that should solve the problem of periodic treatment plant upsets. The tentative permit also limited the amount of phosphorus discharged to no more than 1982 levels and required the city to conduct bioassays on the plant effluent.

There was a considerable amount of public reaction to the tentative state permit. Many people felt that the WQB was holding the city to a different (more lenient) standard for discharging than the one applied to Stone Container Corporation when its permit was renewed. There was concern over the interim BOD and TSS limits and over the possibility of increased phosphorous loading to the river. Although the plant will be held to 1982 phosphorus limits, those limits are considerably higher (593 pounds/day) than the plants actual phosphorus discharge in 1986 (275 pounds/day).

A final permit was issued by the WQB in July 1988 with in effective date of August 1, 1988. The interim limits for BOD_5 and TSS were removed from the permit. Final effluent limitations for BOD_5 and TSS are equivalent to the National Secondary Standards. A lower phosphorus limit has been imposed as a goal, along with conditions requiring additional studies to be done that will result in examination of various phosphorus-reducing alternatives.

WATER RESERVATIONS

Introduction

Montana's 1973 Water Use Act allows public entities, such as conservation districts, municipalities, counties, and state and federal agencies to reserve water for future uses. These include diversionary and consumptive uses, as well as instream flows for the protection of fish, wildlife and water quality.

The main advantage of a water reservation over an individual water-use permit is that once approved, the reservation sets aside water for a particular use. Thus, the reservation law allows for the planning and allocation of water for future uses. Those entities eligible to use reserved water have a longer time period (up to 30 years or more) to put the water to beneficial use and still maintain their early priority date. By comparison, water-use permits must be put to beneficial use within a few years.

To justify the need for a reservation, an applicant must prepare a water use plan that identifies future water users and their estimated water needs. This information explains why the water must be limited to a specific future use and why the applicant is unable to appropriate water by means of a permit. The reservation statute and rules require the applicant to fully support the purpose, need, amount and public interest of a proposed reservation. Reservations for instream flow are limited to 50 percent of the average annual flow on gaged streams. The statute assigns administrative responsibilities to the Board of Natural Resources and Conservation. The Board, which is made up of seven citizens from around the state, is appointed by the governor.

The Montana Environmental Policy Act (MEPA) requires an environmental impact statement for actions of state government that have the potential to create a significant impact on the environment. The EIS examines the environmental, social, and economic impacts of the reservation.

Upper Clark Fork Water Reservations Proceedings

The DNRC has received two applications to reserve water in the upper Clark Fork Basin above Milltown Dam. One applicant is the DFWP, which wishes to reserve instream flows in the mainstem of the Clark Fork and 17 of its tributaries (DFWP 1986). The other, Granite County Conservation District, is seeking to reserve water for irrigation use by developing a storage reservoir on the North Fork of Willow Creek between Drummond and Philipsburg. Table 2-22 summarizes the reservation applications.

A draft EIS on the reservation applications in the upper Clark Fork Basin was issued in August 1988 (DNRC 1988a). Following a 45-day comment period, the final EIS will be prepared and distributed. The DNRC will then publish the notice and receive written objections to the reservation applications. If the DNRC determines that the objections are valid, a formal contested case hearing will be held. The Board will probably make the decision on the upper Clark Fork reservations in late fall of 1988, based on the hearing record, the EIS, and other relevant information. Unless otherwise specified by the state legislature, the priority dates for the reservations would be the dates the Board adopts an order reserving water. Such reservations, once granted by the Board, are water rights.

TABLE 2-22. SUMMARY OF PROPOSED UPPER CLARK FORK BASIN WATER RESERVATIONS.

Stream Name	Length of Stream Reach (miles)	Flows and Volume of water Requested Year Round	Instream Flows for Water Quality Jan 1 to May 1
A) FISH, WILDLIFE AND PARKS (instream flow)			
Clark Fork mainstem			
Reach 1 (Warm Springs Creek to Little Blackfoot River)	37.8	180 cfs 130,314 AF	None
Reach 2 (Little Blackfoot to Flint Creek)	28.1	400 cfs 289,587 AF	None
Reach 3 (Flint Creek to Rock Creek)	35.8	500 cfs 361,983 AF	None
Reach 4 (Rock Creek to Blackfoot River)	17.2	600 cfs 434,380 AF	None
Warm Springs Creek			
Reach 1 (Confluence of Middle Fork Warm Springs Creek to Meyers Dam)	15.3	50 cfs 36,198 AF	For all Clark Fork Tributaries: All of the instantaneous base flow, subject to existing, lawfully appropriated water rights until such time as mine waste reclamation allows copper concentrations entering the Clark Fork above Warm Springs Creek to reach acceptable levels in downstream reaches. Flow is requested at each stream's confluence with the Clark Fork.
Reach 2 (Meyers Dam to Mouth)	16.6	40 cfs 28,959 AF	
Barker Creek	5.1	12 cfs 8,688 AF	
Storm Lake Creek[1]	10.0	10 cfs 7,240 AF 3 cfs 2,172 AF	
Cable Creek	5.8	10 cfs 7,240 AF	
Twin Lakes Creek	7.5	13 cfs 9,412 AF	
Lost Creek	19.9	16 cfs 11,583 AF	
Racetrack Creek			
Reach 1 (Confluence of North Fork Racetrack Creek to USFS boundary)	9.3	26 cfs 18,823 AF	
Reach 2 (USFS Boundary to Mouth)	10.8	3 cfs 2,172 AF	

TABLE 2-22 (CON'T). SUMMARY OF PROPOSED UPPER CLARK FORK BASIN WATER RESERVATIONS.

Stream Name	Length of Stream Reach (miles)	Flows and Volume of water Requested Year Round	Instream Flows for Water Quality Jan 1 to May 1
Dempsey Creek	17.1	3.5 cfs 2,543 AF	
Little Blackfoot River			
Reach 1 (Blackfoot Meadows to Dog Creek)	17.4	17 cfs 12,307 AF	
Reach 2 (Dog Creek to Mouth)	26.9	85 cfs 61,537 AF	
Snowshoe Creek	9.2	9 cfs 6,516 AF	
Dog Creek	15.5	12 cfs 8,688 AF	
Gold Creek	15.0	34 cfs 24,615 AF	
Flint Creek			
Reach 1 (Georgetown Lake to Boulder Creek)	28.0	50 cfs 36,198 AF	
Reach 2 (Boulder Creek to Mouth)	15.7	45 cfs 32,578 AF	
Boulder Creek	13.4	20 cfs 14,479 AF	
North Fork of Flint Creek	7.5	6 cfs 4,344 AF	
Stuart Mill Creek	0.3	14 cfs 10,136 AF	
Harvey Creek	14.6	3 cfs 2,172 AF	
B) GRANITE COUNTY CONSERVATION DISTRICT (for supplemental irrigation)			
North Fork of Lower Willow Creek		up to 15.4 cfs up to 11,165 AF	

[1] 10 cfs is requested if historic diversions to Storm Lake do not occur. If historic diversions are resumed, the flow request is 3 cfs.

Source: DNRC 1988a.

CHAPTER 3

ENVIRONMENTAL ISSUES AND PROBLEMS IN THE BASIN

This chapter outlines current environmental issues and problems in the Clark Fork Basin. While water quality problems have often been the focus of discussion in the past, serious water quantity issues in the basin need to be addressed as well.

Many of the environmental problems identified in this report occur throughout the drainage. However, the nature and severity of the problems vary in the three river segments. The most critical issues in the upper basin are heavy metal contamination of surface and ground water, soils, and sediments; seasonal dewatering of the mainstem and tributaries; and high nutrient inputs that result in excessive algae growth. In the middle river segment, the main concerns are industrial and sewage treatment plant discharges that contain nutrients and toxic compounds; a poor quality fishery in some reaches; seasonal dewatering of tributaries; and loss of aesthetic qualities. The lower river's problems stem largely from the flow regime and water-level regulation in the three reservoirs, which has resulted in poor fisheries. Other concerns include nutrient concentrations, nuisance algae and aquatic weeds, and the threat of eutrophication in Lake Pend Oreille, Idaho.

The chapter begins with a discussion of the issues of water rights and instream flow reservations. Sections on the status of Superfund investigations, metals-contaminated lands, surface water quality, eutrophication and nutrients, nonpoint source pollution, ground water quality, and fisheries, recreation and aesthetics follow.

WATER RIGHTS

Introduction

The 1979 Montana Legislature enacted legislation modifying the current statewide general adjudication. All water-right holders, including those in the Clark Fork Basin, were required to file claims on their pre-1973 water uses before April 30, 1982, with the DNRC. Those entities claiming Indian and non-Indian federal reserved water rights had the option of either submitting claims to the DNRC by the April 30, 1982 deadline or initiating negotiation with the Reserved Water Rights Compact Commission. This commission has the authority to negotiate the quantification of Indian and non-Indian federal reserved water rights. Negotiated compacts, after being ratified by the Montana Legislature and tribal governing body, would be included in the appropriate preliminary and final decree as part of the statewide general adjudication.

The 1973 Water Use Act gave the DNRC responsibility for approving provisional water use permits and changes to water rights. The DNRC was also required to develop a centralized records system that included both existing and permitted water rights. The computerized records system established by the DNRC provides a variety of specific information on certain types of water rights or summary information on water rights by drainage basin. Information on water availability for future development within specific drainage basins is not easily obtainable. Many variables, including water use system efficiencies, the magnitude and timing of return flows, variations in the timing of withdrawals and applications, storage rights, changing hydrologic and meterologic conditions, and the magnitude, location and seniority of water rights affect the supply available at any given time. However, such information is essential for management of water resources in the future.

Pre-1973 Water Rights Claimed Through Statewide Adjudication

A summary of the number of pre-1973 claims for major water uses by drainage basin has been compiled in Table 3-1. A number of claims were submitted after the filing date, and their legal status is unknown.

TABLE 3-1. NUMBER OF PRE-1973 WATER RIGHTS CLAIMED FOR MAJOR WATER USES IN THE CLARK FORK SUBBASINS (JUNE 24, 1985)

Subbasins	Major Water Uses Stock	Irrigation	Domestic	Other	Total
Middle Fork Flathead	3	11	85	79	178
South Fork Flathead	0	1	34	89	124
Swan	60	142	286	69	557
Lower Flathead	1,143	1,133	534	161	2,971
North Fork Flathead , Stillwater and Flathead Lake	548	1,470	2,493	481	4,992
Flint Creek-Rock Creek	551	723	196	241	1,711
Blackfoot	1,490	953	640	535	3,618
Upper Clark Fork	1,665	2,027	452	508	4,652
Bitterroot	2,857	5,015	545	490	8,907
Middle Clark Fork	543	977	402	537	2,459
Lower Clark Fork	296	322	368	182	1,168
	9,156	12,774	6,035	3,372	31,337

Source: DNRC 1985.

The pre-1973 water right claims submitted as part of the general adjudication were computer sorted from the DNRC's centralized records. Six general types of water use were identified--hydropower, fish and wildlife, municipal, irrigation, rural domestic, and other. The amount of water claimed for each type is listed in Table 3-2. Because hydropower and fish and wildlife are primarily nonconsumptive uses, the water can be re-used to satisfy appropriations downstream and/or nonconsumptive appropriations upstream. By definition, consumptive water rights include appropriations of water withdrawn from the stream or ground water profile and used generally outside an aquifer or stream channel. Consumptive uses usually affect the flow of the river by causing a certain depletion. Water that does return to the stream may not do so in a timely and predictable manner.

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TABLE 3-2. THE QUANTITY OF WATER CLAIMED FOR MAJOR WATER USES IN THE CLARK FORK BASIN

Use	Number of Claims	Flow Rate (cfs)	Volume (acre-feet)	Acres Irrigated
Hydropower	93	203,568		
Fish & Wildlife	533	220,137		
Municipal	117	548	276,469	
Irrigation	10,961	329,393	62,240,779	1,937,721
Rural Domestic	3,063	829	1,775,115	
Other	781	15,925	1,936,932	
Totals	15,548	770,400	66,229,795	1,937,721
(Consumptive)		346,695		
(Nonconsumptive)		423,705		

Sources.

Source: DNRC 1988b.

Note: The total number of claims referenced in Table 3-1 does not equal the number of claims tallied in Table 3-2 because diversion information was incomplete on some of the claims accounted for in Table 3-1. Claims with incomplete diversion data were not included in Table 3-2.

The information in Table 3-2 suggests that the amount of water claimed would exceed by several times the normal flow or volume of the Clark Fork. The number of claimed irrigated acres exceeds by about four times the 400,000 acres referenced in Chapter 2. These statistics may indicate that considerable overestimating of water use occurred during the claim filing as part of the general adjudication of the Clark Fork.

Hydropower

There are several large hydropower projects in the Clark Fork Basin. These include the Bureau of Reclamation's Hungry Horse Dam on the South Fork Flathead River; the Montana Power Company's Kerr Dam on Flathead Lake and Thompson Falls Dam on the lower Clark Fork; and Washington Water Power Company's Noxon Rapids and Cabinet Gorge dams on the lower Clark Fork River.

The hydropower claims for the five largest Montana facilities are:

Claimant	River	Flow
US Bureau of Reclamation (Hungry Horse)	South Fork Flathead	55,156cfs
Washington Water Power Co. (Noxon Rapids)	Lower Clark Fork	35,000cfs
Montana Power Company (Kerr)	Lower Flathead	14,540cfs
Montana Power Company (Thompson Falls)	Lower Clark Fork	11,120cfs
Montana Power Company (Milltown)	Middle Clark Fork	2,000cfs

Instream Flow Rights

In 1969, the Montana Legislature passed a law that allowed the Montana Fish and Game Commission to appropriate water for instream flows in 12 "blue ribbon" streams. Section 89-801 RCM 1947 (Chapter 345, laws of 1969) is the authority for these appropriations. In the Columbia Basin, these streams were Rock Creek near Missoula, the Blackfoot River, the Flathead River and its North, Middle and South forks. These appropriations were completed by the Commission in December 1970 and January 1971 under the water law procedures of that time, and became known as "Murphy Rights," after the sponsor of the legislation.

Rock Creek and the Blackfoot River are the only Murphy Rights streams in the portion of the basin considered in this report. Those rights are described below.

Rock Creek (near Missoula). Rock Creek has an instream flow right with a priority date of January 6, 1971, from the mouth to Ranch Creek (14 miles), and January 7, 1971, from

Ranch Creek to the headwaters (42 miles). The following flow quantities were claimed under Senate Bill 76:

Stream Reach	Period of the Year	Flow (cfs)	Volume (AF)
Mouth to Ranch Creek (14 miles)	7/16-4/30	250	143,272
	5/1-5/15	454	13,504
	5/16-5/31	975	30,935
	6/1-6/15	926	27,544
	6/16-6/30	766	22,785
	7/1-7/15	382	11,363
Ranch Creek to Headwaters	7/16-4/30	150	85,963
	5/1-5/15	454	13,504
	5/1 6-5/31	975	30,935
	6/1-6/15	926	27,544
	6/16-6/30	766	22,785
	7/1-7/15	382	11,363

<u>Blackfoot River</u>. This stream has an instream flow right with a priority date of January 6, 1971, from the mouth to the Clearwater River (34 miles) and January 7, 1971, from the Clearwater River to the north fork of the Blackfoot River (18 miles). The following flow quantities were claimed under senate Bill 76:

Stream Reach	Period of the Year	Flow (cfs)	Volume (AF)
Mouth to Clearwater River (34 miles)	9/1-3/31	650	273,257
	4/1-4/15	700	20,822
	4/16-4/30	1,130	33,612
	5/1-6/30	2,000	241,926
	7/1-7/15	1,523	45,302
	7/16-8/31	700	65,241
Clearwater River to NF of Blackfoot (18 miles)	9/1-3/31	360	151,343
	4/1-4/30	500	29,745
	5/1-5/15	837	24,897
	5/16-6/15	1,750	107,578
	6/16-6/30	1,423	42,327
	7/1-7/15	848	25,224
	7/16-8/31	500	46,601

<u>Other Claims</u>. Under Section 85-2-223 MCA, DFWP filed an instream flow claim on the Bitterroot River as the exclusive state representative of the public to establish a prior and existing public recreational use of these waters.

A priority date of July 1, 1970, is claimed for this use. The following instream flows were claimed:

Stream Reach	Period of the Year	Flow (cfs)	Volume (AF)
Mouth to Stevensville Bridge	10/1-4/30	900	378,356
	05/1-6/30	7,700	916,146
		15,000 (1 day)	29,745
	07/1-9/30	600	109,462
			1,433,709
Stevensville Bridge to Sleeping Child Creek	10/1-4/30	500	210,198
	05/1-6/30	5,500	654,390
		11,000 (1 day)	21,813
	07/1-9/30	300	54,731
			941,132
Sleeping Child Creek to Jct/East and West Forks	10/1-4/30	350	147,139
	05/1-6/30	3,000	356,940
		6,000 (1 day)	11,898
	07/1-9/30	250	45,609
			561,586

In addition, recreational claims related to fish and wildlife have been filed on 11 lakes in the Clark Fork Basin below Kerr Dam. One lake is a pothole on the Ninepipe Wildlife Management Area and the other ten lakes are in the Blackfoot drainage. The following is a list of the claims:

		Flow (cfs)	Volume AF/YR	Claimed Priority Date
1.	Unnamed Pothole Ninepipe WMA	2.0	15.0	5-4-62
2.	Brown's Lake	50.0	7,273.0	5-14-28
3.	Clearwater Lake	25.0	10,399.2	9-30-36
4.	Harper's Lake	5.0	273.2	5-24-33
5.	Lake Alva	500.0	88,013.0	9-5-28
6.	Lake Inez	1.5	101,936.0	8-7-28
7.	Placid Lake	800.0	104,741.0	9-15-28
8.	Rainy Lake	300.0	23,105.0	5-7-31
9.	Salmon Lake	2,800.0	242,749.0	9-13-28
10.	Seeley Lake	1,500.0	203,091.0	9-20-28
11.	Upsata Lake	5.0	1,477.9	5-27-58

Status of Statewide Adjudication

There are 13 subbasins within the Clark Fork River drainage. A total of 31,337 claims were filed in these subbasins. Temporary preliminary decrees have been issued in seven of the 13 subbasins as part of the statewide general adjudication (Table 3-3). A temporary preliminary decree (which precedes a preliminary decree) does not include Indian and non-Indian federally reserved water rights. The negotiated reserved water rights are required by statute to be included in a preliminary decree.

TABLE 3-3. TEMPORARY PRELIMINARY DECREE ISSUANCE DATES, CLARK FORK SUBBASINS

Subbasin Name	Issue Date	Claims Submitted	Total Claims Decreed
Lower Clark Fork	2-28-84	1,168	1,128
Flint Creek-Rock Creek	3-29-84	1,711	1,699
Middle Fork Flathead	8-09-84	178	200
South Fork Flathead	8-09-84	124	124
Swan	8-09-84	557	633
Middle Clark Fork	3-05-85	2,459	2,486
Upper Clark Fork	5-17-85	4,652	4,592
Lower Flathead	----	2,971	----
North Fork Flathead, Stillwater and Flathead Lake	----	4,992	----
Blackfoot	----	3,618	----
Bitterroot	----	8,907	----
		31,337	10,862

Source: DNRC 1988b.

31,337
10,862
20,475

A total of 10,862 claims have been incorporated in temporary preliminary decrees in the seven subbasins. Temporary preliminary decrees have yet to be issued in six subbasins that affect 20,488 claims.

The DNRC is providing claim examination assistance to the Montana Water Court by identifying certain issues and factual discrepancies related to the claimed historic water use. From 1982 through 1985, the DNRC followed a set of verification procedures that were authorized by the Water Court. These procedures were prohibited from public inspection and comment during their drafting and implementation. In addition, the rules were frequently changed as they were being applied by the DNRC.

As the result of dissatisfaction by water claimants, a petition for writ of supervisory control of the Water Court was filed before the Montana Supreme Court in July 1985. The petition questioned the accuracy and validity of the decrees, suggested due process violation, and speculated on substantive errors in the adjudication. Before the Supreme Court ruled on the petition, a stipulation was negotiated out of court and signed by the Water Court and several parties agreeing to resolve the petitioned allegations. Among other things, the stipulation called for new procedures for examining pre-1973 water right claims.

The stipulation also confirmed what assistance the DNRC would provide to the Water Court in the adjudication process. The DNRC would factually analyze water right claims for accuracy and completeness and identify issues. The issues would include apparent factual discrepancies that appear to have uncertain support from historical evidence. The legal and due process considerations would not be issues reported by DNRC as part of their assistance to the Water Court. The stipulation also described how the DNRC's analysis would be incorporated into the Water Court's decrees.

In response to the stipulation, the DNRC drafted a set of procedural rules for examining water right claims. These examination procedures were prepared for adoption as administrative rules under the Montana Administrative Procedures Act (MAPA). The Montana Water Court ordered the DNRC to refrain from adopting the rules under MAPA. The Water Court, as the judicial authority for the general adjudication of water rights, claimed autocratic control over all adjudication activity and preferred to adopt the administrative rules as judicial rules. This issue went before the Montana Supreme Court. On March 31, 1986, the Supreme Court decided the claim examination procedures were of such significant relevance that they would adopt the rules with a notice and review similar to the MAPA process.

The DNRC, working with the Water Court, submitted a draft of the rules to the Supreme Court for adoption on April 30, 1986. The Supreme Court issued these Water Rights Claim Examination Rules with an effective July 15, 1987 date for implementation. A review period until March 15, 1988 was provided to allow comment and suggestion on the application and structure of the rules. A final ruling is pending.

The Supreme Court's Water Rights Claims examination Rules are expected to provide a markedly improved opportunity for an equitable and thorough claims examination. The rules are intended to provide a standard format for the DNRC to provide assistance to the Water Court. The new rules will also improve the consistency of claims examination. The examination rules, however, do not address judicial due process consideration of separation of judicial and executive power concerns.

Following adoption of the rules by the Montana Supreme Court, several parties, such as the U. S. Department of Justice, the Montana Department of Fish, Wildlife and Parks, and Montana Power Company, have asked the Water Court to prepare reports comparing the former claims examination with the recently adopted Supreme Court procedures. The parties feel that the new rules may afford a factually prudent examination that is more consistent, thorough, equitable, and accurate than the previous Water Court verification procedures.

At the current rate of claims examination and with the current level of staffing, the DNRC believes that it will require until the year 2000 to examine the remaining non-decreed claims within the Clark Fork drainage. In 1987, the DNRC estimated that it would take four and one-half years to reexamine the Clark Fork drainage claims previously entered into temporary preliminary decrees, using procedures consistent with the new examination rules (Larry Holman, DNRC, Helena, personal communication, April 1988).

The timetable for the final adjudication of all water rights in the Clark Fork drainage is uncertain for several reasons. First, it is uncertain if and when compacts regarding Indian and federal reserved rights will be reached. Second, because of the controversy over the adequacy of the present adjudication, a legislative study of the adjudication by out-of-state consultants is presently underway. That study, due to be completed in the fall of 1988, is to recommend possible legislative changes. It is unclear at this time what changes, if any, might be recommended or enacted and how they might affect the timing of the adjudication. Third, litigation over the adequacy of the adjudication continues and could increase. The federal government has recently been before the Water Court claiming that the present adjudication is not adequate as currently applied. Additionally, the Confederated Salish and Kootenai Tribes are currently before the Montana Supreme Court arguing that the Supreme Court's adoption of the new examination rules, which allows total control of the DNRC by the Water Court, violates due process and separation of powers principles.

Provisional Permits Issued Since 1973

The Montana Water Use Act of 1973 requires that any new or additional development of water made after July 1, 1973, be approved by the DNRC with a provisional water use permit.

Applications for permits can be made at the DNRC Water Rights Field Offices located in Helena, Missoula, and Kalispell. Before the Department can issue a provisional permit, the applicant must show that the new use will not adversely affect senior users holding water rights. The statutes (85-2-311, MCA) outline the criteria that must be met before a provisional permit can be issued.

Table 3-4 identifies the number of provisional permits issued since 1973 for each major category of use. Irrigation accounts for the largest percentage of the diversionary uses of water. The number of domestic use permits issued is increasing because of many new rural subdivisions. Industrial uses include both commercial and mining. There were a number of provisional permits issued for fish and wildlife purposes, and many of these were for fish farms. The largest new-user category is hydropower. However, it should be noted that 15,000 cfs of the total flow rate under the hydropower category is associated with the provisional permit issued to the Washington Water Power Company. The remaining 26 provisional permits for 477 cfs are for small-scale hydropower developments. Because of the projected need for additional power during the early 1980s and tax-related financial incentives, there was considerable interest in developing small-scale hydropower facilities.

TABLE 3-4. PROVISIONAL WATER USE PERMITS ISSUED SINCE 1973

Purpose	Number of Permits	Total Flow (cfs)	Volume AF/Y	Acres
Irrigation	765	720.0	73,677	35,664
Industrial	53	73.0	28,325	---
Domestic	707	26.0	1,520	255
Municipal	2	3.7	2,142	---
Hydropower*	33	15,441.0	180,282	---
Fish & Wildlife	150	130.0	67,599	790
Other	80	9.0	1,900	76

* A permitted flow of 15,000 cfs was granted to Washington Water Power, which, when added to its existing water right flow of 35,000 cfs, allows the hydroelectric facility to be operated at full capacity.

Source: DNRC 1988b.

Ground Water Permitting Process

DNRC's maintenance of separate permitting procedures for surface water and ground water uses raises some difficult questions about basinwide management in the Clark Fork system. Generally, ground water permitting decisions consider the surface water effects of ground water withdrawals only where the relationship is straightforward and the interaction a proximal one. Most commonly, this means that if it is shown that a ground water diversion is inducing recharge of an aquifer from a surface water source (or "pumping surface water"), then the ground water proposal will be viewed critically with regard to surface water availability. In the absence of such readily calculable interactions, DNRC may notify controlling surface water users in the basin, but beyond that step it will not normally analyze ground water applications in the context of surface water availability, instream flows, or surface water quality objectives.

Aquifers constitute one flowpath component by which water moves from the headwaters to the mainstem Clark Fork and beyond. Most major aquifers in the Clark Fork Basin receive recharge from the surface environment (precipitation, losing reaches of tributary streams, or the Clark Fork itself), and most discharge along relatively short flowpaths back to the surface environment. Aquifers respond to new ground water withdrawals (wells) with potentiometric adjustments that either increase inflow to the aquifer or decrease discharge to the surface environment or both. Some part of this response may involve increased inflows from other aquifers with more remote relationships to the basin's surface water environment. More often, the major hydrologic response is likely to be an eventual adjustment of surface water flows in some other part of the system.

The fact that DNRC's ground water permitting has not reflected these physical realities can be attributed to two factors. First is the information requirement for realistically assessing the overall hydrologic consequences of a given level and manner of ground water development. This level of understanding is only achieved for a given aquifer system through an intensive research program. Often, complex aquifer responses are only predictable through the creation of computer simulations, which in turn rest heavily on an adequate base of regional field information. Because DNRC is unable to collect this type of data itself (viewing it as a research function appropriately left to other agencies and the university system), the opportunities for the ground water permitting process to meaningfully consider integrated hydrologic implications are limited by others' research priorities and DNRC's ability to influence those priorities.

The second factor is the comparative scale of ground water withdrawals with respect to surface water use in the major hydrologic basins. In the Missoula aquifer, for instance, annual withdrawals for all purposes average about 60,700 acre-feet (Missoula City-County Health Department, 1987), some of which returns to the aquifers as water main leakage, septic system discharge, and other recharge flowpaths. This appears minor in relation to the discharge of the Clark Fork, which averages 2.2 million acre-feet/year at a point upstream of the Missoula aquifer's recharge area. However, the generous hydraulic characteristics of the Missoula aquifer present the possibility of substantially increasing ground water withdrawals on a sustainable basis. Ground water withdrawals amounting to several percent of the mainstem Clark Fork's flows seem significant where consumptive and instream priorities, including surface water quality, compete for available flows. Similar arguments could be made regarding other aquifers in the basin that are capable of supplying high yields to wells, as most have significant recharge/discharge relationships with the basin's streams.

Meaningful basinwide water management requires that new water use permitting recognize the unity of water resources in the basin's streams and principal aquifers. Surface water permitting will have to recognize aquifer recharge among the significant "instream" water needs and ground water permitting will have to recognize effects on downgradient-gaining streams, though the consequences may seem minor on an individual project basis and remote at the time of permitting. In a practical sense, this means adopting as management tools the research data and aquifer model derived from areas where such work has been done. Just as importantly, the permitting process must recognize the concept of conjunctive surface water and ground water management. Without such recognition, there will be no management framework in which to incorporate detailed information on regional aquifer behavior as it accumulates.

Indian and Non-Indian Federal Reserved Water Rights

U. S. Forest Service

Rights Claimed by the U. S. for National Forest Purposes. Water claimed by the United States on behalf of the USDA Forest Service in the Clark Fork Basin is both consumptive and nonconsumptive. These claims are based upon "Federal reserved rights" and Montana water laws. Reserved rights are established when lands are withdrawn from the public domain for a federal purpose. At that time, appurtenant water, then unappropriated, is implicitly reserved to the extent necessary to accomplish those purposes. The extent of these "rights" and the specific purposes of the reservation is an ongoing litigative process and is yet unclear.

Consumptive claims are a minor part of the U.S. Forest Service reserved water rights in the Clark Fork Basin. However, claims have been filed with the Montana Water Court for many uses, such as: stock water, summer homes, recreational facilities, and Forest Service work facilities.

Federal reserved rights claimed by the Forest Service for national forests in the Clark Fork Basin are generally grouped into two categories--channel maintenance flow needs and other resource needs. Both of these flow needs are nonconsumptive, and the water claims would be available to other users below the forest boundaries. Channel maintenance flows are needed to maintain natural stream channel systems and are an integral part of sound watershed management. These flows help to maintain streambank stability and riparian vegetation and provide for sediment transport. Channel maintenance flows are similar to maintaining irrigation ditches so that irrigation water can flow freely. While the irrigator uses mechanical means to keep his ditches clean, the Forest Service aims for channels that maintain themselves naturally through instream flows.

Flows for other resource needs include purposes as set forth by Congress for wilderness, wild and scenic rivers, fisheries, wildlife, etc. Flows for the various purposes will be negotiated with the Reserved Water Rights Compact Commission.

Status of Negotiation with Reserved Water Rights Compact Commission. The Forest Service is the only USDA agency with reserved rights claims in the Clark Fork Basin. Negotiations between the Reserved Water Rights Compact Commission and the USDA have been initiated. Although this negotiation is currently inactive, the USDA negotiator is still optimistic that a compact can be developed by the parties.

Current Water Related Litigation. In United States v. Jesse, the federal government asserted that lands withdrawn for the Pike and San Isabel national forests in Colorado, included the water necessary to maintain minimum instream flows. The claim was based on a definition of favorable conditions of water flow as identified in the Organic Administration Act of 1897. The act requires streamflows necessary to maintain stream channels so that hydrologic function is not impaired. The decision against the United States by the District Court was reversed and remanded by the Colorado Supreme Court on the basis of recent advances in the science of fluvial geomorphology. While the Colorado Supreme

Court has stated in United States v. City and County of Denver that the Organic Act did not implicitly reserve water necessary to maintain instream water flows in national forests, it was also not excluded. Because the United States has not attempted to prove instream flow rights in previous litigation, the court found that the matter had not been litigated and that the Forest Service should have its day in court. While the court did not give the Forest Service instream flow rights, it has provided the opportunity to prove the case.

The Confederated Salish and Kootenai Tribes of the Flathead Reservation

The Flathead Indian Reservation, located in Lake, Sanders, Flathead, and Missoula counties, consists of 1,242,969 acres, over half of which is tribal or individual trust land. The population on the reservation is approximately 4,550 Indians and 16,000 non-Indians. The BIA, on behalf of the tribe, made claims for Indian water rights, all appropriative water rights previously acquired, and water rights appurtenant to lands owned by the Confederated Salish and Kootenai Tribes as required by the statewide adjudication. The generic claims are for "all water arising upon, flowing by, through, or under the reservation, necessary for purposes of the reservation...as of the date of the reservation, and/or from time immemorial based on the tribe's aboriginal ownership of the lands and waters that now comprise the reservation, whichever is earlier." The BIA has also submitted claims for instream flows in the Flathead Basin necessary to protect the tribe's aboriginal rights recognized and guaranteed pursuant to the treaty of Hellgate, Montana, July 16, 1855. A major concern of non-Indians on this reservation is the effect the tribal water rights will have on non-Indian water rights and uses associated with the Flathead Indian Irrigation Project.

The tribes have met a few times with the Reserved Water Rights Compact Commission over the past ten years, but little progress has been made. The Compact Commission has made no attempt to meet with the Confederated Tribes since 1985, because of the legislature's directive to focus the adjudication on the Milk River Basin.

INSTREAM FLOW RESERVATIONS

Introduction

A water right for instream beneficial use for fish, wildlife, and recreation may be obtained, under existing statutes and rules, only by an application for reservation of water and not by a petition, an application for a water use permit, or a change of an existing water right.

Since the implementation of the 1973 Water Use Act, the DFWP has objected to the issuance of water use permits where such permits were thought to adversely affect instream flows necessary to protect fish and wildlife. The DNRC has determined that objections to new water use permits are invalid unless the objector has a water right that would be adversely affected. DNRC has determined that the DFWP has valid objections only on those streams where it has instream flow reservations or Murphy Rights. DFWP has no such reservations in the Clark Fork Basin and has Murphy Rights only on Rock Creek (near Missoula) and the Blackfoot River.

Water reservations will not make more water occur in streams. They only establish a water use priority date for fish and wildlife relative to other water right uses. They prevent further dewatering through use of the appropriation doctrine "first in time is first in right," and can affect only those water users whose priority dates are later than those of the reservations. The reservations' priority dates are, by law, effective only after the reservations are granted by the Board of Natural Resources.

The following sections explain why instream flows are important for the Clark Fork Basin.

Hydropower Rights

The Washington Water Power Company has a water right of 50,000 cfs at Noxon Rapids Dam, of which 15,000 cfs is by a provisional water use permit issued in 1976, and 35,000 cfs is by a right filed in 1951. A flow of 50,000 cfs equals more than 36 million AF per year--over twice the average annual discharge of the river at Cabinet Gorge Dam (16 million AF). These rights and the rights at the other hydropower projects should, theoretically, preclude, or at least limit, the issuance of additional upstream consumptive water use permits. However, in addition to the 1976 permit issued to the Washington Water Power Company, DNRC has issued, since 1973, 1,683 water use permits upstream of Noxon Rapids Dam, for a total of 380,589 AF of water (as of September 1986). However, most of the volume of water permitted is associated with hydropower. Only a diversionary volume of 72,692 AF/Y is associated with irrigated agriculture in the basin. Of the 1,683 water use permits, 214 permits totaling 95,436 AF have been issued in the upper Clark Fork Basin above Milltown Dam.

15000 cfs

How much

Change

9-21-88 Carole is striking this from the 2nd draft.

The downstream hydropower water rights holders have not objected to the issuance of water use permits by DNRC, nor the use of water by the junior appropriators. Studies now underway by BOR and DNRC may clarify existing circumstances and stimulate new activity in those areas. DNRC may intervene in the relicensing and amending of operating licenses issued by the Federal Energy Regulatory Commission (FERC) with the intent of subordinating the hydropower water rights to upstream consumptive use (primarily irrigation) if state interests are not adequately addressed.

DNRC is investigating whether water exchanges between the large hydropower projects that would allow increased consumptive use while still satisfying existing hydropower rights is a viable option. An example of this is the transfer of stored water from Hungry Horse Reservoir to Noxon Rapids to satisfy those hydropower rights, while at the same time allowing continued issuance of consumptive water use permits in the upper Clark Fork Basin. A recent study by the BOR (1988) suggests that this may not be feasible. Even if this were feasible and solved the hydropower rights problem, it would not solve additional dewatering problems in other parts of the basin. In view of these circumstances, it has not been practical or prudent to rely on the downstream hydropower water rights to protect instream flows in the Clark Fork Basin.

Fish, Wildlife, and Aquatic Resources

Fish, wildlife, and other living organisms depend upon the flow of the Clark Fork and its tributary streams for their basic habitat requirements. Due to the serious and chronic nature of the pollution in the upper Clark Fork, adequate streamflows must be maintained to prevent further deterioration in water quality and to help protect the investment being made to restore the river's water quality.

The reservations are needed to maintain fish habitat, aquatic insect populations, and other aquatic plant and animal life that sustain fish. Channel configuration in conjunction with flow provides the only living space available to aquatic organisms in streams. Adequate streamflows are necessary for maintaining spawning and rearing areas, providing suitable shelter, and producing food organisms, including aquatic macroinvertebrates and forage fish. In an aquatic ecosystem, water quantity is as critical a component of fish habitat as is water quality.

Water Quality Benefits

Surface water in the upper Clark Fork suffers from dramatic water pollution problems. The most serious problems are the result of decades of mining and smelting activities in the headwaters. There are massive deposits of mine tailings in the Butte area, along Silver Bow Creek, and at the sites of the Anaconda Smelter and Opportunity Pond system. Runoff entering Silver Bow Creek from these areas is acidic and has high concentrations of metals. Silver Bow Creek is treated with lime at the Warm Springs Ponds to raise the pH and precipitate the metals that are in solution.

In addition to mine tailings in the Butte-Anaconda area, there are substantial deposits of mine tailings in the riparian zone and floodplain of the upper Clark Fork itself. These deposits are chronic sources of metal contamination to the upper Clark Fork and they may contribute acutely toxic concentrations of metals during periods of precipitation and runoff.

There are several reasons why water pollution in the Clark Fork is related to flows: 1) high flows in the spring greatly increase metal concentrations by eroding mine tailings that have been deposited in the floodplain. Some of the highest metal concentrations in the Clark Fork occur during spring runoff; 2) flows in Silver Bow Creek that exceed the capacity of the Warm Springs Ponds are bypassed directly into the upper Clark Fork; and 3) low-flow conditions can aggravate water quality problems by reducing the amount of water available for dilution of industrial and municipal discharges and nonpoint pollution. Current and future industrial and municipal waste discharge permits could be affected by chronic low-flow conditions, i.e., the allowable amount of discharge would be reduced to accommodate the reduction in dilution water of the receiving stream.

Reduced streamflows during the normal low-flow period can affect the quality of water that is necessary to sustain aquatic organisms. Other possible consequences of this lowered streamflow are higher water temperatures, increased amounts of dissolved solids, increased nutrient concentrations, and lower dissolved oxygen levels. Reduced streamflows seasonally limit the ability of the Clark Fork to assimilate its present pollution load. A reduction in tributary streamflows will reduce the current capability of tributary streams to discharge clean water into the Clark Fork for dilution of pollutants.

An instream flow reservation can help to prevent the further deterioration of water quality during low-flow periods. A reservation can also help to provide adequate flows for enhanced aquatic populations that may occur in the future as existing pollution problems are reduced or, hopefully, eliminated.

Water Supply

Instream flows in the Clark Fork Basin are also important from a water supply standpoint, particularly in the Missoula area. The Clark Fork provides about 46 percent of the annual recharge to the Missoula Aquifer, which is the major source of drinking water for the Missoula area. It also supplies water to over 30 small community water systems and to several industrial users. An estimated 65,000 of Missoula County's 77,400 residents use water from the Missoula Aquifer (Missoula City-County Health Department 1987). Therefore, maintaining adequate instream flows in the Clark Fork is crucial to these residents and to others in the basin who derive their water from aquifers recharged by the river.

Recreation, Aesthetics, and Tourism

The Clark Fork and its tributaries are important fishing and recreation areas. Montana statutes recognize this resource as worthy of protection. The fish species that would be protected by instream flow reservations contribute to the well-being of the people of Montana and visitors who enjoy the fishing opportunities Montana has to offer. In addition to sustaining existing recreation, adequate instream flows would preserve the opportunity to enhance fish populations as water quality improves. This, in turn, would result in more recreational opportunities in the future.

If the instream flow reservations requested by DFWP in the upper Clark Fork Basin are not granted, the deterioration of aquatic habitat and recreational interests is inevitable. The rate of deterioration would depend upon the degree to which further dewatering would be allowed to occur. Such deterioration is already evident in the Bitterroot River drainage and in portions of the upper Clark Fork Basin.

The DFWP reservations are for the amounts of water necessary to sustain the organisms without significant long-term reduction in quantity and quality. Increased water withdrawals over existing levels would, in the long run, reduce the availability of habitat and, consequently, the number of organisms that can occupy that habitat. There is a limit to the amount of water that can be removed from any stream channel without severely changing the quantity and quality of the aquatic species present or limiting the biological potential of the stream. In portions of the Clark Fork Basin, that limit has already been exceeded.

Tourism for recreational purposes is rapidly becoming Montana's second-most important industry. The high quality and abundance of Montana's natural resources provide unique opportunities for fishing, hunting, boating, river running, and simply relaxing in an aesthetic environment. The City of Missoula, for example, seeks to maintain adequate flows in the Clark Fork through its riverside park and greenway and to develop a kayak racecourse in this same river reach. The tourism, recreation, and aesthetic values are directly related to the adequacy of instream flows. Reservations of instream flow are the only current means to preserve these amenities.

Riparian Areas

The riparian ecosystems of the Clark Fork and its tributaries are transitional zones between the aquatic and terrestrial habitats. This streamside zone of vegetation is characterized by the combination of high species diversity, high species densities, and high productivity. Many of the trees and shrubs that dominate this zone require ground water within the rooting zones through the growing season. Fluctuations in streamflow cause concomitant fluctuations in associated shallow ground water tables.

The riparian zone is ecologically important because it provides seasonal and year-long habitat for a greater number of species of wildlife than any other habitat in Montana. In addition to its rich assemblage of plants and animals, the riparian zone plays an essential role in determining the quality of the aquatic environment for supporting fish and aquatic invertebrates.

Although the specific relationships among riparian vegetation and the amount and availability of ground water have not been quantified in the Clark Fork drainage, the existing plant communities and associated wildlife populations require adequate instream flows for their perpetuation.

STATUS OF SUPERFUND INVESTIGATIONS

Introduction

Although this document primarily addresses non-Superfund issues, the activities at the Superfund sites are of the utmost importance to the future of the Clark Fork Basin. Certainly, the fate of at least the upper river is inexorably tied to the outcome of Superfund.

The Superfund program was created by Congress in 1980 to identify, investigate, and clean up hazardous substances that have been or may be released into the environment. EPA has initiated Superfund activities in the Clark Fork Basin primarily because of the problems left by over 100 years of mining and processing operations. Waste disposal practices have resulted in the contamination of soils and water quality by metals and other substances throughout a large area of the upper basin.

The Superfund program provides for investigation and cleanup of hazardous wastes by either the responsible party (RP) or the government. If there is an RP, EPA and/or the state oversees the cleanup efforts by the RP through an administrative order. If there is no RP, or the RP declines to undertake the studies and cleanup efforts, EPA conducts the studies or provides funds to the state to do so. The RP is provided the results of the studies and is asked to conduct appropriate clean up. If the responsible party refuses, EPA may use resources from the Superfund to clean up the site and then seek to recover up to three times the cost of the cleanup from the responsible party. If the responsible party undertakes the recommended cleanup, EPA oversees the activity through a court-ordered consent decree.

Studies were initiated by EPA in 1982 to characterize the extent and severity of contamination in the headwaters area. There are currently four separate, but contiguous Superfund sites in the Clark Fork Basin (Figure 3-1). The three in the headwaters are the Silver Bow Creek/Butte Addition site, the Montana Pole site and the Anaconda Smelter site. The fourth is the Milltown Reservoir site a few miles upstream of Missoula. Site histories, current status and future activities for each site are presented in Table 3-5.

Seventy-seven existing or potential contamination problems were initially identified within the four sites. The EPA, with state support, is developing a Superfund Master Plan to describe these problems and their interrelationships, define cleanup goals and objectives, and coordinate the actions that will be taken to reach these goals. The Master Plan is intended to be a public document that will briefly describe the problems at the sites and the corrective actions and schedules for dealing with the problems. Schedules for priority activities planned for the next several years will be presented in the plan, which is to be released in September 1988.

Some of the more specific objectives of the Master Plan are the following:

- Communicate information on Superfund activities to all interested parties.
- Identify, prioritize, and coordinate intersite activities.
- Coordinate Superfund activities with other environmental improvement programs.
- Provide for consistent and uniform data requirements and cleanup standards for all sites.

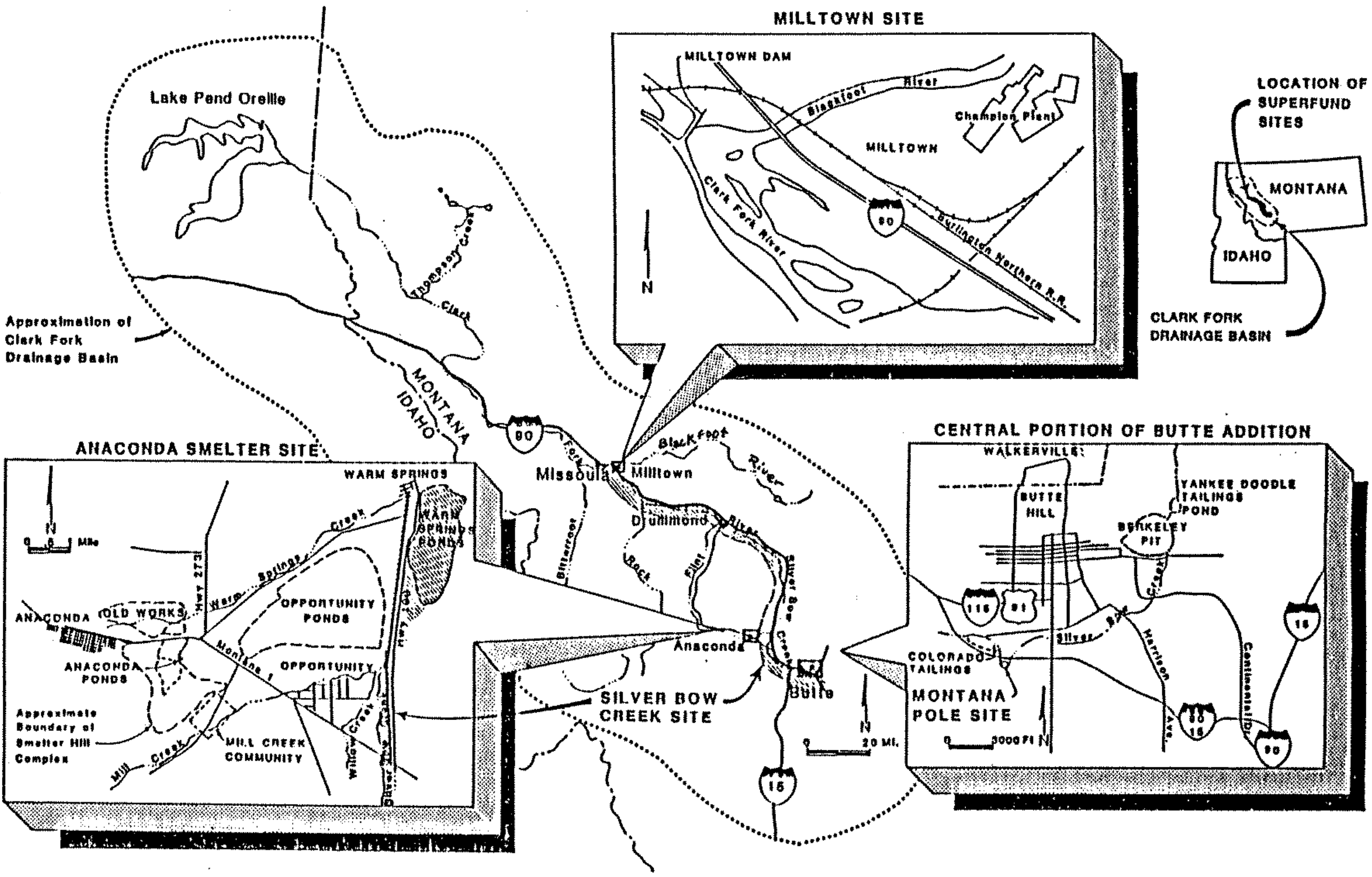


FIGURE 3-1. SUPERFUND SITES IN THE CLARK FORK BASIN. SOURCE: EPA 1988

TABLE 3-5. HISTORY AND STATUS OF SUPERFUND INVESTIGATIONS IN THE CLARK FORK BASIN

SITE/LOCATION	RESPONSIBILITIES	HISTORY	HISTORY (cont)	CURRENT STATUS/ACTIVITIES
SILVER BOW CREEK/BUTTE ADDITION				
• Original site boundary was Silver Bow Creek to the Warm Springs Ponds. • In June 1986 the study area was officially expanded to include the Clark Fork between the Warm Springs Pond system and Milltown, and the City of Butte (Butte Addition).	• DHES has lead responsibility to conduct Silver Bow Creek studies. • The EPA has lead responsibility for the Butte Addition. • Camp, Dresser and McKee (CDM) is EPA's prime oversight contractor for both the Silver Bow Creek and Butte Addition sites.	• The site was placed on the National Priorities List in December 1982. • DHES contracted with MultiTech to conduct Phase I Remedial Investigation (RI) studies in 1984. • Phase I RI field activities were conducted from November 1984 to January 1986. • MultiTech submitted final draft phase I RI reports between March 1986 and May 1987. • DHES contracted with CH$_2$M Hill to conduct Phase II RI/FS studies in February, 1986; these activities got underway in 1987. • In fall 1986 the EPA Emergency Response Branch began investigations concerning mercury contamination in Walkerville. • From June-August 1987, CDM conducted a soil screening study for EPA in Butte and vicinity to obtain enough information to plan RI/FS work for the area. CDM submitted a data report in June 1988.	• DHES contracted with CH$_2$M Hill to conduct the Clark Fork screening study in April 1987; field work was conducted summer and fall 1987; data report was submitted August 1988. • EPA proposed a plan for removals associated with lead and mercury in Walkerville in September 1987. The consent order was signed in spring 1988. AMC began removal action work at waste dump sites in April 1988. EPA began clean up of private residences in May 1988.	• Warm Springs Ponds Phase II RI/FS activities (initiated in September 1987) are underway. The draft feasibility study is due October • Flood hydrologic evaluations for Silver Bow Creek (initiated September 1987) are in progress. Modeling was completed June 1988. • The Streambank Tailings and Revegetation Studies (STARS), initiated in in September 1987, are underway. Lab and greenhouse activities will be completed by July-August 1988. Field demonstration planting scheduled for fall 1988; field plots will be monitored for two planting seasons. • Studies are on-going to address the potential mine flooding problems in the Butte area. • A background soil contaminant level study will be conducted in the Butte vicinity.

TABLE 3-5 (CON'T). HISTORY AND STATUS OF SUPERFUND INVESTIGATIONS IN THE CLARK FORK BASIN

SITE/LOCATION	RESPONSIBILITIES	HISTORY	HISTORY (cont)	CURRENT STATUS/ACTIVITIES
MONTANA POLE				
• Greenwood Avenue, Butte, Montana. SW 1/4, section 24, and SE 1/4, section 23, T 3N, R8W. • Covers approximately 40 acres.	• DHES has lead responsibility for the Montana Pole site under cooperative agreement with EPA. • EPA has oversight role for this site.	• The facility produced chemically treated utility poles, posts, and bridge timbers from 1947 to 1983. • Petroleum seep emanating from south bank of Silver Bow Creek was identified in 1981. • Grab samples of seep and Silver Bow Creek water collected April 1983; nine ground water monitoring wells installed by MBMG in July 1983. • Due to sample results and seepage rates, EPA Emergency Response Branch was called in to conduct a site investigation. A removal action to alleviate seepage, collect product from ground water, excavate contaminated soil, and stabilize the site has been underway since July 1985. • The site was officially added to the National Priorities List in November 1986.	• Emergency Response Branch removal activities were phased out in summer, 1988; remedial action was taken over by State of Montana and EPA. • Ground water treatment will be dealt with as an Expedited Removal Action (ERA) or as an expedited operable unit under the RI/FS. • The Emergency Response Branch completed an Engineering Evaluation and Cost Analysis (EE/CA) to address cleanup and treatment of contaminated ground water. This will be incorporated into the ERA or RI/FS.	• DHES contracted with CDM in August 1988 to develop an RI/FS workplan for the site.

TABLE 3-5 (CON'T). HISTORY AND STATUS OF SUPERFUND INVESTIGATIONS IN THE CLARK FORK BASIN

SITE/LOCATION	RESPONSIBILITIES	HISTORY	HISTORY (cont)	CURRENT STATUS/ACTIVITIES
ANACONDA SMELTER				
• The site includes the smelter complex and Old Works areas, nearby communities, and extensive areas of the Deer Lodge Valley contaminated from 100 years of stack emissions.	• AMC, as potentially responsible party, has lead responsibility to conduct Anaconda Smelter RI/FS studies under EPA Administrative Order. • EPA has retained the lead responsibility to perform Risk Assessments/Public Health Assessments and determination of ARARS. • Currently AMC has PTI Environmental Services as prime contractor. • EPA oversees all work done by AMC. • EPA's oversight contractor for this site is the Bureau of Reclamation.	• Placed on National Priorities List in 1983. • AMC contracted with Tetra Tech, Inc. to conduct Stage I RI studies in October 1984. • Stage I RI field activities conducted from October 1984 to November 1985. • AMC/Tetra Tech submitted RI reports between March 1985 and March 1987. • Health Effect Soils Investigation revealed extreme contamination in Mill Creek relative to other communities. • Centers for Disease Control demonstrated Mill Creek children were exposed to elevated levels of arsenic. • EPA changed the focus of RI/FS activities at the smelter site to Mill Creek where exposure was demonstrated and human health risk occurred. • EPA Mill Creek Endangerment Assessment completed in April 1986. • EPA relocated families with small children and	• EPA negotiated orders with AMC in summer 1986 to inventory and control flue dust and to conduct a separate expedited RI/FS for Mill Creek. • Mill Creek RI/FS field work conducted from May 1986 to March 1987. • Anaconda RI/FS activity was on hold during most of 1987. • International risk assessment forum completed work regarding arsenic risk assessment in August 1987. • AMC began buy-out process in 1987 and demolished homes as they were bought; by end of 1987, about 30 homes had been demolished, leaving seven occupied homes. • Mill Creek RI/FS was finalized in September 1987; the EPA filed a Record of Decision (ROD) in October 1987 whereby relocation of all Mill Creek residents was the remedial alternative chosen. • In the fall of 1987, AMC conducted a pilot test to extract precious metals from flue dust and convert arsenic into less soluble form.	• The workplans for Smelter Hill and the Old Works submitted by AMC were revised by EPA with assistance from BOR and USGS. Remedial investigation work is expected to begin summer or fall of 1988.

TABLE 3-5 (CON'T). HISTORY AND STATUS OF SUPERFUND INVESTIGATIONS IN THE CLARK FORK BASIN

SITE/LOCATION	RESPONSIBILITIES	HISTORY	HISTORY (cont)	CURRENT STATUS/ACTIVITIES
MILLTOWN RESERVOIR				
• The site includes the dam area, reservoir, and community of Milltown. • Site is located at the confluence of the Clark Fork and Blackfoot Rivers.	• DHES has lead responsibility for the Milltown site under a July 1983 cooperative agreement with EPA.	• Four community wells were found to be contaminated with arsenic during DHES-WQB sampling in May 1981. • Reconnaissance level hydrologic investigation undertaken in 1982 by UM identified reservoir sediments as a potential source of arsenic, iron, lead, manganese, and zinc. • Milltown Dam site placed on National Priorities List in December 1982. • Remedial investigation field activities initiated by UM in July 1983 to investigate the groundwater contamination problem and to identify alternative water supply. • The Cooperative Agreement was amended in February 1984 to obtain funds for design and construction of replacement water system. Design completed summer 1984; construction completed June 1985. • Water heaters were replaced in homes where arsenic levels were still elevated following installation of new water supply; water samples were collected for six months following water heater replacement.	• Draft RI/FS reports were submitted by HLA in August and September 1985. A change of scope followed and supplemental work was performed. • HLA submitted draft data report August 1986 and draft FS report November 1986. DHES and EPA subsequently determined that HLA had not fulfilled the terms of its contract. • In 1986 an emergency order was issued by FERC to rebuild the Milltown Dam spillway. This work, performed by the Montana Power Company, was initiated in August 1986 and completed in March 1987. • In February 1987 DHES terminated the Feasibility Agreement with HLA. • The cooperative agreement was amended in December 1987 to obtain funds to complete the FS, conduct a downstream screening study, and validate data for the site. • In 1988 FERC issued an order to complete the rehabilitation of the Milltown Dam.	• Activities at the Milltown site were on hold through much of 1987 due to contract problems with HLA and lack of funding. • DHES is currently negotiating a contract settlement with HLA. • DHES contracted with CDM in May 1988 to perform data validation, complete the feasibility study and perform a downstream screening study (down to confluence with the Bitterroot). Field activities for the downstream screening study are underway and CDM is currently developing a workplan for completion of the FS.

Investigations at each site must include an evaluation of the applicable and relevant or appropriate requirements (ARARs). These evaluations are intended to determine the standards that must be achieved during cleanup. There is a strong linkage between Superfund ARARs and water quality standards in the Clark Fork Basin. Superfund actions taken to alleviate metal and organic contamination problems in soils and surface and ground water will be guided by selected ARARs that protect public health and help to achieve improved water quality in Silver Bow Creek and the Clark Fork. These actions will also be coordinated with other environmental improvement programs being conducted in the area.

The schedule for achieving cleanup goals depends on a large number of variables, but substantial progress will likely be made during the next several years. The following are high-priority problem areas that are either already being addressed or will be addressed during the next two years:

Mill Creek
Walkerville Soils
Warm Springs Ponds
Butte Priority Soils
Anaconda Old Works
Berkeley Pit Mine Flooding
Travona Flooding
Montana Pole
Anaconda Flue Dust
Rocker

Some of these investigations are still in the negotiation stage, and completion dates are not firm. Periodic site-specific fact sheets and master plan updates will be prepared for public dissemination as long as studies and corrective actions continue.

The following text provides a summary of each Superfund site. The discussion is brief by design, as these sites will be addressed further in the Master Plan. Any reader seeking more detailed information regarding the status and future plans at these sites should refer to the study documents for each site located in the following public document repositories:

Montana College of Mineral Sciences and Technology
Library
West Park Street
Butte, MT 59701 (406)496-4281

Economic Development Agency
Butte/Silver Bow Government
Courthouse Building
155 West Granite
Butte, MT 59701 (406)723-8262

Butte-Silver Bow Library
106 West Broadway
Butte, MT 59701 (406)723-8262

Metcalf Senior Citizens Center
Anaconda, MT 59711 (406)563-3110

Hearst Free Library
Fourth and Main Streets
Anaconda, MT 59711 (406)563-9990

National Park Service
Deer Lodge, MT 59722 (406)846-2622

Mansfield Library
University of Montana
Missoula, MT 59812 (406)721-2665

Montana Department of Health and Environmental Sciences
Bureau of Solid and Hazardous Waste
A201 Cogswell Building
Helena, MT 59620 (406)444-2957 or (800)648-8465

Environmental Protection Agency
Montana Office
Room 292, Federal Building
301 South Park
Helena, MT 59626 (406)449-5414

Silver Bow Creek/Butte Addition

Over 100 years of mining, milling, and smelting activities in the Butte area have resulted in a myriad of environmental problems, including contamination of soils, surface water, and ground water. In late 1982, the EPA designated Silver Bow Creek down through the Warm Springs Ponds system as a Superfund site. In 1986 the boundaries of the site were officially expanded to include the City of Butte (Butte Addition) and the upper Clark Fork River to the Milltown Dam. The site is currently one of the largest, and perhaps one of the most complex Superfund sites in the nation.

The Montana Department of Health and Environmental Sciences has lead responsibility for Silver Bow Creek and the upper Clark Fork investigations. Phase I of the RI, completed in 1986, included the study of surface water and point sources, tailings, ground water, algae, agricultural lands, macroinvertebrates, bioassays, fish tissue, waterfowl, vegetation, and the Warm Springs Pond System. Phase II remedial investigations are now underway to gather remaining information needed to complete the feasibility study (FS), in which remedial actions for the site will be chosen. Phase II RI/FS activities include a screening study along the upper Clark Fork, additional studies of the Warm Springs Ponds system, a flood hydrologic evaluation of Silver Bow Creek, and a streambank tailings and revegetation study (STARS) designed to explore a range of reclamation alternatives for the drainages.

Contaminants of concern in the Silver Bow Creek site include arsenic, cadmium, copper, iron, lead, mercury, zinc, and various organic contaminants. Potential contaminant sources identified include (MultiTech 1987a):

- buried tailings associated with the former Parrot Smelter operations
- the Weed Concentrator complex
- tailings associated with the former Butte Reduction Works
- the Anaconda Pole Treatment Facility site at Rocker
- the Colorado Tailings
- Ramsay Flats mining wastes
- fluvially deposited mining wastes
- the Warm Springs Ponds
- the Metro Storm Drain
- Missoula Gulch and Browns Gulch
- the Butte WWTP
- storm drain outfalls
- the Montana Post and Pole Treatment seep (a separate Superfund site).

All of these contaminant sources will be addressed to some degree in the feasibility study of the site. Remedial actions designed for the major contaminant sources could have far reaching positive effects on the quality of water in the Clark Fork. Of primary concern is the Warm Springs Ponds system, which is the pivotal point in the drainage. An intensive study is now focused on that system and some action alternatives should be defined by the end of 1988.

The EPA has lead responsibility for the Butte Addition portion of the site. In the fall of 1986, the EPA Emergency Response Branch began investigations of mercury contamination in the Walkerville area. A year later, they proposed a plan for removals associated with lead and mercury contamination. Removal actions were initiated in April 1988 and should be completed by fall 1988. In the summer of 1987, EPA conducted a soil screening study of Butte, Centerville and surrounding areas. The data report submitted in May 1988, is being utilized to plan RI/FS activities for the Butte Addition. A draft workplan that will address both residential and nonresidential areas is expected to be finalized in fall 1988.

A key issue at the Butte Addition site is the mine flooding that has occurred in the Berkeley Pit and the underground mine workings since the Anaconda Minerals Company ceased dewatering pumpage in 1982. The water level in the pit is rising at about 72 feet per year, and worst-case projections suggest that the pit may be filled to capacity by the end of the century if no remedial actions are taken. There is concern that rising pit water may cause encroachment of contaminated water into the alluvial aquifer, and arsenic and other metals may migrate downgradient and adversely affect Silver Bow Creek and the Clark Fork (Camp, Dresser and McKee 1987, 1988a). Water levels in the Travona mine shaft and other mine workings southwest of the Berkeley Pit have also been rising since 1984, and there is concern over the potential for discharge of contaminated ground water to the alluvium and/or the ground surface (Camp, Dresser and McKee 1988b). However, during the first quarter of 1988, the rate of rise in the water level had decreased from two to five feet per month to 1.5 feet per month.

EPA has conducted several preliminary studies to evaluate the entire mine system, including a Berkeley Pit water balance study (Camp, Dresser and McKee 1987), an evaluation of flooding in the West Camp area mine workings (Camp, Dresser and McKee 1988b), and an analysis of the aqueous geochemistry of Berkeley Pit water (Camp, Dresser and McKee 1988a). Additional work on the mine flooding issues will be done during the RI/FS phase.

Montana Pole

The Montana Post and Pole Treatment facility in Butte operated from 1946-84, using a solution of 5 percent pentachlorophenol (PCP) and 95 percent diesel petroleum to preserve utility poles, posts, and bridge timbers. The pole plant discharged condensate from the treating operation into a ditch that runs north from the plant under the interstate bridge toward Silver Bow Creek until 1982 (it is not known for what period of time this discharge occurred). In 1983, an oil seep, most likely from a variety of sources, was identified on the south bank of Silver Bow Creek. The seep and Silver Bow Creek were sampled and analyzed for PCP, oil, and grease. Nine monitoring wells were installed in July 1983, two upgradient and seven downgradient of the facility. Based on the ground and surface water sample results and the estimated seepage of two to five gallons per day, the EPA Emergency Response Branch was brought in to conduct a site investigation.

A removal action has been underway at the site since July 1985 to alleviate seepage to Silver Bow Creek, collect product from the ground water, remove contaminated soil, and stabilize the site. Two separate product recovery systems were installed, and an interception trench was constructed to prevent further seepage into Silver Bow Creek. In 1986, about 9,000 gallons of product were detoxified and are now held on-site. Approximately 10,000 cubic yards of contaminated soil were excavated and bagged and are also stored on-site in five steel buildings.

Contaminants identified at the site include PCP, diesel, dioxin, hydrocarbons, and small amounts of creosote and polychlorinated biphenyls (PCB). At present, the site is stabilized, and only a very small amount of oil is seeping from the area. There is still contaminant movement through the ground water system, but so far most contaminants have been intercepted by the three recovery trenches that are still being pumped. A floating boom or pads placed in Silver Bow Creek are used to trap oil seeping into the creek.

To date, Superfund dollars have been utilized to fund the cleanup at the Montana Pole site. EPA and DHES have recently completed a potentially responsible party (PRP) search to determine if some cost recovery will be possible (the owner of the facility at the time of shutdown is bankrupt).

The EPA Emergency Response Branch activities were phased out during the summer of 1988. The State of Montana (DHES) has assumed lead responsibility for the site under cooperative agreement with EPA. DHES contracted with CDM in

August 1988 to develop a remedial investigation and feasibility study workplan for the site. The RI/FS will address the characterization and cleanup of soils, surface water, and ground water contamination. At present, contamination of ground water and the potential threat to Silver Bow Creek is the most serious concern. Therefore, ground water treatment may be addressed through an Expedited Response Action (ERA) or as an expedited operable unit under the RI/FS process. The Emergency Response Branch prepared an Engineering Evaluation and Cost Analysis (EE/CA) to address cleanup and treatment of contaminated ground water. This information will be incorporated into the ERA or RI/FS, as the Emergency Response Branch will not be conducting further work at the site.

Anaconda Smelter

Copper ores were processed at the Anaconda Smelter site at various times between 1884 and 1980. When operations ceased in 1980, approximately 6,000 acres of waste materials were left behind. The area was designated a Superfund site in early 1983. In the fall of 1984, the Anaconda Minerals Company, as the potentially responsible party, entered into an agreement with EPA to conduct several site remedial investigations.

In the first stage of the RIs, a variety of sites and media were studied. Four focused investigations included the slag piles, the arbiter plant, flue dust, and beryllium disposal areas. For the master investigation, the Old Works, ground water, surface water, soils, tailings, alluvium, hydrogeology, and geochemistry were studied.

The RI reports submitted by the Anaconda Minerals Company are still under review by EPA. During the course of the soils investigation, levels of arsenic and other heavy metals of concern to human health were found in the community of Mill Creek, located immediately adjacent to the Anaconda Smelter site. A study conducted by the Centers for Disease Control (CDC) revealed elevated levels of urinary arsenic in seven of ten Mill Creek children. As a result, the Anaconda Minerals Company entered into an agreement with EPA in July 1986 to conduct a separate expedited remedial investigation of the Mill Creek area. In May 1986, EPA began to temporarily relocate families with small children and others at high risk, while a permanent solution to the contamination problems was developed. These families never returned to Mill Creek and, along with many others, sold their properties to the Anaconda Minerals Company. All of the properties purchased by AMC have been demolished. By the end of 1987, only seven families remained in Mill Creek.

The Mill Creek RI/FS was finalized in September 1987, and a Record of Decision (ROD) was filed by the EPA in October 1987. The remedial alternative chosen was permanent relocation of all Mill Creek residents. The relocation action is scheduled to be completed by the end of 1988.

With the Mill Creek problem at the forefront, Anaconda Smelter RI/FS activities remained on hold through much of 1987. The Anaconda Minerals Company conducted some reclamation work on Smelter Hill (the smelter was demolished between 1982 and 1985), and the EPA conducted soil sampling in the communities of Anaconda, Opportunity, Warm Springs, Galen, and Deer Lodge.

Activities planned for 1988 include RI/FS studies of Smelter Hill, flue dust, and the Old Works. This work will be performed by the Anaconda Minerals contractor, PTI Environmental Services.

Contaminants identified at the Anaconda Smelter Superfund site include arsenic, beryllium, cadmium, copper, lead, and zinc, and there are likely some organic contaminants on Smelter Hill. Flue dust, a waste that is highly contaminated with arsenic and heavy metals, is located in various areas on Smelter Hill and is being addressed as a separate operable unit. EPA and state personnel are reviewing results of a pilot process that extracts valuable metals and converts the arsenic to a more stable compound. The process will be considered as a possible remedy along with other alternatives.

The Old Works area, which is the site of the first smelters in Anaconda, is probably of most immediate concern to the Clark Fork system. Warm Springs Creek, which is a tributary of the Clark Fork, flows through the middle of the Old Works area very close to deposits of slag and tailings. These wastes have elevated levels of contaminants, and some are within the floodplain of the creek. Although the Stage I RI/FS studies showed Warm Springs Creek water to be generally of good quality (Tetra Tech 1987), there is potential for water quality degradation in a large runoff or flood event. The RI/FS studies of the Old Works will likely lead to the removal of at least some of the contaminant sources, thereby increasing the chances that Warm Springs Creek will continue to deliver good quality dilution water to the Clark Fork system.

Milltown Reservoir

The Milltown Reservoir Superfund site is located at the confluence of the Clark Fork and Blackfoot River, approximately five miles upstream from Missoula, Montana. This hydroelectric facility was built in 1906 and is currently owned and operated by the Montana Power Company. The dam has served as a trap for an estimated 120 million cubic feet of arsenic-and-heavy-metals-laden sediments (Woessner et al. 1984) resulting from past mining and milling operations in the headwaters of the Clark Fork.

During a routine sampling in May 1981, the DHES Water Quality Bureau discovered that four wells serving 33 homes in the community of Milltown were contaminated with arsenic. In December 1982, the Milltown Reservoir area was listed as a Superfund site, and DHES entered into a cooperative agreement with EPA in July 1983 to conduct an RI/FS at the site. DHES hired the University of Montana to do the initial studies, and by December 1983, reservoir sediments had been identified as the likely source of ground water contamination. Construction of a new well and distribution system was started in November 1984, and was operational in June 1985. Subsequent sampling from homes on the system revealed that about half the homes tested had hot water arsenic levels above the drinking water standard. Replacement of hot water heaters and, in some cases, hot water lines, solved the problem, and Milltown residents now have an uncontaminated water supply.

In April 1985, a continuing RI/FS for the Milltown Reservoir site was initiated. DHES selected Harding Lawson Associates (HLA) as contractor. The RI was expanded to include a more detailed hydrogeologic evaluation downgradient of the reservoir, and the FS was to address long-term remedial action. A review of the RI/FS draft reports submitted by HLA in fall 1985 indicated a change of scope, and supplemental work was performed in the 1986 field season. After a review of the draft data report (August 1986) and draft FS report (November 1986), DHES and EPA determined that HLA had not fulfilled the terms of its contract. The Feasibility Study Agreement with HLA was terminated in February 1987.

RI/FS activities at the Milltown Reservoir site were minimal during most of 1987 and early 1988 while negotiation for a contract settlement with HLA proceeded. In addition, funding was not available for continuing work at the site until December 1987. DHES also attempted to obtain the original documentation it needed to validate the data collected by HLA. In May 1988, DHES contracted with Camp, Dresser and McKee (CDM), to perform the data validation, complete the FS, and conduct a downstream screening study. Field activities are underway and CDM is developing a workplan for completion of the FS.

The Milltown Dam has been repaired several times through the years. Recently, a two-phase reconstruction of the facility was initiated in response to an emergency order issued by the Federal Energy Regulatory Commission. Phase I work involved reconstruction of the spillway and was performed by MPC from August 1986 to March 1987. This work was carefully monitored to ensure minimal degradation of the Clark Fork downstream from the dam. Phase II of the rehabilitation project is underway and involves extensive repairs to the dam structure.

METALS-CONTAMINATED LANDS

Introduction

A vast acreage in the upper Clark Fork Basin is affected by elevated concentrations of metals in the soil. The extent and degree of contamination varies considerably, as do the sources of contamination. The major types of metals-contaminated lands are:

- areas covered by tailings disposal facilities or impoundments (e.g., Colorado Tailings area, Old Works, tailings ponds near Anaconda, Warm Springs Ponds)
- lands affected by aerial deposition of metals from historic smelting activities (e.g., Butte area, Deer Lodge Valley)
- agricultural lands affected by the historic use of tailings-laden irrigation water that was conveyed through extensive ditch systems
- floodplain areas of Silver Bow Creek and the upper Clark Fork that have accumulated tailings during historic flood events.

Each of these types of affected lands is discussed in the following sections. Sediment transport mechanisms, reservoir sediments, and reclamation are also discussed.

Tailings disposal areas

There are two major tailings disposal areas in or near the floodplain in the headwaters of the Clark Fork. The Colorado Tailings southwest of Butte cover about 30 acres within the floodplain of Silver Bow Creek (Duaime et al. 1987). The Anaconda and Opportunity tailings ponds east of Anaconda cover approximately 4,000 acres (Tetra Tech 1987).

Colorado Tailings

The Colorado Tailings lie between the Butte Sewage Treatment Plant on the east and the Ranchland Packing Company on the west. The site is bounded by Silver Bow Creek on the north, east, and west and the Burlington Northern Railroad grade on the south (Figure 3-2). The tailings are the waste product of the smelter and concentrator of the Colorado and Montana Smelter Company, which began operation in 1879. Eventually, the facility was bought by the Anaconda Company, and the smelter and concentrator were demolished between 1905 and 1907 (Duaime et al. 1987).

Tailings were disposed of in a marshy area adjacent to Silver Bow Creek, north of the facility. The earliest tailings were quite coarse but became finer as mill technology improved. The tailings average about five to six feet in depth and overlie an organic-rich peat layer that is discontinuous, particularly near the edges of the tailings deposit. Approximately 15 to 30 feet of alluvium underlie this layer (Duaime et al. 1987).

Heavy metals and arsenic concentrations in the Colorado Tailings and underlying layers are summarized in Table 3-6. Typical values for uncontaminated natural soils are provided for comparative purposes. The enrichment in the peat layer relative to the overlying tailings and the underlying alluvium indicates that the peat layer is concentrating metals that have leached down through the tailings.
The Colorado Tailings are of particular concern because of documented ground water and surface water degradation in the vicinity. These problems are discussed later in this chapter.

A variety of reclamation alternatives for the Colorado Tailings have been discussed, including: amendment of the existing surface, tailings removal and revegetation, covering the tailings with soil and revegetation, application of a rock mulch, relocation of Silver Bow Creek to the southern edge of the tailings, and construction of a drainage ditch along the southern edge of the tailings (Hydrometrics 1983a).

The ultimate fate of the Colorado Tailings will be determined by the Superfund program. The Colorado Tailings and the Butte Reduction Works (adjacent to the Colorado Tailings) constitute a separate operable unit that is being evaluated by the state and EPA. This operable unit is a fairly high priority, with Phase II activities scheduled to be underway in third-quarter FY 88. If a removal alternative were chosen, the contaminated peat layer beneath the tailings would have to be addressed as well as the tailings themselves.

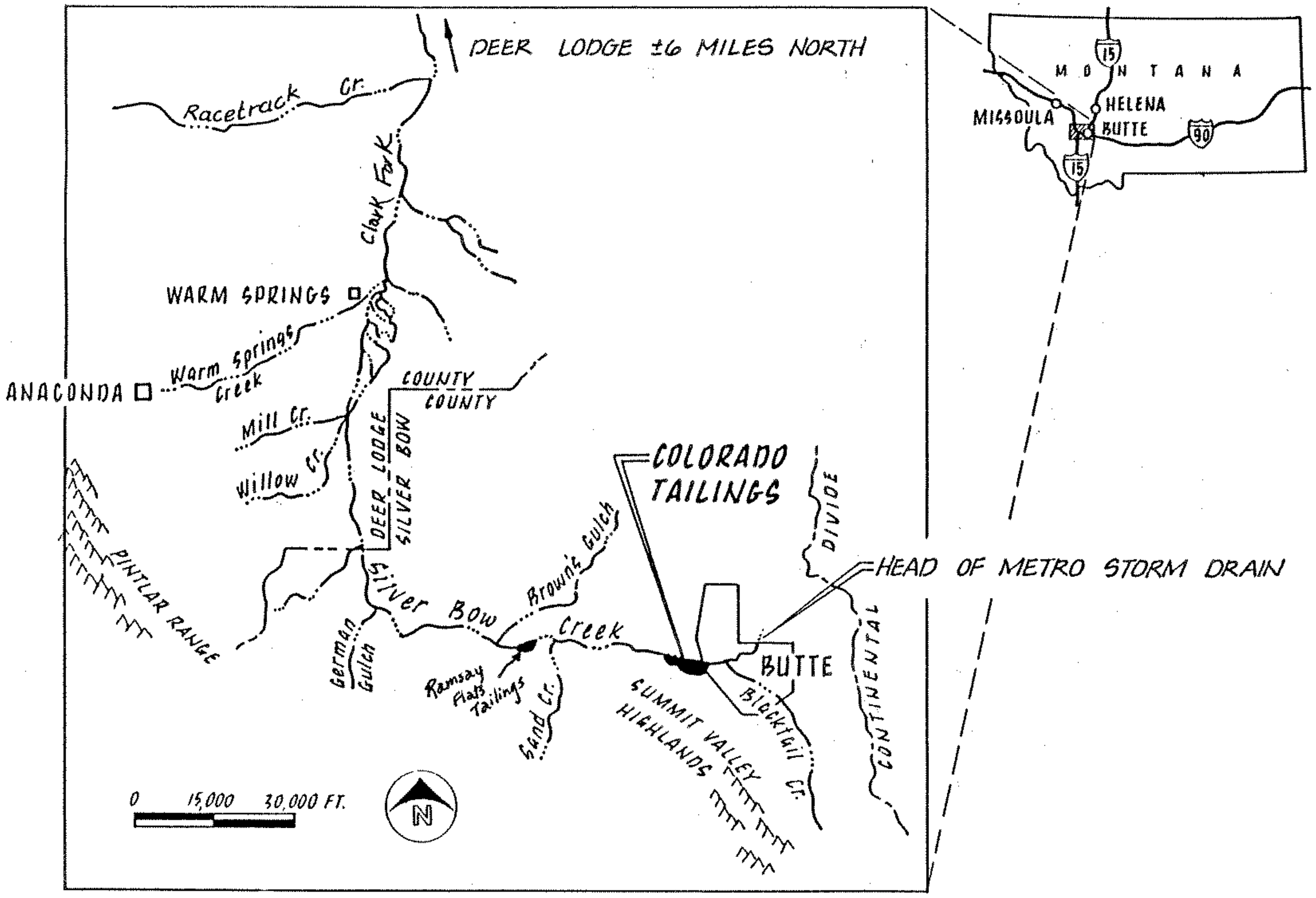


FIGURE 3-2. MAP SHOWING THE COLORADO AND RAMSAY FLATS TAILINGS ALONG SILVER BOW CREEK

TABLE 3-6. CONCENTRATIONS OF ARSENIC, COPPER, LEAD, AND ZINC IN THE COLORADO TAILINGS

SOURCE	MATERIAL	SAMPLE TYPE/LOCATION		ARSENIC	COPPER	LEAD	ZINC
					(ppm)		
Duaime et al. 1987	Tailings	Center field Series (13 holes)	Max	---	6,775	1,383	---
			Min	---	183	331	---
			Mean	---	1,370	667	---
	Tailings	West field Series (7 holes)	Max	---	8,965	942	---
			Min	---	222	277	---
			Mean	---	3,055	615	---
	Tailings	East field Series (8 holes)	Max	---	4,059	1,196	---
			Min	---	661	410	---
			Mean	---	1,390	765	---
Thornell 1985	Tailings	One drill hole (8 intervals)	Max	2,960	6,730	2,740	8,230
			Min	678	663	480	2,430
			Mean	1,742	3,058	1,264	4,945
	Peat	One drill hole (6 intervals)	Max	1,550	14,300	14,900	22,500
			Min	504	1,730	6,370	13,800
			Mean	821	6,022	9,933	17,333
	Alluvium	One sample from a drill hole	---	---	188	28	300
Peckham 1979	Tailings	48 in auger hole	---	---	1,400	1,300	11,000
		24 in auger hole	---	---	500	470	3,700
		50 in auger hole	---	---	3,900	530	12,000
Bohn et al. 1979	Natural soils	Typical value		5	20	10	50
		Range		1-50	2-100	2-200	10-300

* These samples were analyzed using metal assay techniques rather than digestion techniques.

Old Works

As mentioned in the previous section, the Old Works area (Figure 3-3) is the site of the first smelters in Anaconda. Nine discrete waste deposits have been identified in the vicinity of the Old Works. Waste types include tailings, black slag, heap-roast slag and red sands (mixed slag and tailings). Flue dust deposits are also found near the flues of the Upper and Lower Works. Combined, these wastes are estimated to cover about 326 acres (Tetra Tech 1987).

For the Stage I Remedial Investigation, Tetra Tech (1987) collected grab samples, tailings cores, and trench samples from these wastes. The ranges of selected metals concentrations in the grab samples are provided in Table 3-7.

The EPA considers the Old Works area to be a high-priority operable unit, due to its proximity to a housing development and Warm Springs Creek. Work plan negotiations are underway with the Anaconda Minerals Company, and work will likely begin there this summer or fall.

TABLE 3-7. RANGES OF METAL CONCENTRATIONS IN OLD WORKS GRAB SAMPLES

Waste Type	Arsenic (ppm)	Cadmium (ppm)	Copper (ppm)	Lead (ppm)	Zinc (ppm)
Black slag	54-80	1.3-1.9	4,580-6,030	594-634	8,840-9,460
Red sands	1,200-2,170	7.7-13.3	2,160-3,170	292-618	2,420-4,640
Tailings	1,840	8.5	3,420	459	4,510
Heap-roast slag	910-1,070	12.8-13.4	6,100-7,000	985-1,030	17,400-18,100
Flue material	68-10,400	0.9-71.5	184-37,100	17-639	46-2,140

Source: Tetra Tech 1987.

Anaconda and Opportunity Ponds

Tailings from operations at the Anaconda Smelter were slurried into a series of ponds northeast of the smelter complex (Figure 3-3). The first pond, Opportunity A, was built in 1914. The Opportunity B, C, and D ponds were constructed as needed through the next 40 years. Anaconda pond 1 was constructed in 1943, and Anaconda pond 2 was built in 1954. Together, the Anaconda and Opportunity ponds cover approximately 4,000 acres and contain an estimated 185 million cubic yards of tailings material (Tetra Tech 1987).

Wastes in the Anaconda and Opportunity Ponds are relatively homogeneous compared with other wastes in the upper Clark Fork because almost all of these wastes are

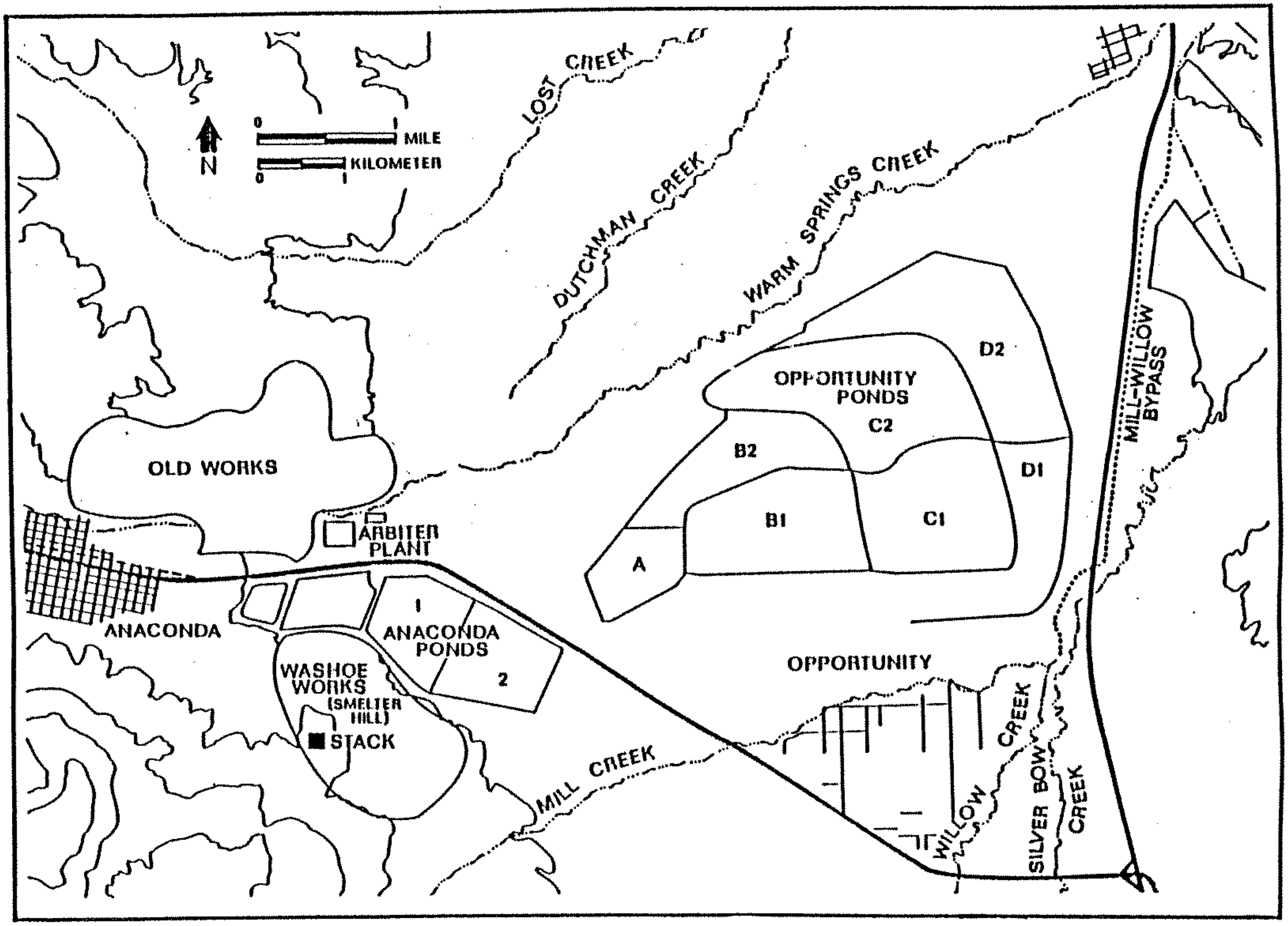


FIGURE 3-3. MAP SHOWING THE OLD WORKS AREA AND THE ANACONDA AND OPPORTUNITY PONDS, ANACONDA SMELTER SUPERFUND SITE. SOURCE: TETRA TECH 1986b.

smelter tailings. However, even the materials in this system exhibit considerable physical and chemical variability due to evolving smelting processes, extensive reworking of the deposits, and variabilities in the parent ores. Average concentrations of several key trace elements are 210 ppm arsenic, 470 ppm lead, 2,030 ppm copper and 1,200 ppm zinc (Tetra Tech 1986b).

An initial remedial investigation (Tetra Tech 1986b, 1987) has been concluded for the Anaconda and Opportunity Ponds. Included in the remedial investigation were waste characterization, surface and ground water studies, ground water modeling, and geochemical modeling. Here are some of the results of the waste characterization:

- In most of the tailings boreholes, three zones were recognized: an oxidizing zone in the upper part of the tailings, a transition zone, and an unaltered reduced zone.
- Concentrations of arsenic and most metals were generally lower near the tailings surface, increased with depth, and then decreased.
- The tailings are underlain by carbonate-rich alluvial gravels. At the tailings-alluvium interface, dramatic decreases in metal concentrations usually occurred, while the levels in the upper alluvium were still elevated relative to typical background values. Where multiple samples were recovered in the alluvium, the deepest samples often approached background levels.

As a result of changes instituted during the smelter demolition, the Opportunity Ponds system is in a state of physical and geochemical flux. Tailings areas that were continuously flooded since the early 1950s as a dust control measure are now draining. At present, the only external source of water to the site is treated wastewater from the city of Anaconda. This source may be discontinued in the near future. As the tailings dry out, an oxidizing front is predicted to move down through the tailings. Acid produced during this process could liberate significant quantities of trace metals to the ground water system.

Elimination of surface water to the site has resulted in increased wind migration of contaminants to adjacent areas, a gradual lowering of the ground water elevation across the site, and the potential for increased contamination movement into ground waters as tailings become oxidized. Assuming that the remedial investigation is validated, additional investigation activity is likely to focus mainly on providing information for the evaluation of permanent control strategies. Possible control options for the ponds include a variety of capping alternatives, erosion control measures, ground water containment, and perhaps ground water treatment. Ground water conditions in the vicinity of the Opportunity Ponds are discussed in more detail later in this chapter.

Warm Springs Ponds

The Anaconda Copper Company constructed three treatment ponds near Warm Springs, Montana, in 1911, 1916, and between 1954 and 1959. The purpose of the ponds was to settle out industrial wastes to improve the quality of water released to the Clark Fork. Lime has been added to pond inputs since 1959 to aid in precipitating dissolved metals.

The ponds cover about 2,800 acres, and Hydrometrics (1983a) estimated that they contain approximately 19 million cubic yards of mill tailings, mine waste rock, natural sediments, and precipitates.

A comprehensive study of the ponds is now underway as part of the Silver Bow Creek Superfund site investigations. Phase I of this study was conducted by MultiTech (1987d) and Phase II is being conducted by CH_2M Hill. For this Superfund investigation, the study area extends from the upper pH shack on Silver Bow Creek to the discharge of Pond 2, and includes the Mill-Willow Bypass, the Opportunity Ponds, and the Wildlife Ponds (Figure 3-4). The Mill-Willow Bypass is a manmade ditch along the edge of the Warm Springs Ponds that contains the combined flows of Mill and Willow creeks. The ditch was cut through historic tailings deposits left by Silver Bow Creek before the ponds were built and contains more recent tailings deposited when the creek is allowed to bypass the treatment ponds during periods of high runoff.

Average concentrations of selected metals in bottom sediment samples collected for the Phase I RI are provided in Table 3-8.

TABLE 3-8. TOTAL METAL AVERAGES OF WARM SPRINGS PONDS 2 AND 3 BOTTOM SEDIMENTS

Pond	Metal (total ppm dry weight)					
	As	Cd	Cu	Pb	Fe	Zn
2	294	103	3,940	542	71,000	12,100
3	422	193	5,170	183	95,300	32,300

Source: MultiTech 1987a.

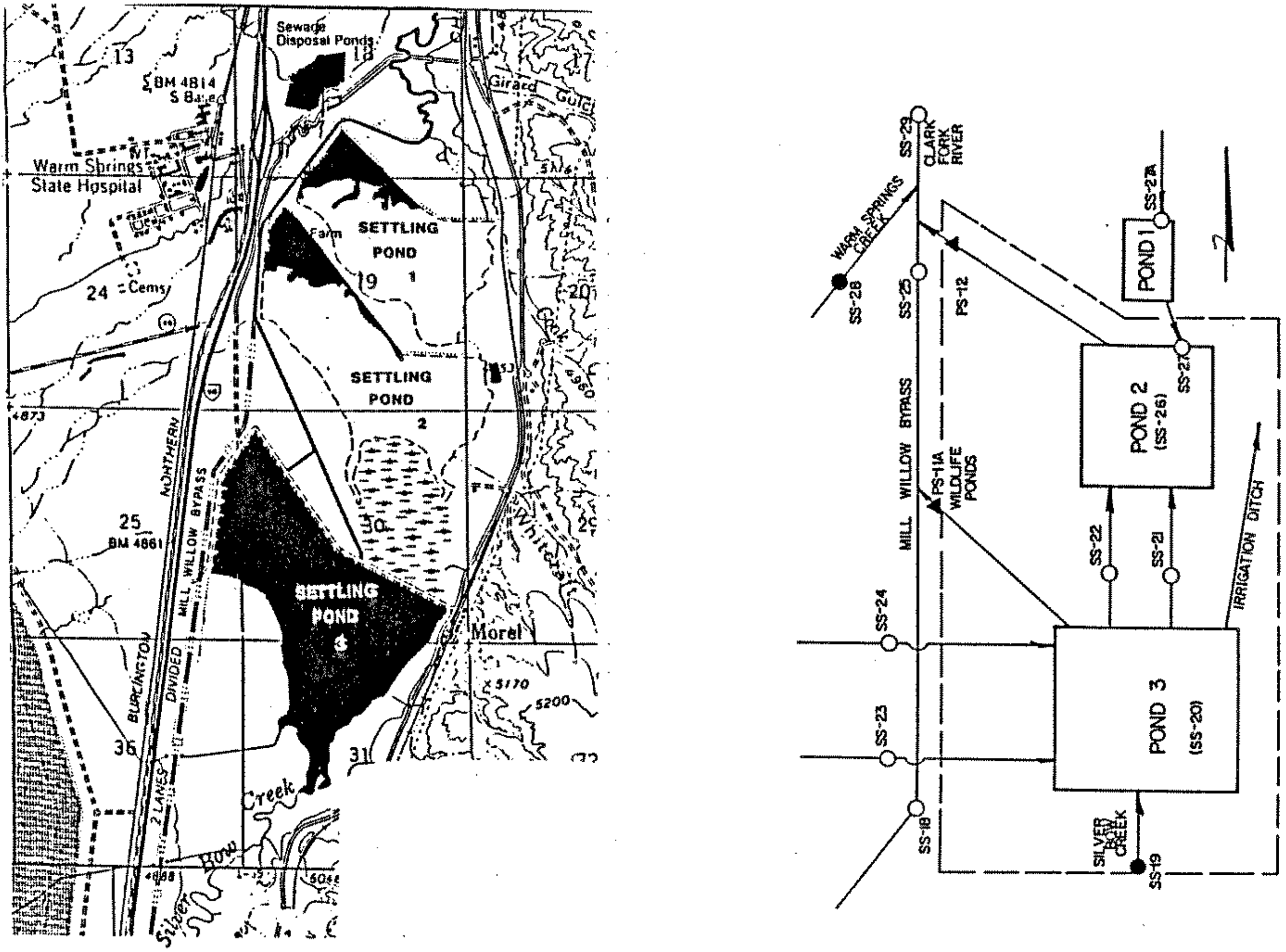


FIGURE 3-4. MAP AND SCHEMATIC OF THE WARM SPRINGS PONDS SYSTEM. SOURCE: MULTITECH 1987d.

The Warm Springs Ponds are designed to contain a flow of about 700 cfs (U.S. Army Corps of Engineers 1978). Silver Bow Creek flows greater than this are diverted around the ponds into the Mill-Willow Bypass, where they continue untreated into the Clark Fork. However, dike failure and bypass due to collection of debris on the gates has occurred at flows much less than 700 cfs (MultiTech 1987a). Bypass events occur on the average of once per year. Although no water quality samples of Silver Bow Creek were obtained by MultiTech during a bypass event, historic and Water Quality Bureau data show that such events trigger large increases in TSS and most metals in the Clark Fork.

The 100-year flood was estimated by Hydrometrics (1983c) to be 3,600cfs, and the pond structures would probably withstand a flood of that magnitude. However, during floods slightly larger than the 100-year flood, risk of pond failure increases significantly. At flows greater than 4,000 cfs on Silver Bow Creek, the diversion structure at the upper pH shack would no longer function reliably, and the full flood would possibly enter the Mill-Willow Bypass through the diversion ditch (IECO 1981). This flood probably would cause failure of at least one of the pond berms and loss of the contents of that pond (U.S. Army Corps of Engineers 1978). Pond 3 could fail directly when its outflow reached 5,600 cfs, and a flow of 7,000 cfs would overtop both Ponds 2 and 3, causing their failure (IECO 1981). Failure of the ponds also could occur if a large magnitude (6.9 Richter Scale) earthquake weakened the pond embankments. Failure of the Warm Springs Ponds embankments would release large amounts of mining and milling wastes to the Clark Fork. Under those conditions, the Warm Springs Ponds would become a major source of contamination.

An evaluation of the remaining useful life of the Warm Springs Ponds treatment system indicates that incoming sediment loads are the principal controlling factor and suggests that the life of the pond system could exceed 100 years under existing operating conditions (this calculation assumes no major changes in pond design or operation for the next 100 years). However, the pond sediments have some of the highest concentrations of toxic metals found anywhere in the area and they pose a long-term potential threat to the water quality of the Clark Fork (MultiTech 1987a).

Lands Affected by Aerial Deposition

Nearly 100 years of smelting activities at the Anaconda Smelter resulted in the migration of a large burden of heavy metals, arsenic, and sulfur compounds to soils in the area. The main mechanisms were smelter stack emissions and fugitive dust from various waste deposits in the Anaconda area.

Studies conducted for the Stage I Superfund investigation of the Anaconda Smelter site included a soils investigation to determine the extent and severity of soil contamination from smelter stack emissions. Soil profiles (0-2", 2-10", 10-25" intervals) were sampled at 23 sites along four transects emanating from the smelter stack in four directions (Figure 3-5). Where possible, adjacent tilled and untilled fields were sampled to determine if there was a difference in the vertical distribution of metals in the soils. Such pairs were sampled at seven of the sample sites. Results of the surface soil sampling are provided in Table 3-9. Typical concentration in natural soils are provided for comparative purposes. The following trends emerged from this study (Tetra Tech 1987):

- Concentration of heavy metals and arsenic decreased with increasing distance from the smelter.
- Soil contamination is most pronounced in the prevailing wind directions; to the northeast up the Deer Lodge Valley and to the southwest up the Mill Creek Valley.
- At all sample sites except the tilled sites, the metals were concentrated in the 0-2 inch interval.
- At the tilled sites, metal concentration were similar in the 0-2 inch and 2-10 inch intervals and considerably lower than those in the 0-2 inch increment at the untilled station in the pair.
- The heavy metals and arsenic have not moved beyond ten inches; most of the values in the 10-25 inch increment were below detection limits or within the range for uncontaminated soils.

In the area immediately surrounding the smelter (within one to three miles), much of the land is devoid of vegetation or very sparsely vegetated. This could be due to heavy metal and arsenic contamination but may also be due to poor soil moisture conditions, poor macronutrient status, or some combination of the above. Most of this land is owned by the Anaconda Minerals Company.

Farther away from the smelter, vegetation is well established and land uses, such as growing crops, are not precluded despite above-normal metal levels. It appears that tillage results in lower levels and a more even distribution

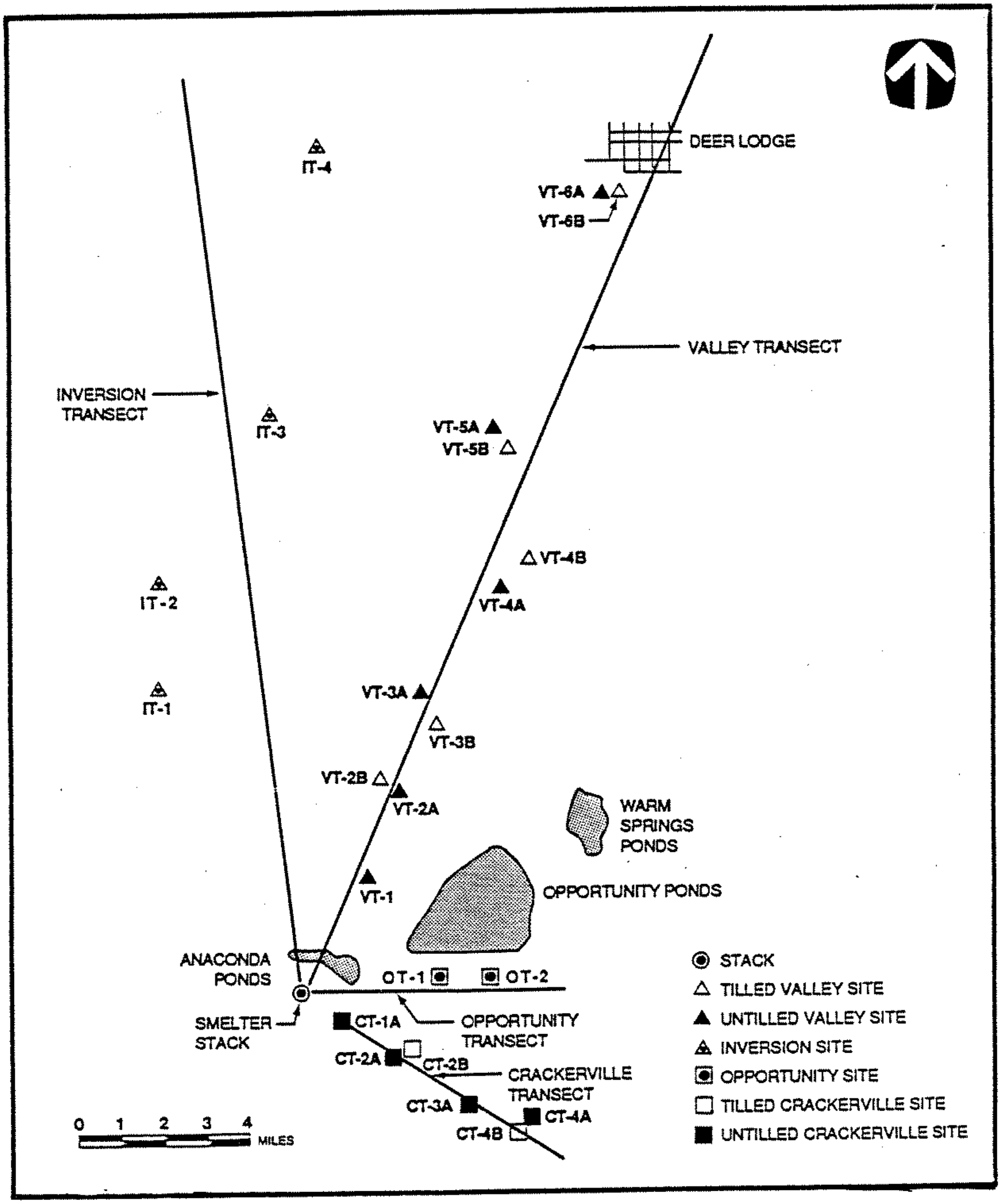


FIGURE 3-5. ANACONDA SMELTER RI SOIL SAMPLING SITES
SOURCE: TETRA TECH 1987.

TABLE 3-9. CONCENTRATIONS OF SELECTED CONTAMINANTS IN ANACONDA RI/FS TRANSECT SOIL SAMPLES[a]

		Depth Interval		Acid-Extractable Concentrations (mg/kg)				Distance from
Transect	Station[b]	(in)	Arsenic	Cadmium	Lead	Copper	Zinc	Stack (mi)
Opportunity	OT-1	0-2	370	5.2	111	583	197	
		2-10	9	3.3	10	319	274	3.1
		10-25	<2.3	<0.4	9	19	39	
	OT-2	0-2	226	5.8	128	590	296	
		2-10	81	1.4	26	140	95	4.2
		10-25	<2.3	<0.4	14	30	40	
Valley	VT-1	0-2	430	10.2	146	1,679	608	
		2-10	86	2.5	26	309	187	3.2
		10-25	32	0.6	15	98	68	
	VT-2A	0-2	143	6.3	103	543	370	
	(untilled)	2-10	100	2.5	42	243	157	5.2
		10-25	<2.3	<0.4	7	17	36	
	VT-2B	0-2	66	2.8	55	302	200	
	(tilled)	2-10	62.5	2.4	44	222	156	5.3
		10-25	16	0.7	11	31	58	
	VT-3A	0-2	318	5.9	146	569	298	
	(untilled)	2-10	97	2.4	31	200	138	7.7
		10-25	8	<0.4	7	21	35	
	VT-3B	0-2	91	3.1	52	254	175	
	(tilled)	2-10	71	1.8	33	157	109	7.1
		10-25	34	0.5	5	18	28	
	VT-4A	0-2	226	9.2	148	449	488	
	(untilled)	2-10	59	1.2	21	98	68	10.3
		10-25	12	0.8	12	27	54	
	VT-4B	0-2	24	1.8	36	133	115	
	(tilled)	2-10	24	1.4	29	102	93	10.7
		10-25	16	0.4	8	27	38	
	VT-5A	0-2	168	5.6	101	387	320	
	(untilled)	2-10	9	<0.4	11	26	63	13.6
		10-25	<2.3	0.4	9	19	49	
	VT-5B	0-2	41	1.6	32	102	120	
	(tilled)	2-10	40	1.6	29	95	119	13.5
		10-25	6	0.5	8	18	53	
	VT-6A	0-2	12	0.9	22	62	68	
	(untilled)	2-10	18	0.8	18	46	60.5	19.5
		10-25	<2.3	0.4	8	19	32	

TABLE 3-9 (CON'T). CONCENTRATIONS OF SELECTED CONTAMINANTS IN ANACONDA RI/FS TRANSECT SOIL SAMPLES[a]

		Depth Interval	Acid-Extractable Concentrations (mg/kg)					Distance from
Transect	Station[b]	(in)	Arsenic	Cadmium	Lead	Copper	Zinc	Stack (mi)
	VT-6B	0-2	8.6	1.1	19	71	189	
	(tilled)	2-10	11	0.9	16	62	169	19.5
		10-25	<2.3	<0.4	6	14	33	
Inversion	IT-1	0-2	157	6.6	95	350	295	
		2-10	<2.3	0.8	37	24	108	8.1
		10-25	<2.3	0.8	38	21	144	
	IT-2	0-2	55	2.0	53	94	133	
		2-10	<2.3	<0.4	17	22	97	10.2
		10-25	<2.3	<0.4	8	20	61	
	IT-3	0-2	53	2.6	38	108	114	
		2-10	19	0.8	9	20	53	13.3
		10-25	3	0.6	8	18	49	
	IT-4	0-2	29	2.4	31	41	132	
		2-10	<2.3	1.3	15	24	84	19.6
		10-25	<2.3	0.4	12	19	65	
Crackerville	CT-1A	0-2	1,660	62	1,000	2,330	1,190	
	(untilled)	2-10	513	15	80	205	526	1.4
		10-25	57	<1U[c]	21	26	57	
	CT-2A	0-2	390	48	769	1,880	1,650	2.9
	(untilled)	2-10	260	4	32	133	103	
	CT-2B	0-2	200	11	167	458	386	3.0
	(tilled)	2-10	230	8.3	104	283	238	
	CT-3A	0-2	200	23	380	723	714	4.9
	(untilled)	2-10	39	<1U	18	51	56	
	CT-4A	0-2	430	8.7	241	500	244	6.15
	(untilled)	2-10	100	3.2	45	115	126	
	CT-4B	0-2	102	3.3	51	132	117	6.1
	(tilled)	2-10	89	3.1	53	138	101	
Natural soils[d]	Typical Value		5	.06	10	20	50	
	Range		1-50	.01-7	2-200	2-100	10-300	

[a] From Tetra Tech 1987.

[b] See Figure 3-5 for station locations.

[c] Undetected at detection limit shown.

[d] From Bohn et al. 1979.

of metals in the upper ten inches of the soil profile, which may allow successful establishment of crops. However, it has not been clearly documented whether heavy metal contamination in the Deer Lodge Valley has resulted in reduced crop yields. One study, performed by Munshower (1977) while the Anaconda Smelter was still in operation, did assess cadmium contamination in the Deer Lodge Valley. He compared cadmium levels in soils, plants, and animals from a site 15 miles northeast of the smelter with those from a control site near Bozeman, Montana (Gallatin Valley). Cadmium concentrations in Deer Lodge Valley soils were significantly higher than those in Gallatin Valley soils used for similar purposes. Similarly, grasses and alfalfa from the Deer Lodge Valley showed higher tissue cadmium levels. Cadmium levels in barley grain averaged eight times greater than those from the Gallatin Valley. Cadmium concentrations in the liver and kidney tissues of cattle and swine from Deer Lodge Valley reflect the excess cadmium in the animals' diets, as concentrations in both livers and kidneys were significantly higher than those collected from Gallatin Valley animals. However, other plant tissue analyses have not been performed recently in the valley; therefore, it is not known if other metals are accumulating in crops or native vegetation or if transference of the metals through the food chain is occurring.

The Stage II RI/FS for the Anaconda Smelter site will likely address such questions; however, the EPA is currently focusing on more immediate hazards at the site that involve human health issues. The agricultural lands are at present a lower priority.

Hazard or action-level criteria have not been developed for soils in the vicinity of the Anaconda Smelter CERCLA site. In fact, the only Superfund site in Montana for which such criteria have been developed is the East Helena site near the ASARCO Smelter. These criteria were developed specifically for the Helena Valley area to assess the potential risk to agriculture (they do not address potential risk to the human population from consumption of these agricultural products). Extrapolation of the hazard criteria to other sites may not be appropriate due to possible differences in geology (hence natural background metals levels), soil physical and chemical characteristics, crops grown, climate, etc. However, it may still be useful to present these criteria to give the reader at least some perspective on what could be considered problem metal levels in soils and plants. The Helena Valley criteria are summarized in Table 3-10.

TABLE 3-10. METAL HAZARD LEVELS FOR THE HELENA VALLEY NEAR THE EAST HELENA CERCLA SITE

	SOIL (TOTAL) (ppm)		SOIL (EXTRACTABLE) (ppm)		PLANT TISSUE (ppm)	
	Hazard	Tolerable	Hazard	Tolerable	Hazard	Tolerable
Arsenic	100	25	50	2	20	3
Cadmium	100	4	30	2	50	10
Copper	100	50	---	---	20	10
Lead	1000	250	500	200	---	25
Zinc	500	200	60	5	500	50

Sources: CH_2M Hill 1987a,b.

Irrigation-Affected Lands

The deleterious effects of using Silver Bow Creek and upper Clark Fork water for irrigation was recognized as long ago as the early 1900s. Haywood (1907) reported that many farmers used Clark Fork water only when absolutely necessary due to its injurious effects. Results of surface water investigations conducted by Haywood and other researchers led him to conclude that Clark Fork water was not suitable for irrigation use and would seriously injure land to which it was applied (Haywood 1907). Haywood also sampled irrigated surface soils up to 15 miles northeast of the smelter and found very high copper concentrations relative to sites west and southwest of the smelter that were not irrigated by Clark Fork water (Haywood 1910).

Little additional research was conducted on contaminated irrigation water until recently, but the problem was still recognized in various documents, such as the 1959 Water Resources Survey for Powell County (Buck et al. 1959) and the Deer Lodge Valley Conservation District's Long Range Program (1982).

Hydrometrics (1983b) reported that several fields (about 200 acres east of the Clark Fork near Deer Lodge) had been affected by tailings and poor-quality irrigation water conveyed by a ditch. These fields have large barren areas with negligible productivity and weed and erosion problems.

In March 1985, the Montana Bureau of Mines collected soil cores from three land types on the Spangler Ranch near Gregson, Montana, for phase I of a study of reclamation techniques on heavy-metal contaminated pasturelands (Osborne et al. 1986). Fifteen soil cores were collected (although only three were analyzed) from a dryland pasture, a pasture site, and an irrigated alfalfa field to determine metal and arsenic distribution in the soil profiles. Elevated levels of arsenic, copper, and zinc were found in the upper nine inches of soil. One of the sites was thought to be within the historic floodplain of Silver Bow Creek and was reportedly flooded and irrigated with creek water in the past.

A literature review conducted in developing the Silver Bow Creek remedial investigation workplan revealed an estimated 5,400 acres of cropland potentially contaminated by irrigation water in Silver Bow, Deer Lodge, and Powell counties (MultiTech and Stiller and Associates 1984).

In June 1985, MultiTech undertook a reconnaissance-level study of irrigated lands between Rocker and Gold Creek as part of the Silver Bow Creek RI Agriculture Investigation (MultiTech 1986). Its objectives were to refine previous estimates of the extent and severity of contamination and to prepare a preliminary evaluation of the impact on irrigated croplands, livestock, and human health and welfare.

During the reconnaissance study, 38 soil samples were collected at 16 sites from six areas (Figure 3-6). At all sites except the one near Gold Creek, soil samples were collected both upgradient and downgradient of abandoned irrigation ditches. Eighteen plant samples were also collected at the 16 sites. Observations from this study include (MultiTech 1986):

- Soil and plant metal levels were elevated more frequently in the downgradient than in the upgradient sites.
- Heavy metals contamination in upgradient soils tended to be limited to the top six inches of soil, whereas contamination commonly extended to 24 inches or more in downgradient soils.
- Contamination of soils was more severe in Silver Bow Creek and upper Clark Fork floodplain areas than in irrigated terrace sites.
- Vegetation growing on contaminated sites contained elevated metal levels (particularly zinc); however, concentrations were generally in the range that is nontoxic to livestock unless such vegetation is the only forage source.
- Deposition of heavy metals and resulting increased acidity from pyrite mineral oxidation was severe enough in some areas to prevent vegetative growth.

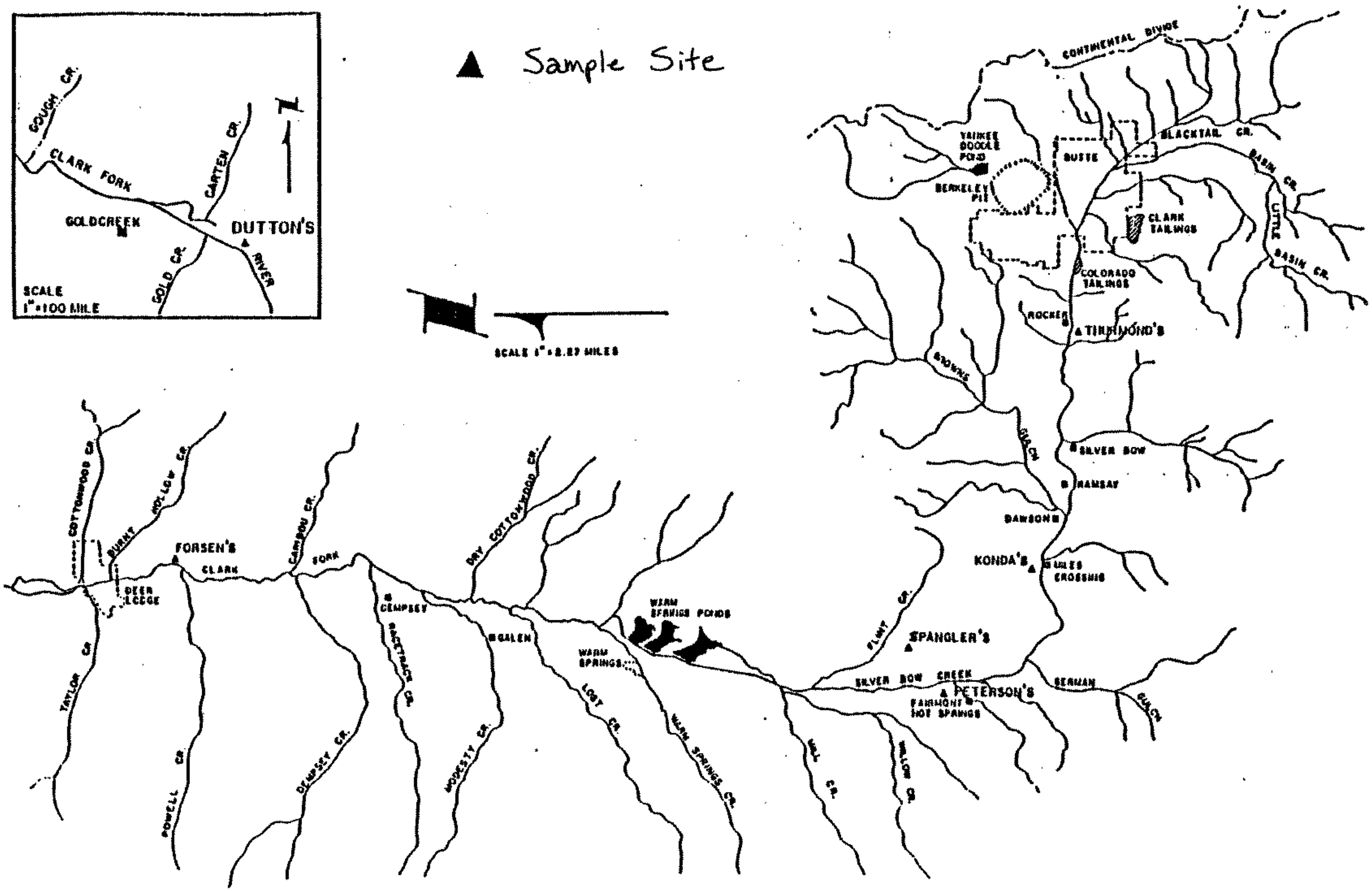


FIGURE 3-6. SILVER BOW CREEK RI SOIL SAMPLING SITES. SOURCE: MULTITECH 1986.

- The rural nature and remoteness of most of the affected areas limited the risk to humans via direct contact or ingestion of metals.

- Airborne contaminants may have constituted some of the soil's heavy-metals burden at the two sites closest to the Anaconda Smelter site.

- Additional aerial photo interpretation of the study area, aided by the field observation, supported the original estimate of about 5,400 acres of obviously affected land in Silver Bow, Deer Lodge, and Powell counties.

In July 1985, Schafer (1985) took this analysis a step further by addressing lands that had reduced yields--a more subtle vegetative productivity effect. Based on photo interpretation and very limited field reconnaissance, he estimated that there were approximately 28,000 acres of irrigated or previously irrigated land affected in some way by tailings contamination in Deer Lodge, Silver Bow, Powell, Missoula, and Granite counties. This total yield loss would be equivalent to 12,475 acres at full production (Schafer 1985).

It is not clear whether mitigation of irrigation-affected lands will be addressed within the confines of the Superfund program. A variety of techniques, including soil treatment, water treatment, and crop management, could be employed to treat these lands (MultiTech and Stiller and Associates 1984).

Floodplain Tailings

Between the late 1880s and the mid-1950s, mining and smelting wastes were discharged directly into Silver Bow Creek and large quantities of tailings were transported downstream to the Clark Fork. The Milltown Reservoir near Missoula, which is the first major impoundment below the Butte-Anaconda mining district, probably trapped most of the tailings and contaminated sediment. However, a large volume of river-borne tailings has been deposited across the floodplain in the Deer Lodge Valley. The most severely affected area is between Butte and Deer Lodge, although floodplain tailings occur down to Missoula. These deposits have had significant detrimental effects on the Clark Fork riparian system, and they may be a source of continued contamination (Johns and Moore 1985).

The first large floodplain deposit in the headwaters is Ramsay Flats, located along Silver Bow Creek between Silver

Bow and Dawson (Figure 3-2). This deposit covers approximately 160 acres and consists of fluvially transported tailings mixed with natural sediment (MultiTech 1986). Its average depth is estimated to be about six feet, and metal analyses conducted in a study by Peckham (1979) indicated a range of 69-5,400 ppm copper, undetected-to-1,900 ppm lead, and 460-5,500 ppm zinc.

For the tailings portion of the Silver Bow Creek Remedial Investigation, 15 samples were collected between Butte and the Warm Springs Ponds. Samples of soil buried by tailings were also collected to determine if metals had migrated out of the tailings. Results of the metal analyses are summarized below (MultiTech 1987b).

	Tailings (ppm)	Buried Soil (ppm)
Total arsenic	399 (geom mean)	53 (geom mean)
Total cadmium	13.4 (average)	58 (max)
Total copper	2,350 (average)	-----
Total lead	989 (average)	98 (geom mean)
Total zinc	3,070 (geom mean)	336 (geom mean)

As expected, these data show greatly elevated concentrations of metals in the tailings. Metal levels in the underlying soils are generally several times typical geochemical background values, indicating that enrichment via leaching is occurring.

MultiTech also collected some samples of the bluish surface salts that form on the floodplain surface in some areas during the summer. These samples contained 7 to nearly 10 percent total copper and 2 to 3 percent total zinc.

Brooks (1988) recently conducted a detailed investigation of the distribution and concentration of metals in sediments and water in the upper Clark Fork floodplain. The study area included about two miles of floodplain near Racetrack Creek. The author mapped the floodplain sediments using aerial photos and data obtained from cores, trenches, and augering. Soil samples were collected at various distances from the river to determine mineralogy, grain size, and lateral distribution of metals concentrations. Water movement into the vadose zone was measured at selected sites with suction lysimeters. Sandpoint piezometers and augered wells were used to measure water levels and collect water samples from the alluvial aquifer.

By examining stratigraphic profiles of floodplain sediment, Brooks delineated three major periods of mine waste deposition: 1) pre-mining, represented by coarse sand and organic overbank deposits under reducing conditions; 2) syn-mining, characterized by transition sediments and tailings

?

during?

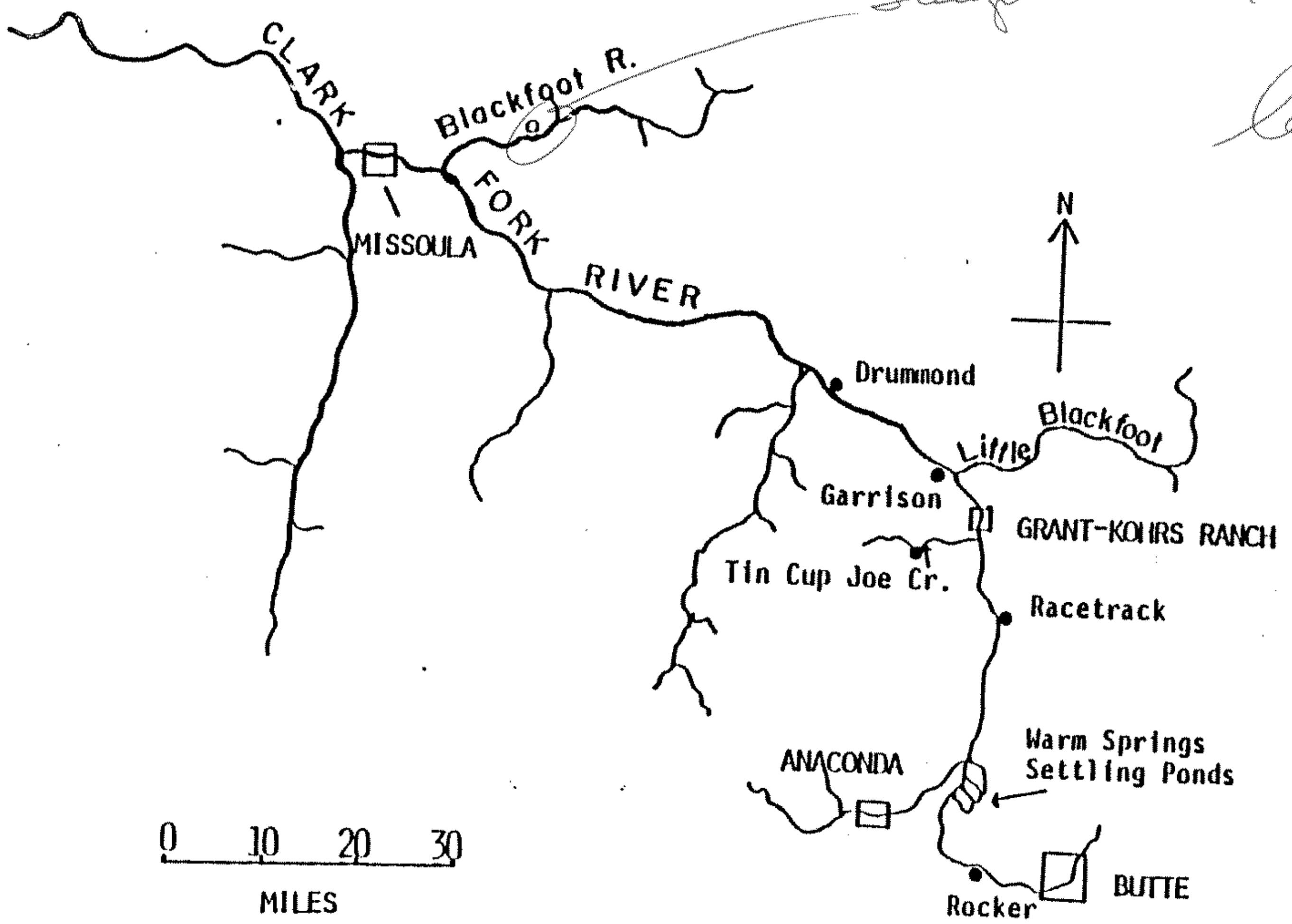
deposits under oxidizing conditions; and 3) post-mining, distinguished by grass-bound topsoil.

In areas contaminated by tailings deposits, the author documented enriched concentrations of cadmium, copper, manganese, and zinc in sediments and porewater, and arsenic in ground water. Mechanisms that chemically distribute metals between particulate and dissolved phases are mainly dependent on the redox conditions and on the pH of the system. Thus, changes in redox conditions or fluctuations in pH could create a potential source of metals and arsenic to local ground water and surface water systems (Brooks 1988).

The distribution of metals indicates that both vertical and lateral migration have occurred. During high-evaporation and low-precipitation periods, metals and sulfate in solution migrate to the surface and are precipitated as metal-enriched sulfate salts. Subsequent intense precipitation and rapid surface runoff results in the instantaneous dissolution of these salts, causing an abrupt lowering of pH and mobilizing metals to surface waters. Also, during flood conditions, metals can be incorporated into bed sediment and surface waters where tailings deposits are directly exposed to the active channel.

Downward vertical migration within the stratigraphic profile is indicated by the highly elevated concentrations of metals in organic-rich clayey silt directly underlying the tailings deposits. Complexation of metals in this unit is highly enhanced by the abundance of organic material, the proximity of the redox boundary, and the fine-grained nature of the sediment. Consequently, these factors prevent movement into the underlying coarse sand and gravel aquifer. Any small-scale downward mobilization of metals into the aquifer would likely be masked by dilution from ground water (Brooks 1988).

Ray (1983) conducted an investigation of metals-enriched fluvial sediments in the upper Clark Fork. Samples were collected from the floodplain near Rocker, Racetrack, Garrison and Drummond (Figure 3-7). A check site was sampled in the Tin Cup Joe Creek drainage, and a control site was sampled in the Blackfoot River drainage. Results of this study are summarized in Table 3-11.



Sample site ?

legend ?
● sample site

FIGURE 3-7. UPPER CLARK FORK SEDIMENT, SOIL, AND BIOTA SAMPLING AREAS (RAY 1983; RICE AND RAY 1984).

TABLE 3-11. AVERAGE CONCENTRATIONS OF SELECTED METALS IN FLOODPLAIN SEDIMENTS

Site	No. of Samples	Average ppm in soil[1] Copper	Arsenic	Cadmium
Clark Fork Floodplain				
Rocker	3	1,102	164	10.0
Racetrack	8	2,375	402	11.6
Garrison	8	1,587	629	5.0
Drummond	7	4,155	578	12.9
Other Floodplains				
Tin Cup Joe Creek check site	3	53	26	1.7
Blackfoot River control site	1	13	4	<0.03

1 Arithmetic means
Source: Ray 1983.

The metal concentrations in the mainstem floodplain are generally several orders of magnitude above the levels expected for noncontaminated sediments. It is interesting to note that the farthest downstream site (Drummond) had the highest average cadmium and copper levels and the second-highest arsenic concentration, indicating that in this study, metal levels did not decrease with distance downstream from the source areas at Butte and Anaconda.

In 1983, Rice and Ray (1984) conducted a study of the Grant-Kohrs Ranch at the north end of Deer Lodge (Figure 3-7). This ranch is a National Historic Site that commemorates the development of the cattle industry in the west. Approximately 75 percent of the ranch acreage is on the floodplain of the Clark Fork, which bisects the site. The study was conducted to describe the flora and fauna of the site and to assess the extent and severity of metal contamination in the ranch soils and biota.

The researchers sampled soil and biota in four distinct zones on the ranch: riparian zone--grass/shrub floodplain, meadow zone--grass/hay, bench zone--grass, creek zone--Cottonwood Creek (minor tributary to the Clark Fork).

The same check and control plots established by Ray (1983) (on Tin Cup Joe Creek, about five miles southwest of the ranch, and along the Blackfoot River, 60 miles northwest of the ranch) were used for this study.

Soil profiles (0-10 inches) and a forage grass were sampled at 94 plots. Concentrations of soil arsenic, cadmium, and copper in all four zones were greatly elevated compared with the control plot in the Blackfoot drainage, with the highest levels occurring in the riparian zone. Metal concentrations in the grasses sampled were higher than concentrations thought to be typical of grasses from uncontaminated areas, but only copper in grass from the riparian zone was significantly elevated relative to the check plot (Rice and Ray 1984).

In a study by Moore (1985) for the EPA, samples of bank sediment were collected at 26 sites along the mainstem Clark Fork to determine if these floodplain deposits could be the source of metals in the Milltown Reservoir. Bank sediments in the Little Blackfoot River, Flint Creek, Rock Creek, and the Blackfoot River were also sampled to assess the possibility of metal-rich sediments coming from the major tributary drainages. To establish natural background levels of metals for the basin, samples were collected from isolated outcrops of the Missoula Lake Beds, which contain only natural concentrations of metals (Moore 1985).

The mainstem Clark Fork sites were five to six river miles apart between the Warm Springs Ponds and the Milltown Reservoir. Where possible, fine-grained sediment from the upper layers of bank deposits on the lowest terrace near the main channel was sampled. Such samples would represent the most recent sediment deposited outside the channel. Between the ponds and Garrison, the sediments were in many places actually tailings, with green and blue copper sulfate and carbonate precipitates on exposed surfaces. The tailings were thickest near the Warm Springs Ponds (over three feet) and decreased downstream (Moore 1985).

Results of this study indicate several trends in the distribution of metals in the floodplain sediments. Arsenic, copper, and lead concentrations showed a distinct decrease downstream from the upper reaches to about Flint Creek, a slight decrease until Rock Creek, and then a slight increase near the Milltown Reservoir (Figures 3-8, 3-9 and 3-10). Cadmium and zinc showed similar trends, although concentrations were more erratic with strong spikes along the mainstem. The mainstem sediment metal levels were generally orders of magnitude higher than tributary and Missoula Lake Bed levels, suggesting that Clark Fork floodplain sediments are extremely enriched over natural background concentrations. However, distribution of the contaminated sediment is not uniform, as two of the mainstem sample sites (river miles

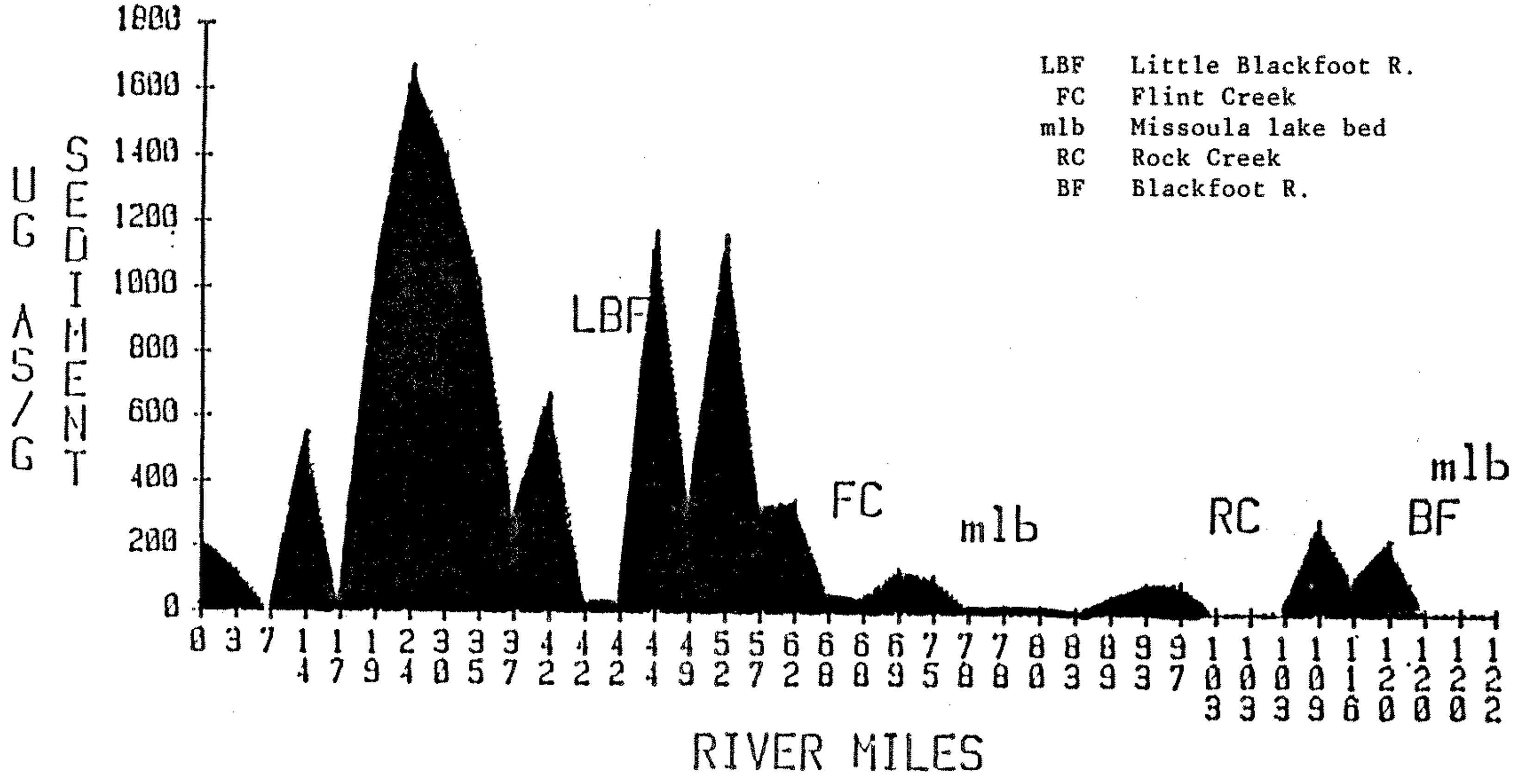


FIGURE 3-8. TOTAL ARSENIC IN BANK SEDIMENT, UPPER CLARK FORK. SOURCE: MOORE 1985.

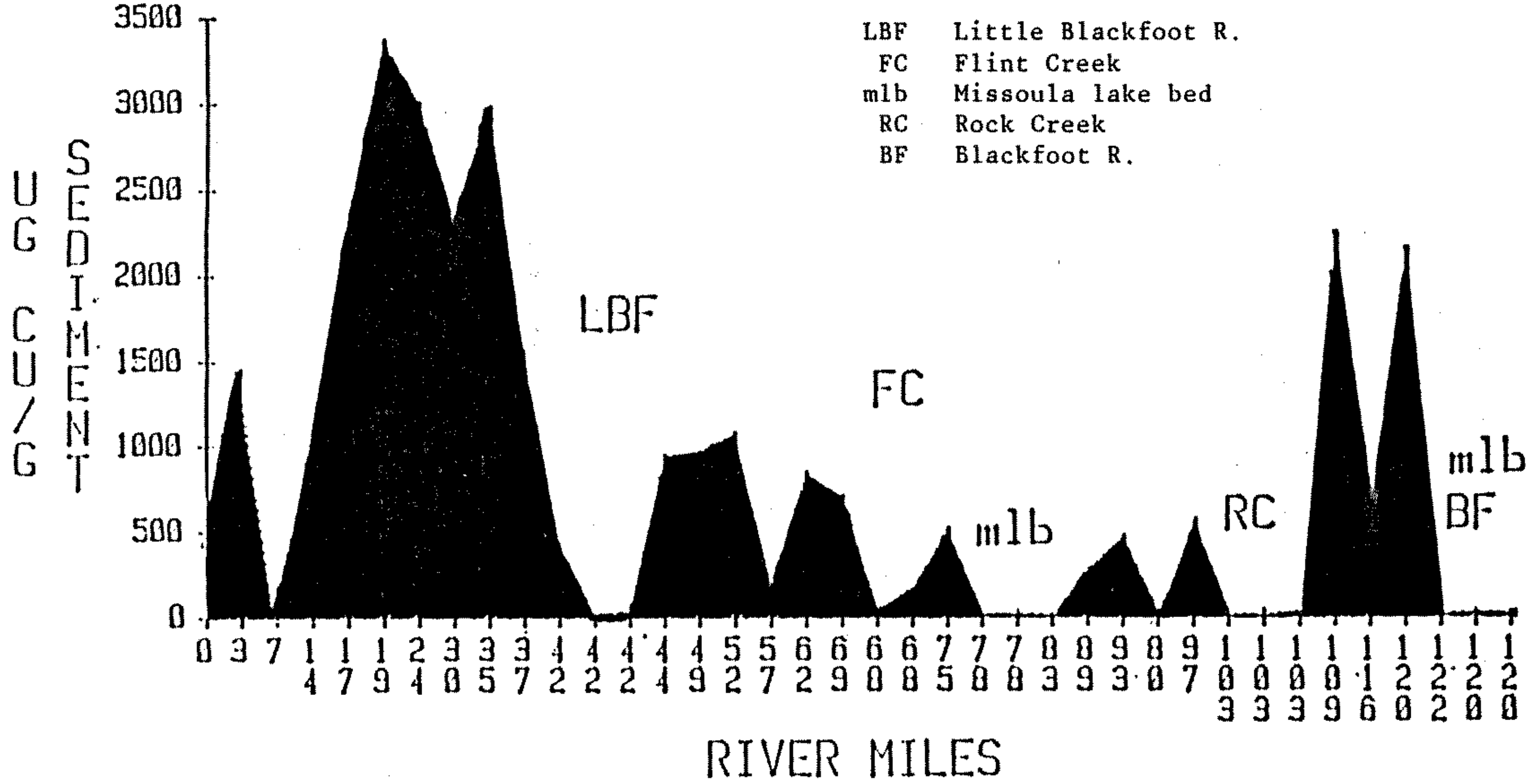


FIGURE 3-9. TOTAL COPPER IN BANK SEDIMENT, UPPER CLARK FORK. SOURCE: MOORE 1985.

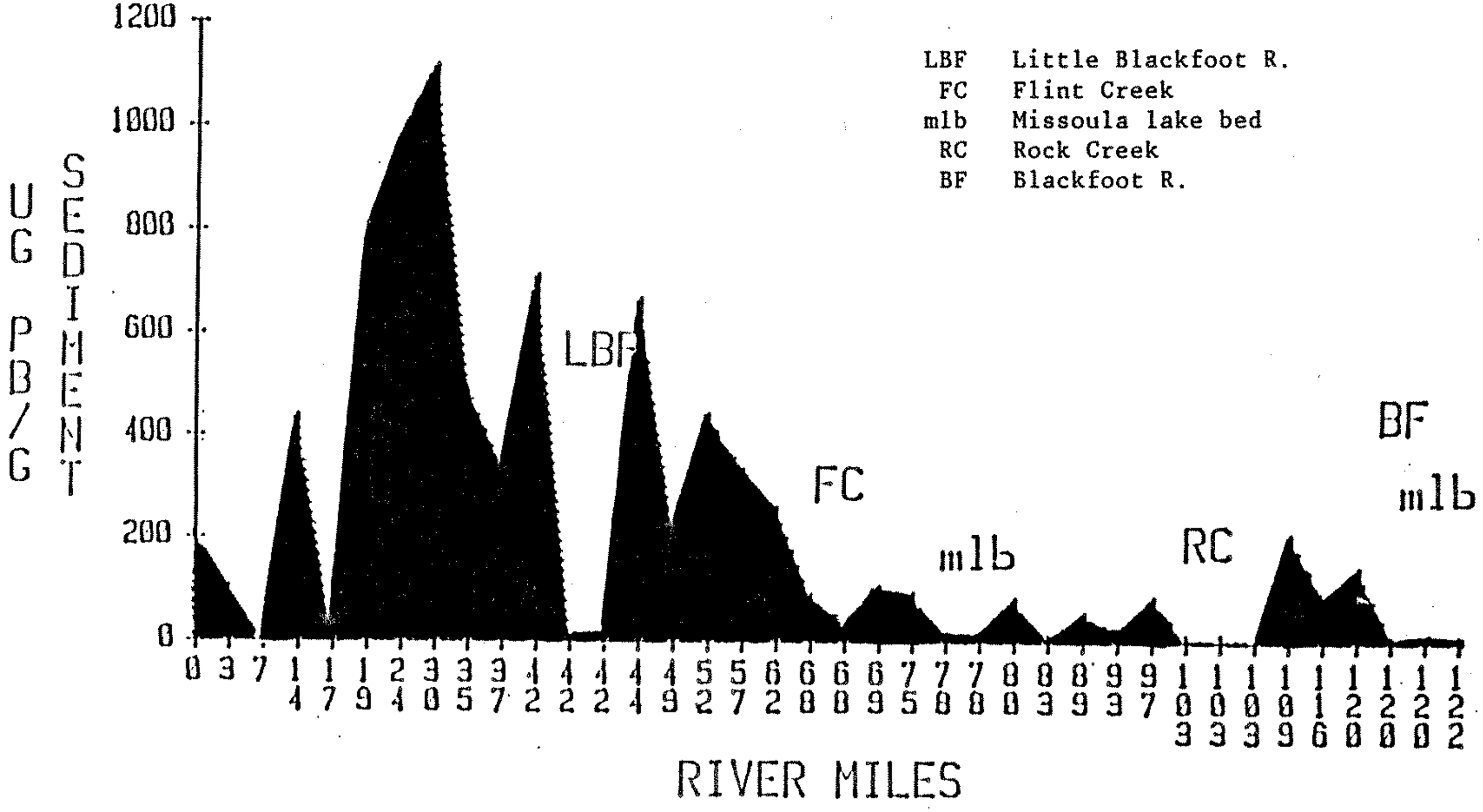


FIGURE 3-10. TOTAL LEAD IN BANK SEDIMENT, UPPER CLARK FORK. SOURCE: MOORE 1985.

7 and 17) contained only background levels of metals (Moore 1985). Such an occurrence would not be that unusual in an active fluvial system. The area between Racetrack and Flint Creek, with a fairly wide floodplain, appears to be a major depositional environment, whereas the narrow floodplain downstream of Flint Creek to above Milltown Reservoir likely restricts such deposition (Moore 1985).

Hydrometrics (1983b) conducted an inventory of tailings-affected areas between the Warm Springs Ponds and Deer Lodge. Fifteen samples were collected from five sites, including both well-vegetated sites and those that appeared to have been affected by tailings. Results of chemical analyses showed considerable variability in the tailings, but generally showed high concentrations of aluminum, copper, and zinc. From field examination and aerial photo interpretation, Hydrometrics estimated that one million cubic yards of tailings covering about 1,250 acres have been deposited on the floodplain between Warm Springs and Deer Lodge. A reconnaissance study of tailings deposits between Deer Lodge and Garrison indicated that tailings are present as scattered point bars and thin overbank deposits along this reach (Hydrometrics 1983b).

Sediment Transport Mechanisms

To effectively deal with the problems caused by floodplain tailings in the Clark Fork system, it is important to have at least a fundamental understanding of the processes of metal transport and accumulation in the sediments. Research that addresses these issues is summarized below.

In 1984, Andrews collected fine-grained bed sediment samples at 21 sites along the Clark Fork from the downstream edge of the Warm Springs Ponds to just below the mouth of the Flathead River. He also collected a sediment sample from each of the five largest tributaries, including the Little Blackfoot River, Flint Creek, Rock Creek, the Blackfoot River, and the Bitterroot River. Concentrations of arsenic, cadmium, copper, lead, zinc, aluminum, iron, and manganese are summarized in Table 3-12. Andrews concluded that the arsenic, cadmium, copper, lead, and zinc were primarily associated with the ferromanganese material on the particle surface, and that with the exception of lead, very little of these elements was bound in silicate minerals.

In bed sediment samples, copper, zinc, and manganese increased significantly with decreased particle size. Concentrations of arsenic, cadmium, cooper, lead, and zinc in fine-grained bed sediments decreased downstream but at different rates. Copper concentrations decreased downstream much more rapidly than lead concentrations, while arsenic,

TABLE 3-12. CONCENTRATIONS OF TRACE METAL ASSOCIATED WITH FINE-GRAINED BED MATERIAL IN THE CLARK FORK AND MAJOR TRIBUTARIES.

Location River Kilometer	Arsenic		Cadmium		Copper		Lead		Zinc	
	Total mg/kg	Partial	Total mg/kg	Partial	Total mg/kg	Partial	Total mg/kg	Partial	Total mg/kg	Partial
14.3	165.0	164	9.3	7.3	1,290	1,300	173	117.0	1,660	1,580
21.2	199.0	194	9.7	10.0	2,490	1,410	179	136.0	1,770	1,770
34.8	151.0	195	8.7	11.0	1,660	1,540	213	151.0	1,850	1,880
48.1	100.0	80	7.3	5.9	1,620	1,080	170	116.0	1,460	1,380
78.4	60.0	62	7.3	6.9	1,700	990	139	89.8	1,380	1,390
89.2	39.0	26	4.8	3.3	1,000	641	100	62.2	1,030	1,030
94.1	46.0	53	4.8	17.0	1,050	747	111	67.9	1,130	1,090
104.4	44.0	11	1.7	5.9	650	680	100	63.4	560	1,130
115.7	54.0	52	3.3	3.7	400	418	112	77.2	900	916
130.7	69.0	50	3.5	3.5	420	428	116	84.9	940	916
140.8	49.0	51	4.1	2.2	335	345	95	36.8	830	836
153.4	40.0	38	2.4	2.7	305	305	87	52.1	800	761
168.3	33.0	35	3.4	1.1	325	321	79	43.5	325	780
181.5	35.0	38	3.1	1.9	333	345	80	51.9	900	873
207.1	18.0	20	2.8	4.3	225	230	54	30.2	690	685
222.4	15.0	19	2.2	1.7	245	231	62	30.1	540	489
228.4	19.0	20	2.0	3.3	325	353	62	37.0	760	740
264.9	17.0	21	1.3	2.6	212	221	45	20.9	610	613
299.6	8.5	17	1.2	<.1	121	107	34	<.5	330	300
387.7	17.0	23	1.2	2.1	235	245	57	27.4	540	527
399.7	9.4	4	<.5	0.79	93	101	24	1.4	250	267
<u>Major Tributaries</u>										
Little Blackfoot River	3.2	17.0	0.7	0.8	25	27.5	31	4.2	153	128
Flint Creek	126.0	128.0	1.5	0.7	48	51.0	165	124.0	560	542
Rock Creek	5.4	14.0	<.5	<.1	10	12.0	6	<.5	38	35
Blackfoot River	4.8	6.4	<.5	0.3	19	17.0	9	<.5	54	41
Bitterroot River	3.0	5.0	<.5	<.1	30	29.0	24	<.5	80	79

Source: Andrews 1987.

cadmium, and zinc decreased less rapidly than copper but more rapidly than lead (Andrews 1987).

The author also found that the addition of relatively clean water and sediment from tributaries had little effect on the distribution of trace metals in the Clark Fork. For example, mixing the sediments with background metal concentrations from the Bitterroot River did not appreciably dilute the trace metal concentrations in mainstem bed sediments. The exchange of sediment between the river and floodplain in the mainstem is large relative to the quantity of sediment contributed by tributaries, therefore, the tributaries have no appreciable effect (Andrews 1987).

In 1986, Brook and Moore conducted a study to evaluate the distribution of metals and the control exerted by sediment particle size on metals concentrations in upper Clark Fork bed sediments. Bed sediments were collected from 26 locations in the mainstem Clark Fork and from several locations in the Little Blackfoot River, Flint Creek, and the Blackfoot River. Fine-grained bed sediments were collected in areas of low- flow velocity and were separated into mud and sand fractions in the laboratory.

The authors reported that mean concentrations of cadmium, copper, manganese, and zinc in mainstem samples were well above those in tributary samples. All four metals showed general decreases in concentration downstream, which were more pronounced in the mud fraction, and variability between sites was high. Brook and Moore attributed this trend to the downstream decline in frequency of metals-laden floodplain deposits and speculated that dilution by uncontaminated tributary sediments might also be a factor. They also found that more of the bulk metals concentrations were derived from the sand fraction than from the mud fraction.

Using the data on bank sediments from Moore's 1985 EPA study (discussed in the previous section), Moore et al. (in press) examined the controls exerted by sediment particle size on metals concentrations in the Clark Fork system. The traditional view of metal-sediment association is that most of the metals are carried in the fine fraction. Moore et al. (in press) found that this relationship held true in the tributaries, where there were significant correlations between most of the metals and the percentage of clay. However, in the mainstem, most or all of the size fractions were found to be important contributors to the high metals concentrations. The Clark Fork is a high-gradient, coarse-grained system that commonly carries coarse sand in suspension during spring runoff. Some of this coarse sand is actually extremely metal-rich mine and smelter tailings. The authors also suggested that the coarse-grained floodplain sediments may reside in an oxygenated environment longer than fine sediments and may have more time to accumulate oxide coatings and associated trace metals.

Moore et al. (in press) concluded that distribution of metals in a complex system such as the Clark Fork is more likely to be based on chemical associations than on grain-size parameters. Application of traditional methods to correct for grain size effects may lead to erroneous conclusions about metal trends in the Clark Fork and other contaminated systems.

Reservoir Sediments

Prior to the construction of the Warm Springs Ponds, the Milltown Reservoir was the primary catch basin for mining-related sediment. This reservoir is basically full, with an estimated 3.4 million cubic meters of metals-contaminated sediment behind the dam (Woessner et al. 1984). Johns and Moore undertook a study to demarcate the lower boundary of detectable metals-contaminated sediments derived from mining and smelting activities in the headwaters. They collected samples from the Thompson Falls, Noxon Rapids, and Cabinet Gorge reservoirs in the lower portion of the Clark Fork Basin. Samples were also collected from three drainages tributary to Noxon Rapids and Cabinet Gorge reservoirs to serve as background checks. Data from these lower reservoirs and tributaries were compared with data from the Clark Fork and Blackfoot arms of the Milltown Reservoir collected during the Milltown Superfund Remedial Investigation.

Results of this study are summarized in Table 3-13. Total metals concentrations, measured in micrograms per gram (ug/g), in the sediments of all four reservoirs are clearly elevated compared with Blackfoot and tributary sediments. In almost all cases, total metals levels in the reservoirs decreased progressively downstream. The same trends were evident for acetic acid-extractable metals, as illustrated by the copper and zinc plots in Figures 3-11 and 3-12.

Although some of the metals concentrations in the three lower reservoirs were not highly enriched over background levels, it is clear that elevated levels of copper and zinc occur as far downstream as Cabinet Gorge Reservoir, some 340 miles from the major source of those metals. Transport of the metals-laden sediment down river may have occurred prior to construction of the Milltown Dam, during exceptional events such as dike breaches at the Warm Springs Ponds, during operational and maintenance drawdowns of the Milltown Reservoir, and as part of the current total suspended sediment load in the Clark Fork. Metal-rich sediments were and are likely diluted by additions of "clean" sediments

TABLE 3-13. MEAN CONCENTRATION AND 95 PERCENT CONFIDENCE LIMITS FOR TRACE ELEMENTS IN SURFACE SEDIMENTS FROM CLARK FORK RESERVOIRS AND TRIBUTARIES.

Reservoir/ Tributary	Trace Element (ug/g)				
	As	Cu	Mn	Pb	Zn
Blackfoot River	14.7 (13.1-16.5)	22 (16-28)	295 (250-348)	15.8 (11-22.7)	68 (57-80)
Milltown Reservoir	50 (41.7-60.3)	422 (344-517)	1,260 (841-1,880)	75.8 (64.2-89.6)	1,585 (1,080-2,330)
Thompson Falls Reservoir	19.3 (14.8-25.1)	108 (86-135)	417 (257-676)	28.4 19.7-40.9)	331 (246-445)
Noxon Reservoir	21 (19.7-22.5)	95 (79-113)	631 (513-776)	35 (31.6-38.8)	309 (281-339)
Vermilion River	15.5	23	225	16.8	70
Trout Creek	14	28	290	21.7	72
Cabinet Gorge Reservoir	12 (8.8-15.5)	42 (27-64)	398 (262-605)	19.4 (14.9-25.3)	200 (132-301)
Bull River	8.3	12	167	7	45

Reservoir means and confidence limits are back-transformed from $\log_{10}$.

Source: Johns and Moore 1986.

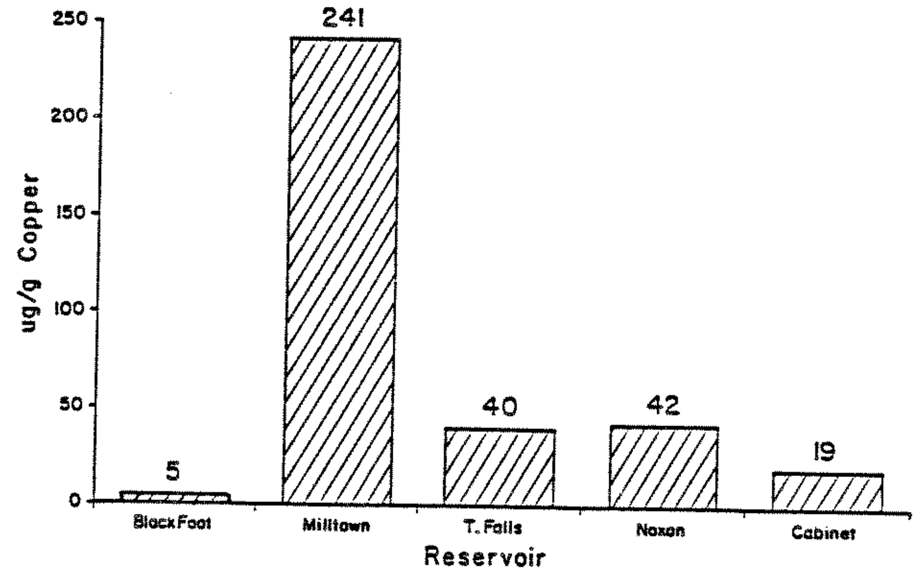


FIGURE 3-11. DOWNRIVER TRENDS IN ACETIC ACID-EXTRACTABLE COPPER. SOURCE: JOHNS AND MOORE 1985.

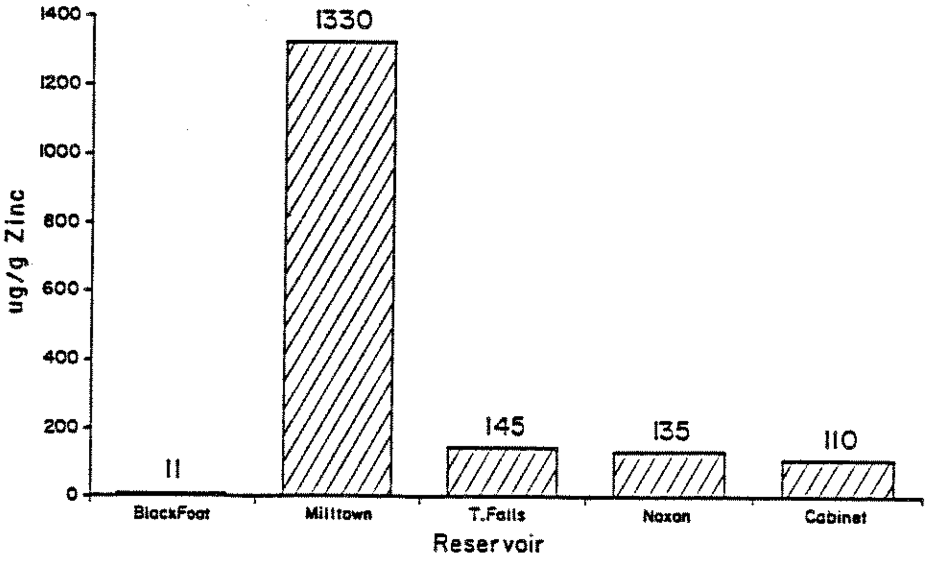


FIGURE 3-12. DOWNRIVER TRENDS IN ACETIC ACID-EXTRACTABLE ZINC. SOURCE: JOHNS AND MOORE 1985.

from major tributaries such as the Blackfoot, Bitterroot, Flathead, and St. Regis rivers (Johns and Moore 1986).

Reclamation of Contaminated Lands

Although several hundred acres of land in the Butte and Anaconda areas have been reclaimed by the Anaconda Minerals Company, a large number of acres of contaminated land remain in the upper reaches of the Clark Fork Basin. It is almost certain that reclamation of at least some of those acres will be attempted in the future. At present, the lack of perennial vegetation in many areas of the Deer Lodge Valley causes a number of problems, including wind erosion, increased surface runoff, increased recharge of the shallow ground water system, and possibly increased heavy metals loading to surface and ground water. If the quality and productivity of the vegetation in the upper Clark Fork Basin were improved, an increase in land quality and overall environmental quality in the region would result (USDA 1985a).

Much of the future reclamation efforts will likely be through the Superfund program, although projects using other sources of funding are currently in progress. Any major revegetation endeavors would have to be preceded by detailed trials and evaluations prior to large-scale application. A few such evaluations have been recently conducted, are ongoing, or are in the planning stages. These and activities by AMC are summarized in the following sections.

Spangler Ranch Study

A study to identify reclamation techniques for heavy metal contaminated agricultural lands in Deer Lodge, Powell, and Silver Bow counties was initiated in 1984. The project was administered by the Headwaters RC&D and received financial support through a grant from DNRC. The project consisted of a forage establishment phase and a hydrogeology phase.

The two-year forage-establishment study was conducted by Schafer and Associates (1986) on the Spangler Ranch about six miles southeast of the Anaconda Smelter. The purpose of the study was to develop and test techniques for reestablishing forages on land contaminated by mining. The affected area, nearly devoid of vegetation, was once-productive dairy farm land but had been irrigated with tailings-laden water through the early 1900s (Schafer and Associates 1986).

A number of treatments were tested, including three different liming rates, several different forage species, and a variety of tillage methods. The results of these trials were:

- Use of lime to neutralize soil acidity was necessary to allow plant establishment. Extensive sampling of a potential reclamation site was needed before the lime requirement could be predicted. Both the average and range in lime requirement should be characterized, and lime rates should be set to improve 85-95 percent of soils to a target pH of 6 to 6.5.

- In soils that were high in copper and zinc, the use of liming alone did not ensure adequate plant performance. Additional soil amendments, such as phosphorus and manure, might be required to further reduce the availability of copper and zinc to plants.

- Plant performance on the test plots was variable. Some plants may have done poorly partly because the first year of the study was hot and dry. However, promising results were obtained with a number of species, including crested wheatgrass, pubescent wheatgrass, basin wildrye, Russian wildrye, altai wildrye, yellow sweetclover, cicer milkvetch, and birdsfoot trefoil. None of the plants sampled appeared to accumulate metal levels that would be toxic to livestock.

- A moldboard plow/chisel, plow/harrow tillage sequence gave the best results due to better seedbed preparation, better mixing of lime, and reduced competition from existing vegetation.

The first phase of the hydrogeologic study was completed in 1986 (Osborne et al. 1986) and was discussed earlier in this chapter. The second phase is on-going and is being conducted by the Montana Bureau of Mines and Geology. The objectives are: 1) to quantify the concentrations of trace elements in selected intervals of soil and unconsolidated deposits underlying the Spangler Ranch agricultural sites, and 2) to identify the mechanisms and rates of trace element movement in the unsaturated zone and shallow aquifers on the sites. The study involves laboratory leaching column experiments and field site lysimeter sampling.

The following observations were made at the conclusion of the first round of leaching column experiments (Wilson et al. 1988):

- Of the elements tested, arsenic was most mobile in both amended and nonamended soils

- The lime-amended soil showed the smallest release of dissolved arsenic, whereas the lime-and-phosphorus-amended soil showed the greatest release of dissolved arsenic.

The field site lysimeters were successfully sampled until the end of August 1987, after which the soils became too dry to obtain samples. Data from these samplings indicate that field site results for arsenic during the first year did not completely parallel laboratory results. The lowest arsenic concentrations were found in lysimeter samples from the control (untreated) plot, rather than from the lime-amended plot. For zinc and copper, the lowest dissolved concentrations were observed in the lime amended soils.

An additional season's results are needed to confirm or alter the field-site interpretations, which are based on a limited sampling in 1987.

Streambank Tailings and Revegetation Study

As part of the Silver Bow Creek CERCLA site Phase II remedial investigation, the DHES has developed a program to address the streambank mine wastes disseminated over much of Silver Bow Creek and the upper Clark Fork. Typical remedial measures for such wastes include removal or capping; however, such measures are not practical for sites such as Silver Bow Creek that involve large areas of contamination and large volumes of material. Therefore, the Streambank Tailings and Revegetation Study (STARS) was initiated in fall 1987 to investigate new and more innovative technologies to address the streambank mine wastes (CH_2M Hill 1987c).

STARS is divided into two phases: a laboratory/greenhouse phase to develop and test treatments at a bench scale and a field scale phase to demonstrate selected remedial alternatives. During Phase I, a variety of remedial measures are being tested to modify the tailings characteristics sufficiently to allow revegetation. Suitable soil amendments to raise soil pH and reduce plant-available metal levels are being developed, and plant species that can thrive in the amended environment will be selected. Criteria for characterizing streambank mine wastes based on their chemical and physical properties are being developed. The Phase I final report will include a preliminary design for innovative remedial alternatives for each waste type identified. Phase I is scheduled to be completed by October 1988.

Phase II activities will include field implementation of the remedial measures designed in Phase I. The response of treatment in reducing leachate quantity and abating metal movement to surface and ground water will also be evaluated (CH_2M Hill 1987c). Siting and construction of the field demonstration are scheduled for summer 1988 so that the plots can be seeded in fall 1988. The plots will be monitored through two field seasons, with a final Phase II report due sometime in 1991.

Clark Fork Reclamation Demonstration Project

In September 1986, a proposal for an upper Clark Fork floodplain reclamation demonstration project was submitted to the DNRC for funding under the Resource Indemnity Trust Grants Program (RIT). The proposal was prepared and submitted by the Governor's Office Clark Fork Basin Project, the Headwaters RC&D, and the Deer Lodge County Conservation District. The purpose of the project was to evaluate the cost and effectiveness of a variety of reclamation techniques applied to an entire floodplain segment (streambanks, riparian area, and adjacent agricultural lands) of the upper Clark Fork. The project was approved for RIT funding in 1987; however, it did not rank sufficiently high on the list of projects to receive funding.

Despite this setback, some preliminary work was conducted on the project in the fall of 1987. With help from a Deer Lodge/Powell County Soil Conservation Service (SCS) Soil Survey party, Schafer and Associates (1988) conducted a detailed survey of the study area under contract with the Governor's Office.

The objectives of the investigation were to:

- determine the source, extent, and severity of tailings contamination in the study area
- determine where and under what conditions metals from streamside tailings may be entering the Clark Fork
- identify potential low-cost remedial measures to reduce or eliminate the movement of contaminants into the river
- propose specific candidate sites for a remedial demonstration.

An order 1 (ultra-detailed) soil survey was completed on a corridor bordering the Clark Fork reach from Warm Springs Ponds to just below Perkins Lane Bridge. A mapping-unit legend was developed to delineate mine-waste deposits from natural soils. Tailings deposits were further separated by depth, amount of vegetation, and soil texture. Mapping units were also separated according to the geomorphic setting, being either above the 100-year floodplain, in the 100-year floodplain, or roughly within the mean annual floodplain. Natural soils and tailings-affected units were classified using the Soil Taxonomy (Soil Survey Staff 1975). A total of 18 map units were delineated on 1981, 1:6,000 scale aerial photographs.

To determine the chemical and physical variability in the tailings deposits, two detailed soil investigation plots were located near the river at sites where tailings deposition was extensive. Data from these sites were encoded and used to produce maps of tailings thickness, surface elevation, and surface soil pH and electrical conductivity (EC). It was found that soil pH levels were highest in the natural soil, with much lower pH found in tailings deposits. Tailings deposits less than 8 to 12 inches thick had higher pH levels than thicker tailings layers. Soil salinity tended to be higher in tailings than in natural soils, but this parameter differed less than pH.

A streambank survey was conducted to assess the condition of the channel banks within the study area. The river bank condition was rated according to bank angle, percentage of protective cover, kind of cover (gravel, vegetation), and depth of tailings. A two-man mapping team floated and/or waded to obtain the data. The bank angle was measured relative to the river, with a vertical bank equaling 90 degrees and an undercut bank less than 90 degrees. This was done to find areas where the river was undercutting and eroding its banks. The protective cover was ranked using a rating from one to four, with one being less than 25 percent cover, two between 25 and 49 percent, three between 50 and 79 percent, and four being greater than 80 percent cover. The classification and rating system of bank conditions was developed into a legend similar to the method described by Platts et al. (1983), and a map of the river bank mapping units was produced. The majority of the streambank within the study corridor was in good shape, with probably ten percent or less in the very erosive category.

If funding were secured for this project, several remedial measures would be employed within the demonstration area. Contaminants would be removed from along the streambank, and willows would be used to improve bank stability. Mine waste removed from areas susceptible to erosion would be redeposited on-site in more stable locations. Chemical amendments would be added to thick (more than eight inches) tailings deposits (point bars) to neutralize acidity and metals, and cover-soil would be placed over them to function as a root-zone medium. Areas with less than 6-8 inches of mine waste would be either amended and reseeded or mixed through deep-plowing. All areas would be seeded with a mixture of species adapted to the conditions on the site. Grazing restrictions would be employed to enhance the stability of crucial areas along the stream channel.

Three possible study locations varying from six to ten acres have been identified. This reach of river has historical fishery and water quality data and is known to suffer a decline in fish numbers. The landowner supports the project. Access to the site is good due to the proximity of Perkins Lane Bridge and an abandoned railroad grade. Detailed soil information gathered from this project will be useful for project planning purposes.

Anaconda Minerals Company Reclamation

The Anaconda Minerals Company has undertaken several reclamation projects in the Butte-Anaconda area in the last three years. They have reclaimed several hundred acres using cover soil, crushed limerock, straw mulch, fertilizer, and grass seed.

In Butte, AMC has reclaimed approximately 120 acres, including 67 individual mine dumps, portions of the Buffalo and Missoula drainages, all of the La Platta drainage, and the Sherman Ballfield-South Alice dump area. They have moved more than 150,000 tons of mine waste rock to the Berkeley Pit. They have also installed 300 feet of large-dimension pipe and constructed over a mile and a half of rock-and-filter-lined ditches to provide controlled drainage from Walkerville to the existing Butte-Silver Bow storm drain system.

On Smelter Hill in Anaconda, AMC has reclaimed approximately 300 acres of land and developed three miles of ditches. They have placed an erosion-resistant cap over the old flue, and moved hundreds of thousands of cubic yards of material to reduce the slopes and cover the substructures of demolished buildings prior to the reclamation work. At the Opportunity tailings ponds system, AMC has reduced the slopes of all dikes and dams, and all of the tailings have been covered with at least 30 tons per acre of crushed limerock to prevent blowing.

SURFACE WATER QUALITY

Introduction

Early 19th century explorers, fur traders, and missionaries described the Clark Fork as a clear and pristine waterway, teeming with life (Horstman 1984). This vision of the Clark Fork faded into a memory with the advent of mining later in that century, as mining, milling, and smelting wastes were dumped directly into Silver Bow Creek and transported downstream. In 1872, James A. Garfield noted that "the beautiful river has been permanently ruined by the miners; and has been for three years as muddy as the Missouri. Before the discovery of gold, it was as clear and pure as any mountain stream could well be." (Horstman 1984).

The mining activities resulted in high heavy metals and sediment loading in the river, and as the basin became more developed, nutrient loading also increased. Those early days of neglect resulted in a river system that was virtually unusable and uninhabitable for fish and other aquatic species. However, as environmental awareness grew and ushered in the age of water quality standards and regulations, conditions in the river system began to slowly rejuvenate. Although it still has much room for improvement, the river has nonetheless staged a rather dramatic recovery.

undergone

The following sections touch briefly on historical water quality (pre-1984) in the Clark Fork and then describe recent and current water quality conditions (1984 to present) in detail. This latter section focuses on heavy metals (particularly copper and zinc) and suspended sediments, as these are the parameters of greatest concern today. Other surface water quality problems, such as ammonia, dissolved oxygen (DO), elevated temperature, color, foam, etc., are discussed in less detail. Nutrients, an important issue in the basin, and their effects on algae growth are discussed in the section following surface water quality.

Historical Surface Water Quality Problems

One of the first comprehensive studies of water quality degradation in the Clark Fork drainage was conducted in the late 1950s by the Montana State Board of Health to obtain information necessary for the classification of streams and the establishment of water quality standards. This study (Spindler 1959) involved a comprehensive chemical and biological survey of the entire mainstem and major tributaries. After publication of that report, there was little activity on the river until the 1970s, when several studies were performed to document the effectiveness of Anaconda Minerals Company's efforts to treat water in Silver Bow

Creek. These earlier studies are discussed in the following sections.

Silver Bow Creek

Spindler (1959) documented grossly polluted conditions in Silver Bow Creek in 1957. He reported very high levels of copper, iron, and zinc; low dissolved oxygen levels; high turbidity; no pollution-sensitive macroinvertebrate species, and only one tolerant form.

The first attempt to address the water quality problems in the headwaters had come in 1911 when the Anaconda Copper Company built a treatment pond near Warm Springs to settle out their industrial wastes. Two more treatment ponds were added in 1916 and between 1954 and 1959. With the addition of the third pond, this system became quite effective in settling metals out of the stream. Water quality in the Clark Fork improved below the ponds, as demonstrated by the following data from Spindler (1959):

	Metals (ug/l)*		
Station	Copper	Zinc	Arsenic
Silver Bow Creek at Silver Bow	11,200	3,350	40
Silver Bow Creek above settling ponds	4,200	3,660	30
Clark Fork below settling ponds	10	400	trace

*maximum of two samplings, summer 1957

However, Silver Bow Creek continued to receive raw mining and milling wastes, and by the mid-1960s, the accumulated solids in the ponds had begun to reduce the pond volume and hence, the efficiency of the system. The Anaconda Company decided to construct new treatment facilities within the Butte Operations to replace the Warm Springs Ponds as the primary wastewater treatment system (Spindler 1976). The new program included lime neutralization, flocculation, co-precipitation, settling, secondary polishing, and pH adjustment (Chadwick et al. 1986).

This new primary treatment facility was put into operation late in 1972. Although water quality began to improve, it was several years before there were signs of recovery in Silver Bow Creek. Gless (1973) conducted a biological study of Silver Bow Creek in 1972 to 1973 and found almost no invertebrates, which he attributed to a lack of suitable substrate and high heavy metals loads. Anaconda Company's self-monitoring turned up no macroinvertebrates in Silver Bow Creek until 1975 (Chadwick et al. 1986). Diebold (1974) studied the physical and chemical properties of Silver Bow Creek water and bottom sediments in 1973 to 1974. He performed laboratory leaching studies and concluded that the sediments had a high metal adsorption capacity.

The primary treatment system was refined in 1974 to increase the holding time prior to discharging wastewater (Chadwick et al. 1986), A secondary treatment system, installed in 1975 (Spindler 1976), further improved water quality, as evidenced by decreased turbidity, TSS, and heavy metals concentrations. By late 1975, a variety of algae and macroinvertebrates were found in Silver Bow Creek (Spindler 1976).

Although water quality in Silver Bow Creek improved greatly over the days when the stream received untreated wastes, metal concentrations at levels potentially toxic to aquatic life were reported by various investigators (Beuerman and Gleason 1978; Peckham 1979; Botz and Karp 1979; Janik and Melancon 1982; and Hydrometrics 1983a). Most reported increased metals loads between Butte and Gregson that were attributable in part to the large tailings deposits (Colorado Tailings and Ramsay Flats) in the floodplain of Silver Bow Creek.

Clark Fork

Spindler (1959) made several observations regarding water quality conditions in the mainstem Clark Fork from his field work conducted in 1957.

He found that, based on bottom fauna analysis, polluted water conditions existed in the Clark Fork from Warm Springs to the Bitterroot River. Evidence of conditions approaching gross pollution existed between Warm Springs and Deer Lodge, between Deer Lodge and the Little Blackfoot River, below Garrison, between Missoula and the Bitterroot River, and below Plains. Among the problems documented were high coliform bacteria concentrations downstream of industrial waste discharges, municipal wastewater, and raw sewage discharges, which rendered the river unsafe for uses other than agricultural and industrial.

The construction of Warm Springs Pond 3 resulted in improved water quality in the upper Clark Fork. For the first time since the turn of the century, limited macroinvertebrate and fish populations became established in a short reach immediately downstream of the ponds. However, despite the significant improvements, water quality as a whole was still marginal. In 1967, the Montana Water Pollution Control Council established water quality standards for Montana surface waters. These standards established beneficial uses to be protected, but did not specify numerical criteria for heavy metals and other contaminants (EPA 1972a). They did, however, require municipal and industrial dischargers to provide secondary treatment or the equivalent.

In 1970, the EPA conducted a study (EPA 1972a) for the DHES to determine the allowable maximum concentrations of heavy metals in the Clark Fork. Some of the results of their study, along with U.S. Geological Survey (USGS) data collected in the early 1970s, are presented in Table 3-14. The data indicate that water quality in the Clark Fork was quite poor as far downstream as Alberton during industrial spills, labor strikes, or high runoff periods. The EPA characterized the Clark Fork above Deer Lodge as severely polluted, as indicated by a deficient and nonbalanced population of benthic organisms and few fish. Waste discharges and spills from the Anaconda Company settling ponds were cited as the principal cause of the high concentrations of most metals and other constituents in the headwaters.

The EPA reported a more balanced and healthy biological system on the mainstem at and below Garrison and high quality water in streams tributary to the Clark Fork.

Between 1973 and 1983, a variety of studies were conducted on the Clark Fork (Braico 1973; EPA 1974; Botz and Karp 1979; Janik and Melancon 1982; Hydrometrics 1983b). However, the best records of surface water quality for that decade are from the DHES-WQB station at Deer Lodge and the USGS station below Missoula. The station at Deer Lodge was sampled by the WQB sporadically from 1974 through 1977 and monthly between 1978 and 1983. The WQB documented high total recoverable copper and zinc concentrations (up to 800 ug/l) associated with spring runoff events, particularly between 1974 and 1976. Although peak concentrations were not as high in the 1977-83 period, many of the concentrations measured exceeded copper and zinc aquatic life toxicity criteria. Total phosphorus concentrations were often greater than 100 ug/l and reached over 500 ug/l on one occasion.

USGS data for part of the same period for the Clark Fork below Missoula document relatively low concentrations of total recoverable copper and zinc from 1978 through 1980, with strong peaks during runoff events in May 1981 and February 1982. Total phosphorus concentrations were

TABLE 3-14. MAXIMUM CONCENTRATIONS OF COPPER AND ZINC IN MAINSTEM CLARK FORK, 1970-72

AGENCY	PERIOD OF RECORD	SAMPLING DATE ON WHICH MAXIMUM CONC. OCCURRED	STATION	MAXIMUM CONCENTRATIONS (ug/1)			
				TOTAL CU	TR[1] CU	TOTAL Zn	TR Zn
EPA	May-Oct. 1970	Oct 21, 1970	Clark Fork at Warm Springs	1,360*	---	4,200*	---
USGS	July 71-June 72	Jan 5, 1972	Clark Fork near Galen	---	120	---	950
EPA	May-Oct. 1970	July 14, 1970	Clark Fork at Dempsey	420*	---	960*	---
USGS	Oct. 70-June 71	Feb 3, 1971	Clark Fork at Deer Lodge	---	210	---	350
EPA	May-Oct. 1970	July 14, 1970	Clark Fork at Deer Lodge	1,200*	---	4,700*	---
USGS	Oct. 70-June 71	Feb 3, 1971	Clark Fork at Garrison	---	130	---	250
EPA	May-Oct. 1970	Cu low flow Zn high flow	Clark Fork at Garrison	240	---	340	---
USGS	July 71-June 72	Cu July 24, 1971 Zn April 17, 1972	Clark Fork at Drummond	---	20	---	120
EPA	May-Oct. 1970	Low flow	Clark Fork at Drummond	90	---	160	---
USGS	Oct. 70-June 71	April 7, 1971	Clark Fork above Missoula	---	340	---	540
USGS	Oct. 70-June 71	April 7, 1971	Clark Fork near Alberton	---	240	---	260
USGS	Oct. 70-June 71	April 13, 1972	Clark Fork at Thompson Falls	---	20	---	40

[1] TR = Total Recoverable

*Samples collected during spills

Sources: EPA 1972a; Brosten and Jacobson 1985.

generally below 100 ug/l, although they reached a peak value of 770 ug/l in February 1982 (Brosten and Jacobson 1985).

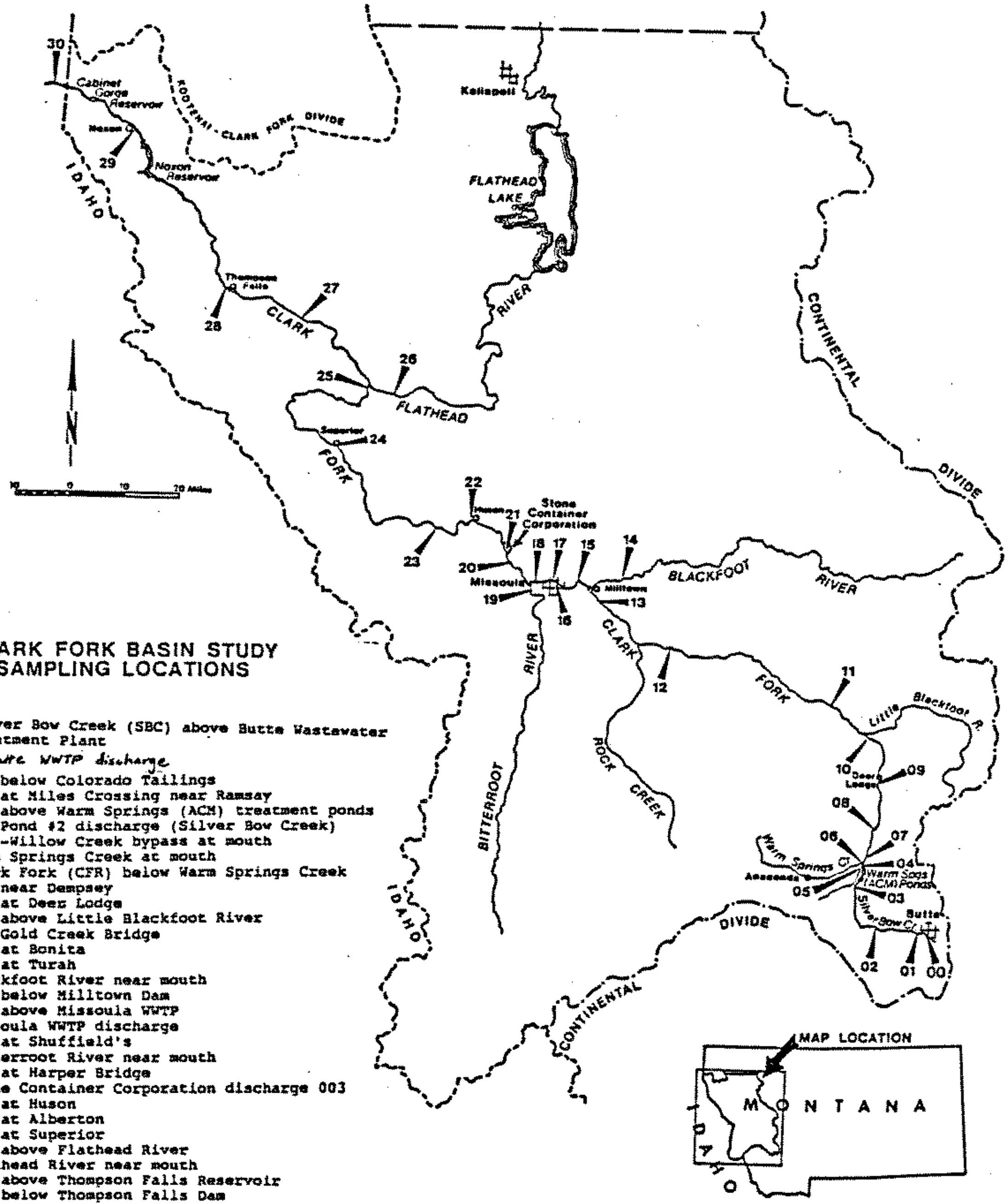
Recent and Current Surface Water Quality Monitoring Programs

The attention that has been focused on the Clark Fork system in the last few years has prompted a number of agencies to conduct monitoring programs or special projects in the basin. As a result, we now know a great deal about the quality of surface waters in the basin, and we should be able to make much more informed resource decisions.

The DHES-WQB and the USGS have collected the majority of surface water data in the basin. A significant amount of data has also been generated as part of the Silver Bow Creek Superfund Investigation. These recent and current programs are described in the following sections.

The DHES-WQB has initiated a number of surface water monitoring programs on the Clark Fork in the last few years. Six stations in the upper Clark Fork have been sampled monthly since December 1982, with two more stations added in January 1984. In March 1984, the Water Quality Bureau began an extensive investigation (31 monitoring stations) of the lower Clark Fork to address public concerns over the general health of the lower river. Much of this concern was generated by the modification of the wastewater discharge permit for the paper mill near Missoula. In September 1985, the upper and lower Clark Fork monitoring programs were merged to form the Clark Fork Basin Study. Several monitoring stations were added in the upper river, including two stations between the Little Blackfoot and Turah, to link the two monitoring sections. Some of the lower river monitoring stations were eliminated so that now a total of 32 fixed stations (Silver Bow Creek, Clark Fork, major tributaries, and wastewater discharges) are sampled in the Clark Fork Basin (Figure 3-13). Monitoring is conducted monthly from August through March and twice monthly from April through July. Parameters monitored include: discharge; field pH and temperature; calcium; magnesium; total and volatile suspended sediment (VSS); alkalinity; total and dissolved algal nutrients; and total recoverable arsenic, copper, and zinc. Biological monitoring (periphyton, macroinvertebrates) and DO surveys are conducted once each summer. Dissolved metals may be added in the future. The project has been funded by EPA, the state general fund, and the RIT program since July 1986. An extension through June 1989 was approved by the 1987 Legislature.

Results of WQB State Fiscal Year 1985-87 monitoring in the Clark Fork Basin are summarized in this report. Each of the three years was characterized by lower-than-normal



CLARK FORK BASIN STUDY SAMPLING LOCATIONS

00 Silver Bow Creek (SBC) above Butte Wastewater Treatment Plant
00.5 Butte WWTP discharge
01 SBC below Colorado Tailings
02 SBC at Miles Crossing near Ramsay
03 SBC above Warm Springs (ACM) treatment ponds
04 ACM Pond #2 discharge (Silver Bow Creek)
05 Mill-Willow Creek bypass at mouth
06 Warm Springs Creek at mouth
07 Clark Fork (CFR) below Warm Springs Creek
08 CFR near Dempsey
09 CFR at Deer Lodge
10 CFR above Little Blackfoot River
11 CFR Gold Creek Bridge
12 CFR at Bonita
13 CFR at Turah
14 Blackfoot River near mouth
15 CFR below Milltown Dam
16 CFR above Missoula WWTP
17 Missoula WWTP discharge
18 CFR at Shuffield's
19 Bitterroot River near mouth
20 CFR at Harper Bridge
21 Stone Container Corporation discharge 003
22 CFR at Huson
23 CFR at Alberton
24 CFR at Superior
25 CFR above Flathead River
26 Flathead River near mouth
27 CFR above Thompson Falls Reservoir
28 CFR below Thompson Falls Dam
29 CFR below Noxon Rapids Dam
30 CFR below Cabinet Gorge Dam

FIGURE 3-13. DHES-WQB SAMPLING STATIONS IN THE CLARK FORK BASIN streamflows. While FY 1986 conditions were not far below normal (and in fact included a major mid-winter flood), FY 1985 and especially FY 1987 can be described as drought years. Consequently, the data collected during the period are not representative of average or above-average flow conditions.

The FY 1986-87 data base is relatively complete and represents 14 to 17 samplings at most of the stations in the monitoring network. However, in FY 1985 nutrient and suspended sediment were monitored infrequently in the Clark Fork above Rock Creek (near Clinton). As a result, discussions of nutrients and suspended sediments rely mostly on FY 1986-87 data.

The USGS has been sampling periodically at six sites in the upper Clark Fork Basin since March 1985 (Figure 3-14). Two of the sites are on the Clark Fork mainstem (at Deer Lodge and at Turah Bridge, near Bonner) and four sites are near the mouths of major tributaries between Deer Lodge and Milltown Reservoir (Little Blackfoot River, Flint Creek, Rock Creek and Blackfoot River). Sampling frequency is limited and generally corresponds to periods of runoff rather than a fixed schedule. Field measurements include stream discharge, specific conductance, pH, temperature, bicarbonate and carbonate, and alkalinity. Laboratory analyses included hardness; selected dissolved, total or total recoverable trace elements; and suspended sediment.

The primary objective of the USGS sampling program is to characterize the geographic and hydrologic variation in trace element and suspended sediment concentrations. Geographically, sampling locations were selected to describe water quality conditions at the upper and lower end of the upper Clark Fork segment and in the major tributary basins entering this reach. Hydrologically, sampling is conducted throughout the range of flow conditions to describe the variation in water quality with streamflow. Because many trace elements are bound to sediments and transported in the suspended phase, concentrations of suspended constituents are likely to be at a maximum during runoff conditions when sediments are eroded into the streams. Developing a data base that describes the volume of sediment transported and the relationship of suspended sediment concentrations to trace element concentrations can help define the nature and magnitude of trace element movement through the surface water system.

In addition to periodic water quality sampling, the two Clark Fork stations at Deer Lodge and Turah Bridge are operated as daily sediment sampling stations to describe the suspended sediment transport characteristics in the upper

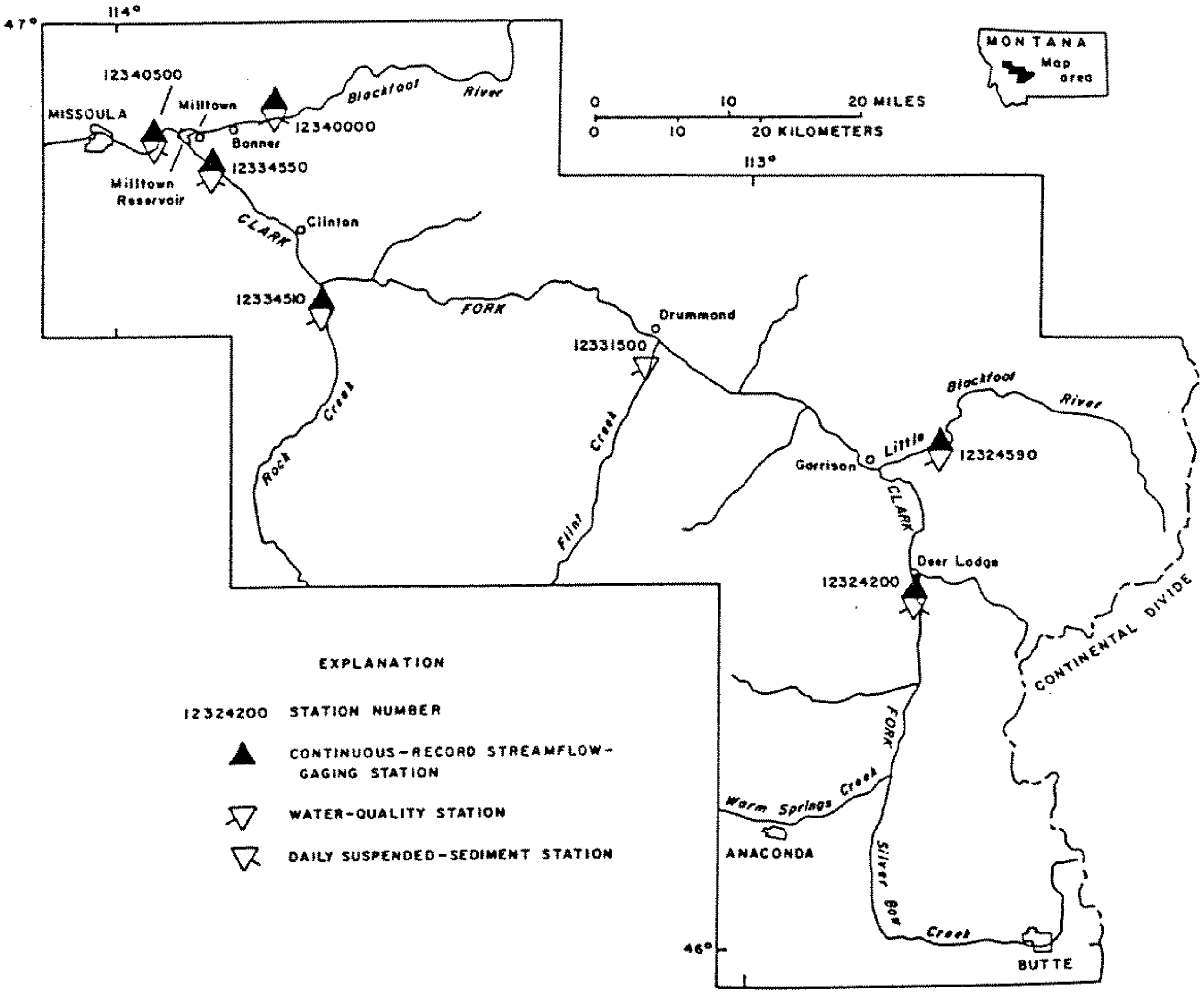


FIGURE 3-14. USGS SAMPLING SITES IN THE UPPER CLARK FORK BASIN.

basin. Funding for the periodic water quality sampling and daily sediment sampling stations has been provided by both state and federal sources since 1985. The EPA is funding the sampling during 1988.

A sampling program was also conducted by the USGS from July 1986 to April 1987 to measure suspended sediment loads entering and leaving Milltown Reservoir during the Phase I emergency reconstruction of Milltown facility. As part of this effort, three daily sediment stations were operated, two upstream from the reservoir (Clark Fork at Turah Bridge and Blackfoot River near Bonner) and one downstream from the reservoir (Clark Fork above Missoula) (Figure 3-14). Daily sediment sampling at these stations probably will be resumed when Phase II reconstruction begins in 1988.

The water quality data collected by the USGS in the upper Clark Fork Basin from March 1985 to September 1987 are published in two data reports (Lambing 1987, 1988). The data represent primarily low-to-medium flow conditions as a result of less than normal runoff during most of the sampling period. However, one high flow from snowmelt runoff was sampled from February 24 to 26, 1986, which gave some indication of the increase in total or total recoverable trace element concentrations present during times of peak sediment discharge.

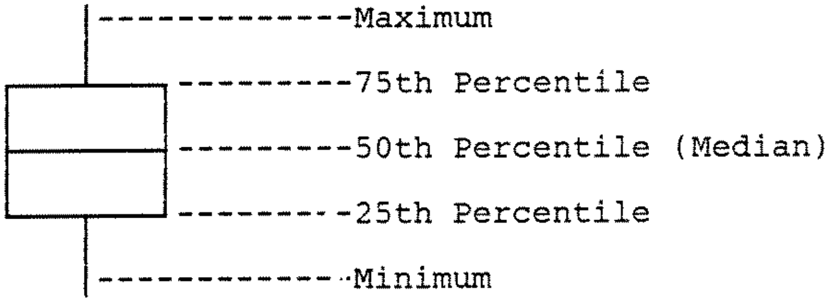
MultiTech (1987c) conducted a surface water and point source investigation of Silver Bow Creek and the upper Clark Fork as part of the Silver Bow Creek Phase I RI. The study area extended from the Weed Concentrator outfall in Butte to near Garrison, Montana. Phase I field work was conducted from November 1984 to September 1985, with additional surface water samples collected in 1986. Metals studied included arsenic, cadmium, copper, iron, lead, and zinc.

During the Phase I rehabilitation of the Milltown Dam, the Montana Power Company monitored water quality in the Clark Fork and Blackfoot River upstream and downstream from the dam from July 14, 1986, to April 4, 1987.

In addition to these programs, several other agencies have collected surface water quality data for specific projects, including the Montana Bureau of Mines and Geology, the University of Montana, the Montana Department of Fish, Wildlife and Parks, and others. These projects are discussed elsewhere in this report.

Current Surface Water Quality

Current surface water quality conditions in Silver Bow Creek, the Warm Springs Ponds, and the mainstem Clark Fork are discussed in the following sections. The discussion of metals, nutrients, and sediment draws primarily from Silver Bow Creek RI, DHES-WQB, and USGS data. Much of the WQB data is presented in the form of box plots. These plots graphically display the maximum, median, minimum, 25th percentile, and 75th percentile values as shown below. In cases where some of these percentile values are the same within a data set for a given station, percentile lines overlie each other. If all the values are the same, the plot is simply a horizontal line at that value, indicating either a small data set or no variation in measured values.



In this discussion, water quality parameters are referred to both in terms of pollutant concentration and pollutant load. Concentration is the weight of a given pollutant per unit volume of water, e.g., milligrams of phosphorus per liter. Load is the weight of a given pollutant transported by a stream or water discharge per unit of time, e.g., pounds of phosphorus per day.

The key to the relationship between pollutant concentrations and pollutant loads is the volume of water in the river. As the Clark Fork flows downstream, it is joined by numerous tributaries, and its volume becomes progressively larger. Each tributary contributes X number of pounds per day of material to the Clark Fork, which adds to the load of material carried by the river. However, the tributaries generally have lower concentrations of those materials than the Clark Fork, and their inflows help to reduce concentrations in the Clark Fork through dilution. This is how a tributary like the Bitterroot River can be a major source of nitrogen loading to the middle Clark Fork, while at the same time cause a reduction in nitrogen concentration in the middle Clark Fork.

The WQB monitored pollutant concentrations and streamflow at each of a number of mainstem locations along the Clark Fork. Measurements were taken once to twice per month from August to March and twice per month from April to July. Monitoring was carefully timed according to streamflow and other factors that would influence water quality. This insured that the data were representative of the time interval (month or half month). Monthly average pollutant concentrations and streamflows were estimated by averaging the instantaneous measurements that were made during each month. Where USGS gaging stations corresponded with WQB sampling sites (most stations), monthly average streamflows based on continuous measurement were provided by the USGS. These data were used to replace the computed values. Monthly pollutant loads were then computed and summed to provide approximations of total annual loads at each monitoring location.

Water quality criteria discussed in this section are provided in Table 3-15.

Heavy Metals

Copper and zinc are potentially the most hazardous metals in the Clark Fork system due to their toxic effects on aquatic life. Except at very high concentrations, the presence of copper and zinc does not preclude other water uses. Copper is more toxic than zinc and is a slightly greater problem in the Clark Fork. Zinc concentrations, however, are typically higher than copper concentrations throughout the system. Synergistic effects of both copper and zinc (effects that are greater than the combined individual toxicities) are an important concern that has yet to be quantified for the Clark Fork. Arsenic is also present in the system, and while the federal drinking water standards are occasionally exceeded at some locations, aquatic life criteria are rarely surpassed.

A variety of analytical techniques for heavy metals analysis is used by the agencies that monitor water quality in the basin. These are summarized in Table 3-16. Because some techniques are more rigorous than others and yield higher values, it is often difficult to make comparisons among data sets.

The current EPA metals toxicity criteria for the protection of freshwater aquatic life give threshold levels in terms of total recoverable concentrations. Although the WQB monitors for total recoverable metals, it should be noted that the EPA and USGS total recoverable analysis method differs from the WQB total recoverable method in that a soft digestion is performed prior to sample analysis. This process releases a certain quantity of sediment-bound metals that may be present in the sample. The WQB method consists of field acidification of the sample followed by analysis. This method is comparable to the EPA acid-soluble method which is compatible with nearly all available data concerning

TABLE 3-15. WATER QUALITY CRITERIA FOR KEY PARAMETERS

Parameter	Beneficial Water Use Protected	Criteria (Concentrations in ug/l except where noted)	Date/ Reference
Copper	Freshwater aquatic life	Acute (1-hour ave. conc.)-18(HD)* Chronic (4-day ave. conc.)-12(HD)	EPA 1985a
Zinc	Freshwater aquatic life	Acute (1-hour ave. conc.)-120(HD) Chronic (4-day ave. conc.)-110(HD)	EPA 1987a
Arsenic	Freshwater aquatic life	Acute (1-hour ave. conc.)-360 Chronic (4-day ave.conc.)-190	EPA 1985a
Suspended sediment	Freshwater fisheries	High level of protection <25 mg/l Moderate level of protection 25-80 mg/l Low level of protection 80-400 mg/l Very low level of protection >400 mg/l	EPA 1972b

* HD Hardness Dependent. 100 mg/l used

TABLE 3-16. ANALYTICAL TECHNIQUES USED FOR HEAVY METALS WATER QUALITY ANALYSIS

1. State of Montana Total Recoverable
    1. Acidify sample upon collection to a pH of <2
    2. Decant off at time of analysis (no filtration)

2. USGS Total Recoverable
    1. Acidify sample upon collection to a pH of <2
    2. Filter with .45u filter at time of analysis

3. EPA Dissolved
    1. Filter sample with .45u filter at time of collection
    2. Acidify to pH of <2
    3. Analyze

4. EPA Total Recoverable
    1. Acidify sample at time of collection to a pH of <2
    2. Digest in the laboratory using hydrochloric acid
    3. Filter sample
    4. Analyze

5. EPA Total
    1. Acidify sample upon collection to a pH of <2
    2. Digest in the laboratory using hot nitric acid
    3. Analyze

Sources: USGS 1982; EPA 1983.

toxicity and bioaccumulation of metals by aquatic organisms. The EPA criteria are based on total recoverable concentrations instead of acid soluble or other forms, because sediment-bound metals in a wastewater discharge can eventually become bioavailable in a receiving stream as the chemical and physical properties of the wastewater change upon mixing. The WQB total recoverable method is suitable for surface waters but could underestimate the toxicity potential of metals present in wastewaters.

Silver Bow Creek. MultiTech (1987a) reported that the Metro Storm Drain was the most severely contaminated part of its study area, which extended from the Weed Concentrator outfall in Butte to near Garrison, Montana. Total cadmium and zinc concentrations regularly exceeded federal drinking water standards. Other contaminants exceeded the standard less frequently. During a storm event in May 1985, all the measured total metal concentrations exceeded federal drinking water standards at most of the Silver Bow Creek (SBC) stations sampled. Aquatic life criteria for copper and zinc were regularly exceeded at most SBC stations. An organic contaminant of concern, pentachlorophenol, or PCP, was detected at a site below the Montana Pole Treatment site and exceeded the drinking water lifetime health advisory for adults (0.22 mg/l) on one occasion (MultiTech 1987a). Major contaminant sources for the Silver Bow Creek study area identified by MultiTech (1987a) are summarized in Table 3-17.

Water Quality Bureau FY 1985-87 investigations indicate that Silver Bow Creek from Butte to the Warm Springs treatment ponds is seriously polluted with copper and zinc on a year-round basis. The highest concentrations of both copper and zinc in the Clark Fork Basin occurred in this area. A large portion of the metals load is attenuated in the Warm Springs Pond treatment system, but when Silver Bow Creek bypasses the ponds during high runoff events, it is clearly a significant source of metals to the mainstem Clark Fork.

Aquatic life toxicity criteria for copper and zinc (EPA 1985a, 87a) were exceeded in all samples from Silver Bow Creek, and annual average concentrations were ten to more than 20 times the threshold levels. Arsenic concentrations were commonly an order of magnitude less than either copper or zinc. Aquatic life criteria for arsenic were not exceeded in Silver Bow Creek or the mainstem Clark Fork during FY 1985-87 WQB sampling.

Figure 3-15 shows FY 1985-87 total recoverable copper concentrations at stations 1-3 above the Warm Springs Ponds and at the Pond 2 discharge (station 4). Stations 1-3 had very high concentrations with the median values about ten

TABLE 3-17. SUMMARY OF CHARACTERIZED AND POTENTIAL SOURCES OF CONTAMINATION TO SILVER BOW CREEK

Potential Source	Type	Contaminants
Metro Storm Drain	Point Source	Cd,Cu,Fe,Zn,SO_4
Missoula Gulch	Point Source	Cd,Cu,Pb,Zn,(low flow) Cd,Cu,Pb,Zn,Fe,As,TSS (high flow)
Browns Gulch	Point Source	As,Fe,Pb,TSS (high flow)
Butte WWTP	Point Source	Total P, Orthophosphate (Cd,SO_4, Zn during ground water pumping)
Montana Street to Colorado Tailings	Nonpoint Source (ground water inflow)	As,Cd,Cu,SO_4, Zn
Mill-Willow Bypass	Nonpoint Source (ground water inflow)	Fe,SO_4,Zn
Colorado Tailings to Silver Bow Siding	Nonpoint Source (re-entrainment)	Channel sediments
Ramsay Flats to Opportunity	Nonpoint Source (re-entrainment)	Channel sediments

Source: MultiTech 1987a

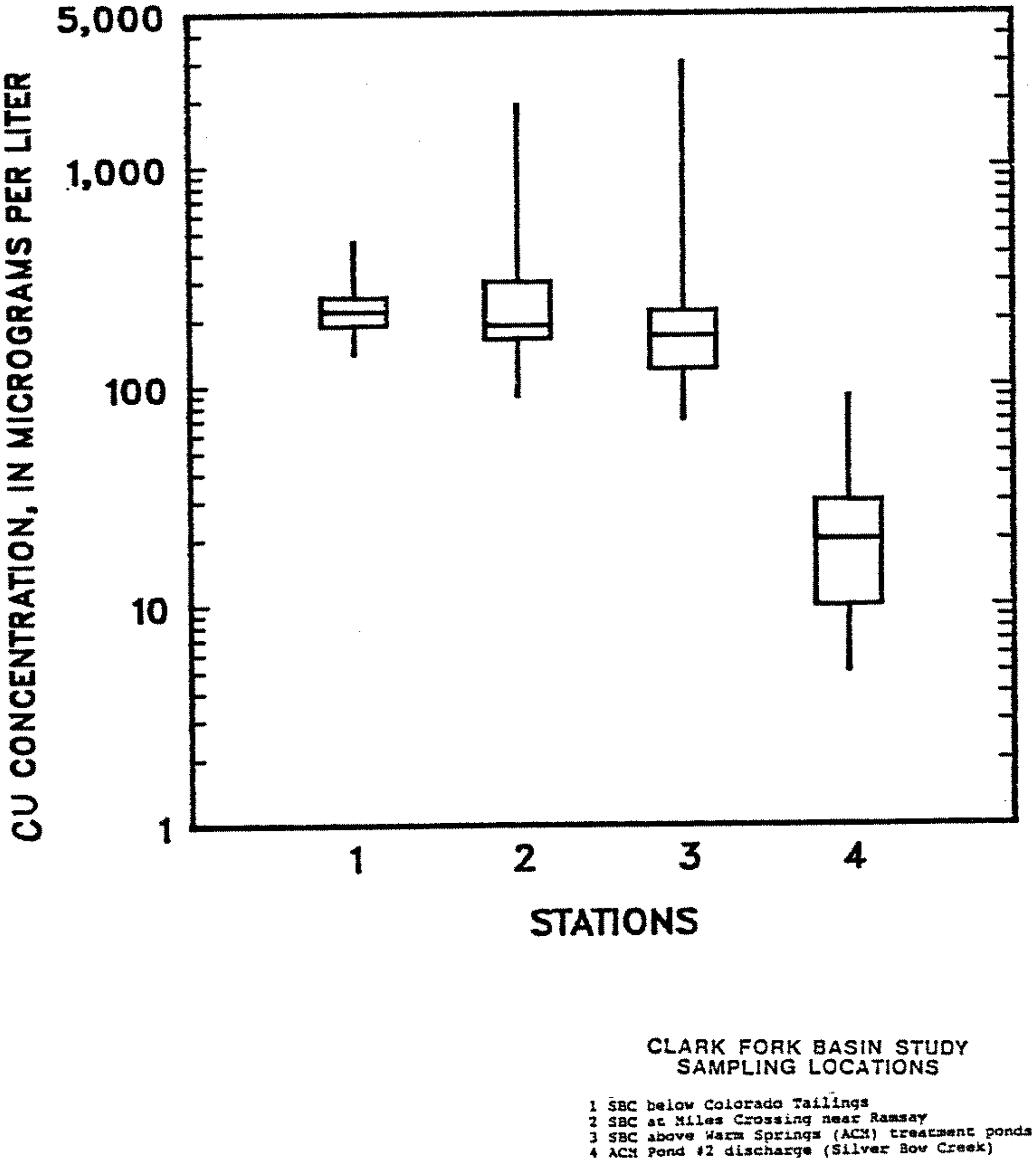


FIGURE 3-15. TOTAL RECOVERABLE COPPER CONCENTRATIONS IN SILVER BOW CREEK, DHES-WQB FY 85-87 DATA. (SEE FIGURE 3-13 FOR STATION LOCATIONS).

times higher than the chronic copper criteria for aquatic life. Station 4 values illustrate the dramatic decrease in copper concentrations due to attenuation by the Warm Springs Ponds, with a median value right at the chronic copper criterion.

Warm Springs Ponds. As mentioned previously, the Warm Springs Ponds were constructed by the Anaconda Company in an attempt to limit the downstream effects of mining. A number of investigations have addressed the pond system and its effect on the water quality of the Clark Fork, including: Casne et al. 1975; Botz and Karp 1979; Hydrometrics 1983c; DHES 1983; and others. However, these studies do not reflect current conditions, and very few of them collected samples from enough stations to identify contaminant sources or to complete a mass balance analysis of the pond system (MultiTech 1987a).

Data on the Warm Springs Ponds were collected for the Phase I RI Superfund investigation from November 1984 to September 1985. Additional, but limited surface water quality data were collected above and below the pond system in 1986. Field data collected included pH, temperature, conductivity, and flow (where appropriate). Water and bottom sediment samples were analyzed for major cations, major anions, and selected trace elements. Meteorological data were collected and surveys of the pond bottoms were performed to aid in volumetric calculations.

The Warm Springs Ponds generally act as a sink for sediment, total metals, dissolved metals, and nutrients. However, the ponds are not 100 percent efficient in trapping metals delivered by Silver Bow Creek and the Opportunity Ponds discharges and can be considered a source of contamination to the Clark Fork. The metals-removal efficiencies of the pond system during the Phase I RI study period exhibited seasonal variation. Overall removal efficiencies were about 87 percent for cadmium, 73 percent for lead, 65 percent for copper, 61 percent for zinc, 58 percent for iron, and 35 percent for arsenic. During the summer months, the ponds showed high metals-removal efficiencies, primarily due to low input rates and higher pH. The drop in pH experienced during the winter months and possibly other factors, such as channeling, allowed more dissolved cadmium, copper, and zinc to pass through the ponds without being precipitated, resulting in lower metals-removal efficiencies. Because the initial remedial investigation was undertaken during a period of drought and low stream flows, the influence of typically high spring runoff inflows to the pond system was not thoroughly evaluated. However, higher flows during the spring lowered the pond's efficiency due to higher contaminant loads and reduced residence times. Solid phases of copper, iron, and zinc, as well as arsenic and lead, were released in large quantities during this period. It appears that the hydrologic regime and algae populations (which influence pH and bioaccumulation of metals) are the most important mechanisms governing the contaminant load the ponds deliver to the Clark Fork (MultiTech 1987a).

Water Quality Bureau monitoring data show that the Warm Springs treatment ponds are extremely effective at decreasing metals loads, concentrations, and toxicity in Silver Bow Creek. On the average, treatment provided by the ponds decreased annual Silver Bow Creek copper loads were decreased nearly 12-fold and zinc loads were decreased about 5.5-fold during the 1985-87 period. Metals concentrations in the creek, after passing through the pond system, were an order of magnitude less. From 1985 to 87, copper toxicity criteria were exceeded slightly more than half the time in Silver Bow Creek downstream of the ponds, and annual average values were not much higher than the criteria. Thus, copper criteria exceedences tended to be frequent, but slight. Zinc toxicity criteria were not exceeded in FY 85 or FY 87 and were only infrequently exceeded in FY 86. The worst water quality occurs in winter due to lower pH and decreased efficiency of the treatment ponds caused by ice cover and colder water temperatures.

The Pond 2 discharge was the largest contributor of contaminant loads to the Clark Fork during the Phase I RI and significantly degraded water quality with sulfate, copper, zinc, iron, and lead. The Mill-Willow Bypass degraded water quality with sulfate, copper, zinc, iron, and cadmium (MultiTech 1987a). This has also been documented by WQB sampling, which shows that metal concentrations in the bypass (when Silver Bow Creek is not bypassing) are highest during snowmelt runoff and after heavy rains. Presumably, the tailings deposits in the bypass are the source of these metals. During FY 1985-87 WQB sampling, the bypass had the highest arsenic concentrations of the stations monitored, and the federal drinking water standard was exceeded periodically. However, federal drinking water standards for arsenic, cadmium, copper, iron, lead, and zinc generally were not exceeded during the Phase I RI, neither in discharges from the Warm Springs Ponds to the upper Clark Fork, nor within the ponds. The four-day (chronic) aquatic life criteria for cadmium, copper, lead, and zinc, and the one-hour (acute) aquatic life criteria for zinc were exceeded occasionally throughout the ponds. The acute aquatic life criteria for copper were usually exceeded within the pond system, but were not exceeded in discharges to the upper Clark Fork. Waters of the Mill-Willow Bypass exhibited chronic aquatic life toxicity with respect to copper and zinc concentrations and acute aquatic life toxicity with respect to copper concentrations. Silver Bow Creek and the Opportunity Ponds surface discharges are the principal sources of contaminants for the pond system (CH_2M Hill 1987d).

Upper Clark Fork. Some general observations of the geographic and hydrologic variations in trace element concentrations can be made from USGS data collected in the upper river (Figures 3-16, 3-17 and 3-18). Differences in height between the dissolved and total or total recoverable bars on the graphs represent the concentration of trace elements transported in suspension.

The median concentrations of total arsenic were not significantly higher than the dissolved phase at most sites (Figure 3-16), which indicates that much of the arsenic was dissolved in the waters during most flows. The highest median concentration of total arsenic among the six stations was 17 ug/l at Deer Lodge, which represents a 5 ug/l difference between the median dissolved and total phases.

In contrast, a greater proportion of copper was present in the suspended fraction (Figure 3-17), which illustrates the greater affinity of copper to the sediments. The highest median concentration of copper also occurred at Deer Lodge, with a total recoverable value of 59 ug/l.

Similarly, zinc also is transported primarily in suspension (Figure 3-18). As with arsenic and copper, the median concentration of zinc was highest at Deer Lodge, with a total recoverable value of 80 ug/l.

Samples collected during the February 1986 snowmelt represented the maximum concentrations measured by the USGS from 1985 to 1987. Total or total recoverable concentrations of arsenic, copper, and zinc during this event were substantially higher than median values. Arsenic concentrations during the February snowmelt were highest at Deer Lodge, with a total arsenic concentration of 130 ug/l, compared with a median of 17 ug/l. The maximum concentration of total recoverable copper was 630 ug/l at Deer Lodge, compared with a median of 59 ug/l, which represents more than a tenfold increase during runoff. More than 95 percent of the copper at Deer Lodge was transported in the suspended phase.

Maximum zinc concentrations were also measured in the mainstem, but the largest total recoverable value of 1,100 ug/l occurred at Turah Bridge. The total recoverable zinc concentration at Deer Lodge was 770 ug/l. Arsenic, copper, and zinc concentrations in the tributaries during this period were only slightly to moderately higher than median concentrations.

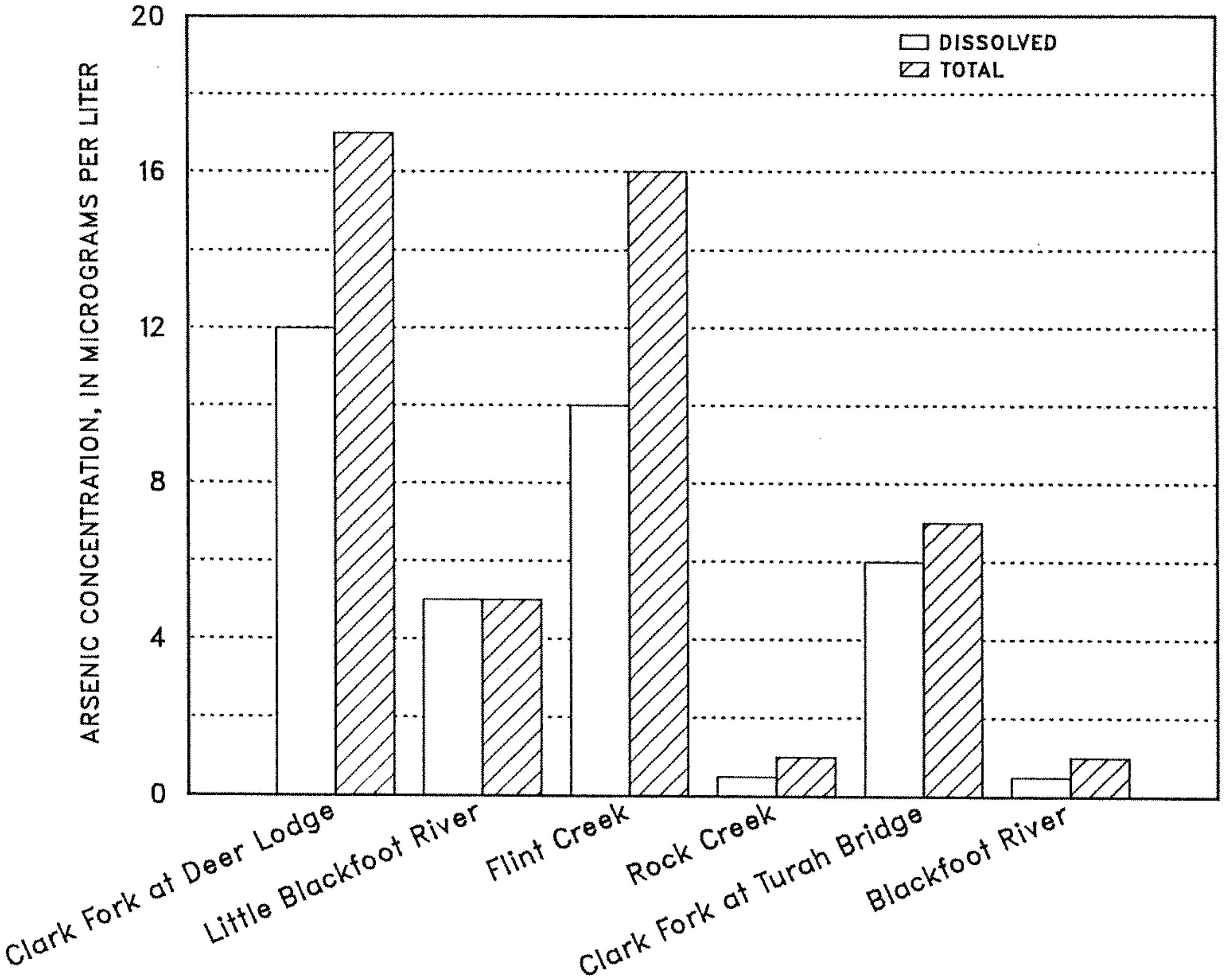


FIGURE 3-16. MEDIAN CONCENTRATIONS OF DISSOLVED AND TOTAL ARSENIC, MARCH 1985 TO SEPT. 1987. SOURCE: LAMBING 1988.

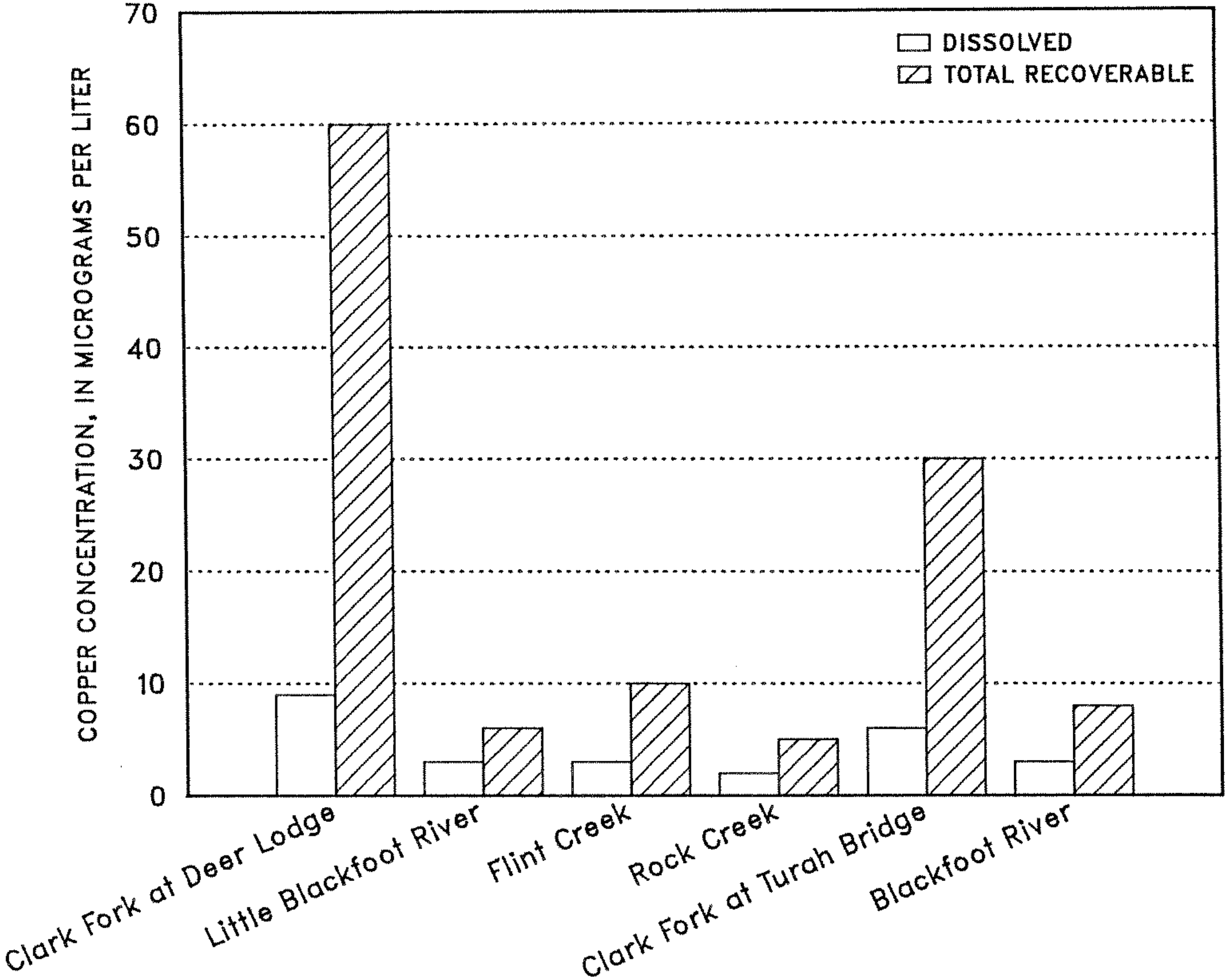


FIGURE 3-17. MEDIAN CONCENTRATIONS OF DISSOLVED AND TOTAL RECOVERABLE COPPER, MARCH 1985 TO SEPTEMBER 1987. SOURCE: LAMBING 1988.

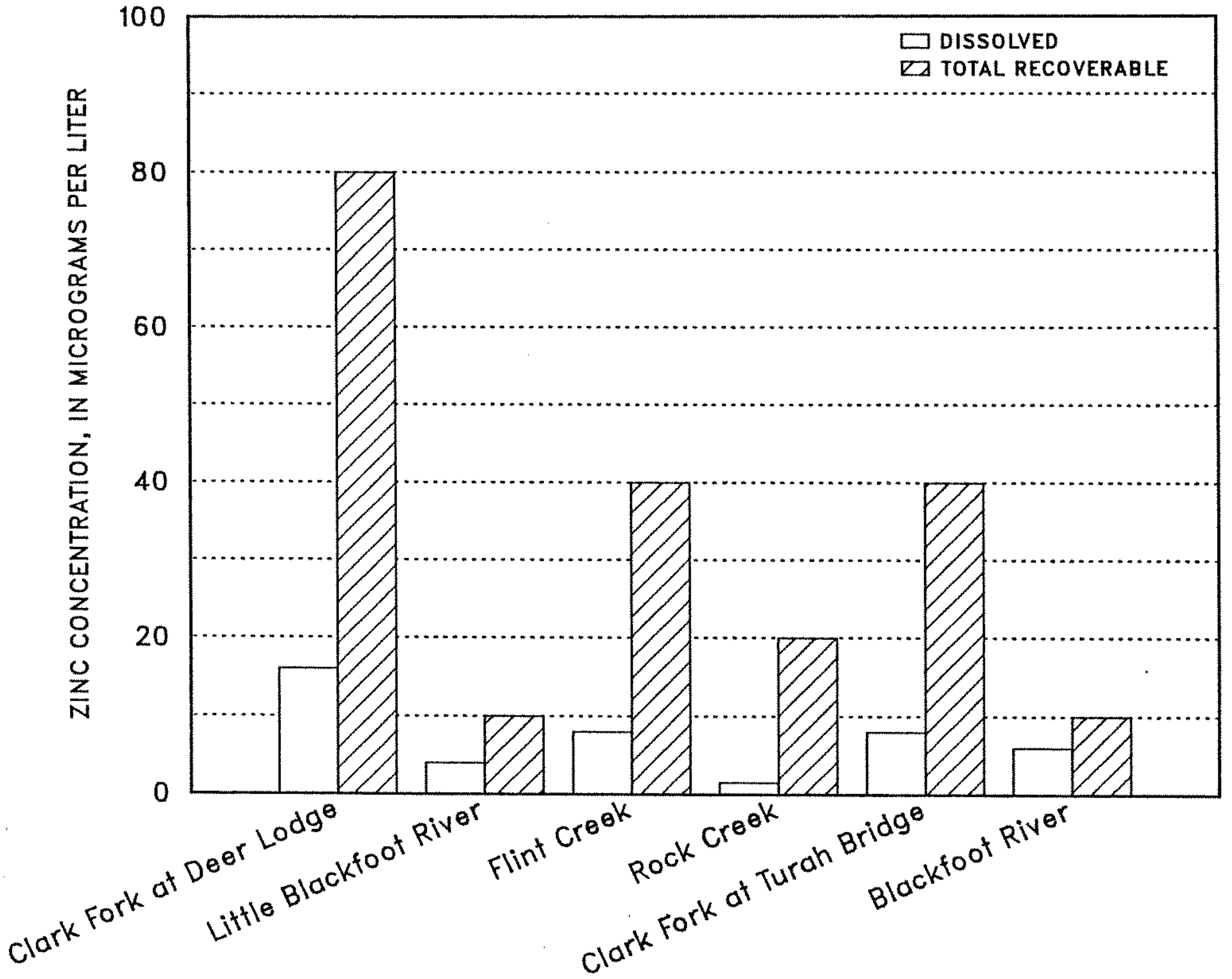


FIGURE 3-18. MEDIAN CONCENTRATIONS OF DISSOLVED AND TOTAL RECOVERABLE ZINC, MARCH 1985 TO SEPTEMBER 1987. SOURCE: LAMBING 1988.

A general observation from the median and maximum measured concentrations is that the most upstream sampling station, Clark Fork at Deer Lodge, typically has the highest concentrations, presumably due to its proximity to the major headwater tailings sources. Flint Creek also has relatively high trace element concentrations, probably as a result of historical and current small-to-moderate-scale mining in its basin. Smaller trace element concentrations are typical of the Little Blackfoot River and Rock Creek. These tributaries aid in diluting the concentrations of trace elements in the Clark Fork mainstem, which has generally smaller concentrations downstream at Turah Bridge compared with Deer Lodge. The Blackfoot River also has small trace element concentrations, despite some abandoned mine areas in its upper basin. Because of their large flow contributions and relatively low trace element concentrations, Rock Creek and the Blackfoot River improve the water quality of the mainstem.

Water Quality Bureau data indicate that water quality varies considerably within different sections of the upper river reach. Water quality is much improved below Warm Springs Creek through a direct dilution of metals concentrations and as a result of increased water hardness and alkalinity that buffer the effects of metals. Warm Springs Creek drains a limestone formation that contributes to its high hardness and moderate alkalinity. Unfortunately, Warm Springs Creek is severely dewatered for irrigation and it is frequently nearly dry in the months of July and August.

Metals concentrations in the Clark Fork tend to decrease from its point of origin at Warm Springs to Dempsey, presumably as a result of dilution from cleaner tributaries. The copper criteria (Figure 3-19) were exceeded less than half the time and exceedences that did occur were usually slight. Zinc criteria were rarely exceeded. From Dempsey to the Little Blackfoot River, water quality progressively deteriorates, especially during winter and spring months. Metals concentrations and frequency of exceedences of the aquatic life criteria tend to increase, despite the entry of additional clean-water tributaries. The copper criteria were exceeded up to half the time during the monitoring period in the Clark Fork above the Little Blackfoot River, with some measurements exceeding the criteria several-fold. Despite an increase in zinc concentrations, criteria were infrequently exceeded.

Average annual copper loads (Figure 3-20) increased by as much as 6.5 times, and zinc loads (Figure 3-21) increased by more than three times in the Clark Fork from Warm Springs to some 15 or more miles below Deer Lodge. Metals sources are streamside tailings deposits and possibly inputs from contaminated ground water. The rate of increase in metals

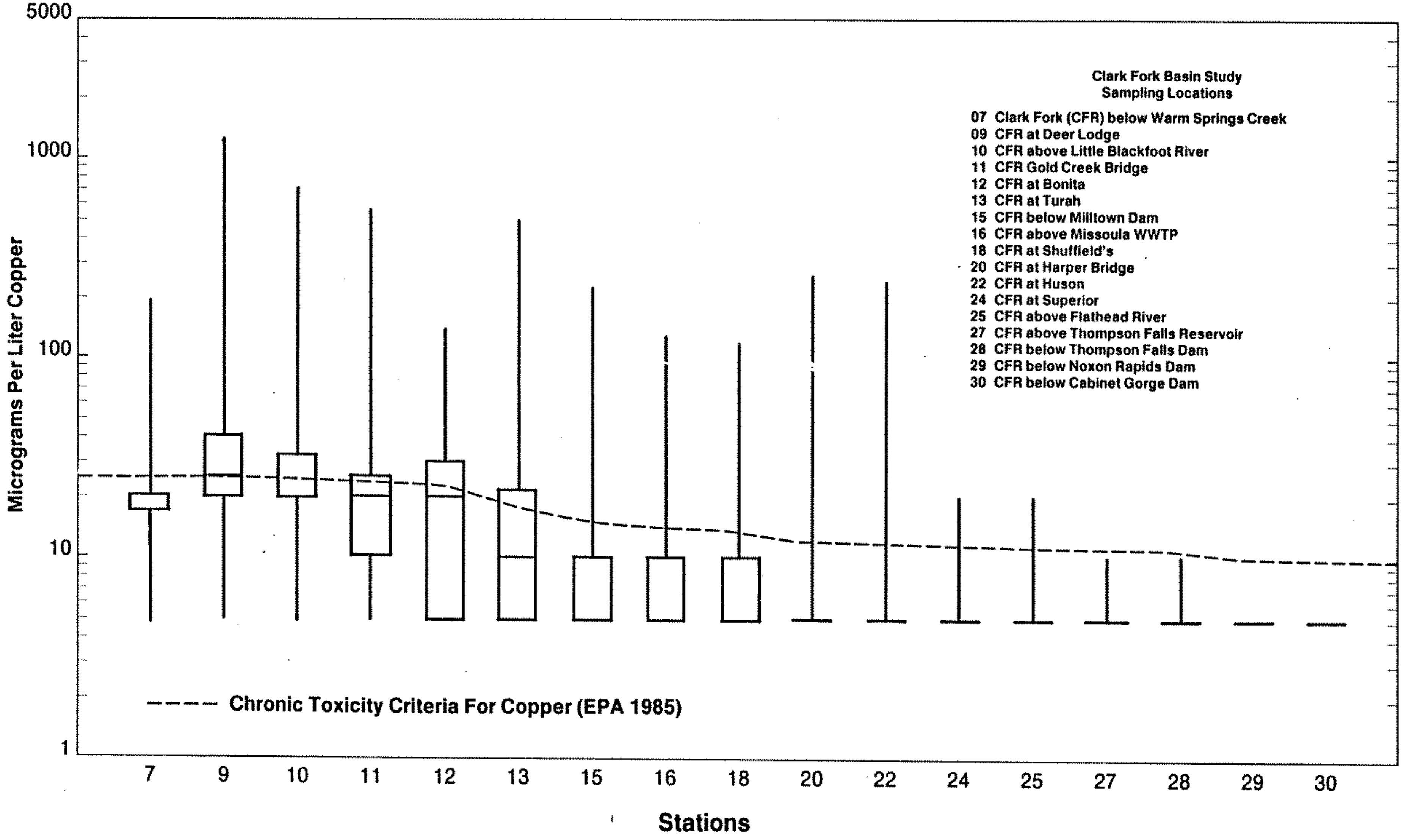


FIGURE 3-19. TOTAL RECOVERABLE COPPER CONCENTRATIONS IN THE CLARK FORK, DHES-WQB FY 85-87 DATA. (SEE FIGURE 3-13 FOR STATION LOCATIONS).

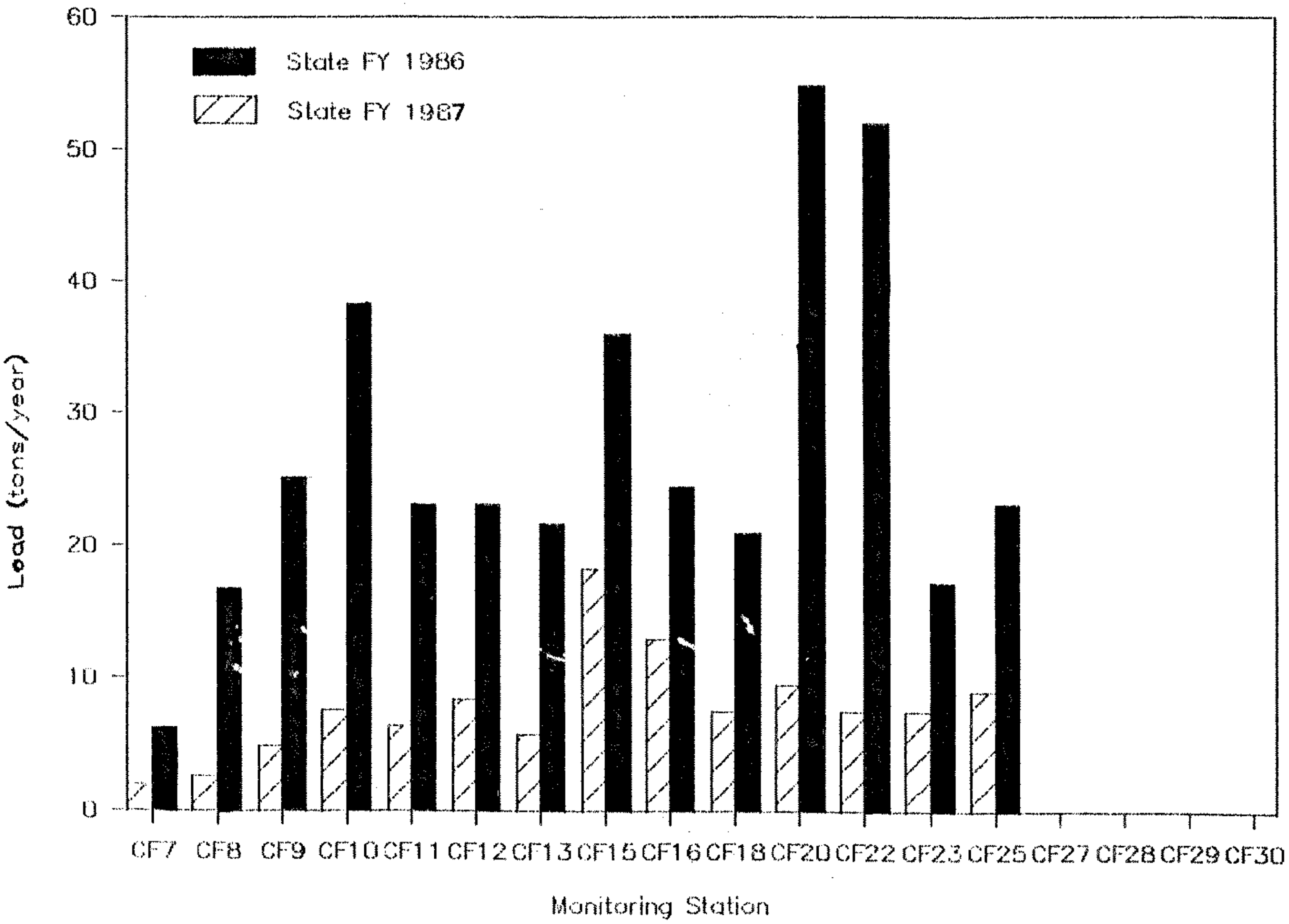


FIGURE 3-20. TOTAL RECOVERABLE COPPER LOAD IN THE CLARK FORK, DHES-WQB FY 86-87 DATA (ESTIMATES BASED ON 14-17 SAMPLINGS/YEAR). SEE FIGURE 3-13 FOR STATION LOCATIONS.

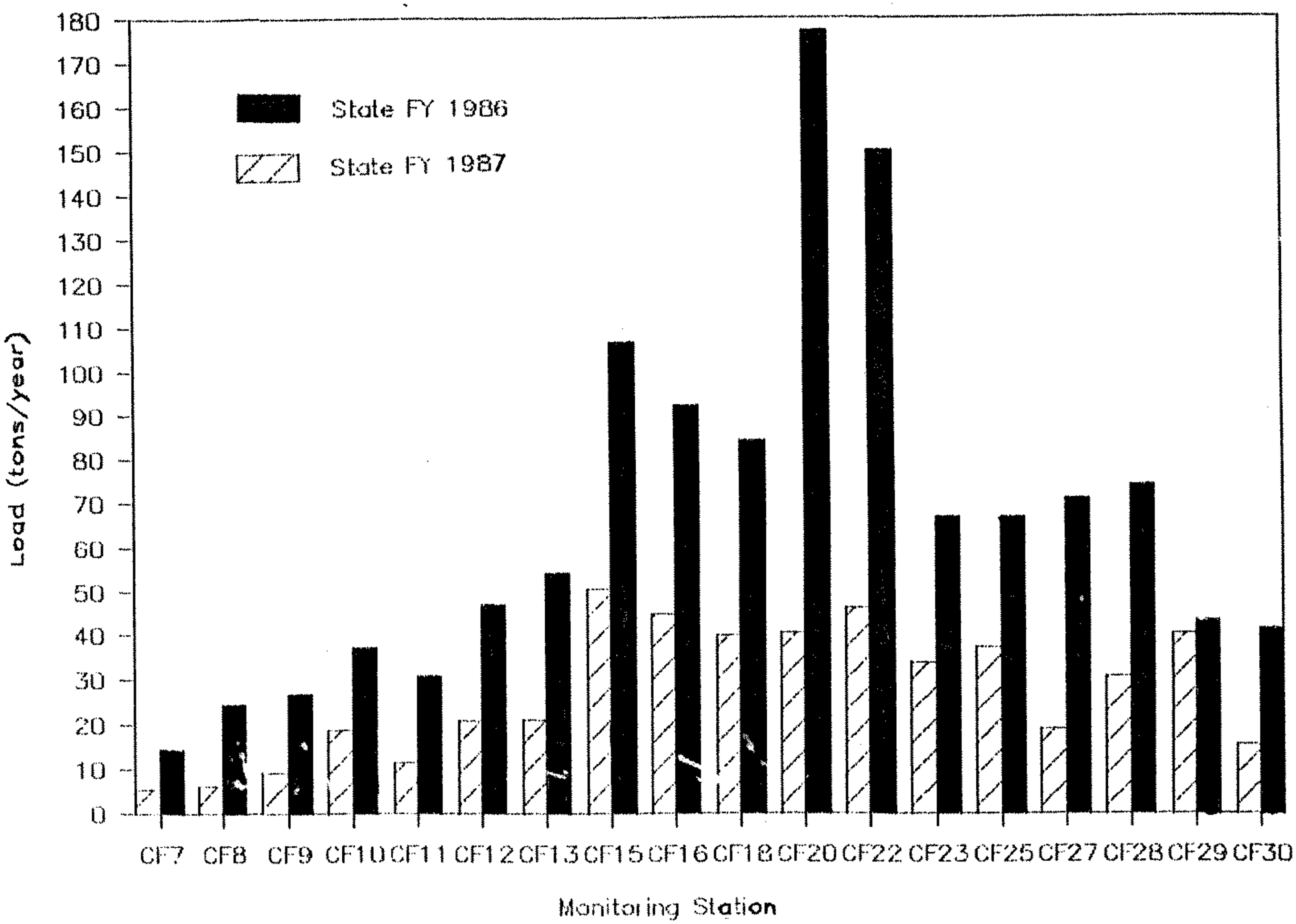


FIGURE 3-21. TOTAL RECOVERABLE ZINC LOAD IN THE CLARK FORK, DHES-WQB FY 86-87 DATA (ESTIMATES BASED ON 14-17 SAMPLINGS/YEAR). SEE FIGURE 3-13 FOR STATION LOCATIONS.

loading seems to be consistent progressing downstream in the reach from Warm Springs Creek to Deer Lodge. However, from Deer Lodge to the Little Blackfoot River, a major increase in loading occurs. This may correspond to the presence of a major ground water recharge zone and the presence of localized tailings deposits in the river floodplain.

Conditions generally improve in the Clark Fork from Garrison downstream to the Blackfoot River as the contributions of clean water from major tributaries such as the Little Blackfoot River and Rock Creek dilute metals concentrations and metals sources become less significant or are left behind. The Blackfoot River joins the Clark Fork just above the Milltown Dam, and its clean water further dilutes metals concentrations in the middle Clark Fork segment. However, in the Clark Fork just below Milltown Dam, these benefits are sometimes masked. Elevated metals levels periodically occur in association with operational drawdowns of Milltown Reservoir that result in the loss of metal-bearing sediments from the reservoir. More recently, short term increases in metals levels below the dam have been associated with reconstruction of the dam's aged spillway, which was severely damaged during the major runoff of February 1986. The occurrence of sediment-metal events resulting from drawdowns will be curtailed by the completion of the Milltown Rehabilitation Project. The installation of a radial gate and fixed wheel panels will allow the control of runoff up to 28,000 cfs without drawing down the reservoir. A drawdown will be required if streamflow exceeds 28,000 cfs, which has a recurrence interval of 14 years. Such a drawdown is not expected to produce high sediment loads because the higher-than-normal runoff (more than 28,000 cfs) will remove susceptible sediment from the reservoir.

River monitoring by the Montana Power Company revealed a sharp spate of zinc in March 1987 before the onset of the runoff period. Concentrations of 1,720 ug/l and 1,120 ug/l acid-soluble zinc were measured at Turah on March 5 and 6, 1987 (MPC 1987). River flow at Turah increased 50 percent from 787 cfs on March 3 to 1,180 cfs on March 5 after being stable (609-836 cfs) since January 1. Total suspended sediment increased from 39.7 mg/l on March 4 to 88.8 mg/l and 88.9 mg/l on March 5 and 6 at Turah. Acid-soluble copper was less markedly elevated to 50 ug/l on both days--up from less than 10 ug/l on March 2, 1987.

Middle Clark Fork. Water Quality Bureau data indicate that metals concentrations in the middle Clark Fork are generally much lower than those in the upper Clark Fork (Figure 3-19). This is likely due to fairly large volumes of clean dilution water provided by the Bitterroot and St. Regis rivers and increasing distance from metals sources.

Exceedences of copper criteria were generally infrequent, slight, and short-lived in this reach. Zinc criteria were exceeded only once in the three-year monitoring period (in February 1986).

Monitoring by MPC in early March 1987 downstream from Milltown Dam and the confluence of the Blackfoot River showed moderate concentrations of acid-soluble zinc. River values on March 5 through 9 were 370, 220, 410, 980 and 50 ug/l, respectively. These findings indicate that a water quality event that may control young fish survival may be triggered by the first rapid increase in river flow after the stable flow period of winter. Additional monitoring needs to be performed during this time of year to determine if early snowmelt events occur regularly and if they are an important element in the Clark Fork fishery problems.

Lower Clark Fork. The Flathead River more than doubles the volume of the Clark Fork, on the average. The result is a dramatic improvement in the water quality of the Clark Fork below the confluence. During the WQB monitoring period, copper criteria were rarely exceeded in samples from the lower river section and have not been documented below Thompson Falls. As shown in Figure 3-19, copper concentrations were stable and quite low at all four stations. Exceedences of zinc criteria have not been documented in the lower river.

Suspended Sediment

The amount of sediment in a river is important because of its potential effect on beneficial uses of the water. A large volume of sediment in a system can adversely affect aquatic life and interfere with water treatment and irrigation. Other pollutants, such as nutrients and metals, can be adsorbed onto sediment particles and transported by them into and through aquatic systems.

Suspended sediment transport in running waters is difficult to quantify accurately, especially in a river system as complex and as large as the Clark Fork watershed. Suspended sediment concentrations and loads in the Clark Fork system are strongly influenced by variations in streamflows and intensity of runoff events. Each of the three years monitored was characterized by lower than normal runoff, on the whole. FY 85 and 87 were particularly low streamflow years, and suspended sediment production, transport, and severity of problems were generally low. Conversely, the rapid snowmelt event of February 1986 created unusually high mid-winter streamflows and excessive sediment concentrations. A large percentage of the estimated annual suspended sediment load was transported during this relatively short-duration event. Total annual suspended sediment loads and mean concentrations were well above FY 85 or 87 values, due primarily to the February snowmelt event.

Both the USGS and the WQB use the Equal Width Increment (EWI) depth-integration technique to sample suspended sediments. Most of the WQB monitoring stations located below Garrison are too deep to wade, as are some of the upper stations during runoff conditions. In those instances, samples were depth-integrated to the limit of wadeability, and as a result, only a portion of the channel cross-section was sampled. In some cases, suspended sediment samples were grab-sampled, but only when stream flows were low and sediment concentrations were negligible.

The emphasis of the WQB Clark Fork water quality assessment has been comparisons with aquatic life criteria because those standards are usually more conservative than the criteria established to protect other water uses. However, it is a difficult proposition to establish aquatic life criteria for suspended sediment concentrations, because impacts are a function of duration of exposure as well as concentration. For example, most Montana streams carry appreciable suspended sediment concentrations during the usually short period of spring runoff. Resident aquatic life forms are adapted to these annual events and are able to tolerate them. The same conditions sustained over a longer period of time would be devastating.

Because the WQB monitoring program is limited in its ability to measure the duration of suspended sediment concentrations, the WQB data are compared to simple criteria that are not based on duration of exposure. The European Inland Fisheries Advisory Council and others have established the following suspended sediment guidelines for the maintenance of freshwater fisheries. The frequency of distribution of measured values among the various categories is the basis for the assessments in this report.

Water normally containing suspended sediment concentrations of:

<25 mg/l	High level of protection; no harmful effects on fisheries.
25-80 mg/l	Moderate level of protection; good or moderate fisheries.
80-400 mg/l	Low level of protection; unlikely to support good fisheries.
>400 mg/l	Very low level of protection; only poor fisheries.

USGS suspended sediment data for the upper river and WQB data for the entire drainage are summarized below.

Silver Bow Creek. Water Quality Bureau data indicate that Silver Bow Creek has a severe inorganic suspended sediment problem. Concentrations were highly variable in FY 85-87 (Figure 3-22), and for its size, sediment production was high, presumably as a result of the preponderance of unvegetated mine tailings in the floodplain. The suspended sediment criterion to maintain a high level of protection for freshwater fisheries was exceeded from 11 to 64 percent of the time, depending on the year and the monitoring location. Various stations fell in the low level of protection category up to 11 percent of the time. Suspended sediment concentrations, loads, and problem severity generally increased from Butte downstream to above the Warm Springs Ponds. The Butte sewage discharge was responsible for an increase in organic suspended sediment in Silver Bow Creek for several miles below the outfall. However, organic concentrations were only a fraction of the total suspended sediment concentrations.

Warm Springs Ponds. The Warm Springs Ponds caused major reductions in Silver Bow Creek's suspended sediment concentrations through their function as large settling basins. Estimated annual total suspended sediment loads in Silver Bow Creek in FY 86 and 87 were decreased fourfold to sixfold from above and below the ponds, and up to 2,000 tons of material was trapped in one year. From the standpoint of fisheries protection, Silver Bow Creek suspended sediment concentrations below the ponds were consistently good.

Upper Clark Fork. Median suspended sediment concentrations for March 1985 to September 1987 at the six USGS sampling stations were low, ranging from 8 mg/l (milligrams per liter) in the Blackfoot River to 36 mg/l in Flint Creek. These values indicate that the quantities of sediment transported during most flows of 1985-87 were minor. Considerably higher concentrations can occur during high-flow conditions, with the largest values measured in the Clark Fork mainstem during the February 1986 snowmelt runoff (1,390 mg/l at Deer Lodge and 1,370 mg/l at Turah Bridge). The large differences in concentration between median and runoff conditions indicate that the amount of suspended materials transported is highly variable, with short-duration events possibly representing a significant portion of the annual load.

Figure 3-23 depicts the range of suspended sediment concentrations in the upper Clark Fork during the WQB monitoring period. There were general increases in concentrations and reduced fisheries protection from the headwaters downstream

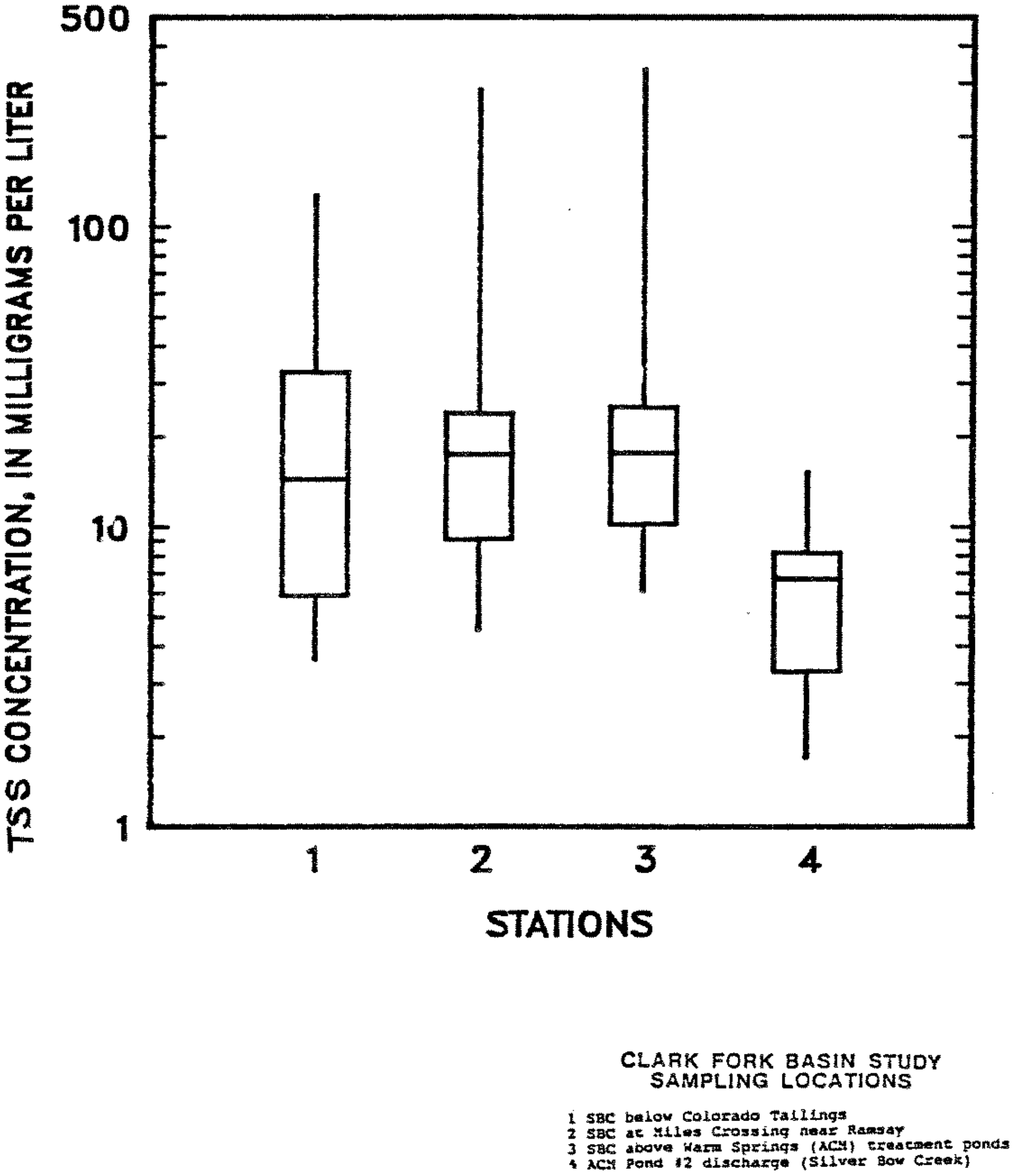


FIGURE 3-22. TOTAL SUSPENDED SEDIMENT CONCENTRATIONS IN SILVER BOW CREEK, DHES-WQB FY 85-87 DATA. (SEE FIGURE 3-13 FOR STATION LOCATIONS).

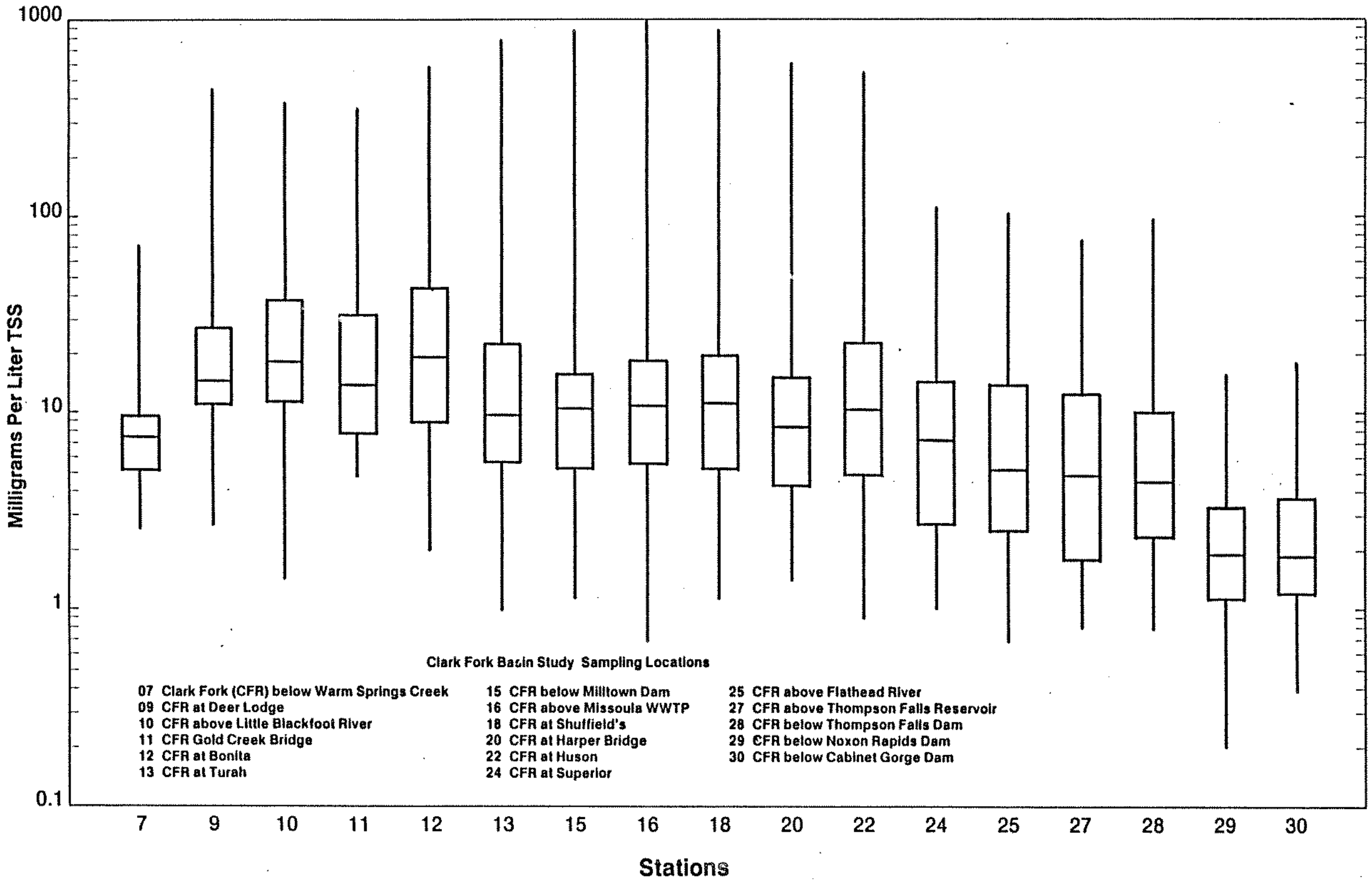


FIGURE 3-23. TOTAL SUSPENDED SEDIMENT CONCENTRATIONS IN THE CLARK FORK, DHES-WQB FY 85-87 DATA (SEE FIGURE 3-13 FOR STATION LOCATIONS).

to monitoring station 12, the Clark Fork at Bonita. The plots of suspended sediment load (Figures 3-24 and 3-25) point to the stream reaches between monitoring stations 9 and 10 and 11 and 12 as possibly containing significant sediment sources, especially during FY 86. The worst overall reach in the upper Clark Fork from the standpoint of fisheries protection was from station 10 to station 12. Suspended sediment concentrations fell in the moderate to low levels of fisheries protection categories from 27 to 55 percent of the time. The presence of streamside tailings deposits and unstable streambanks throughout the upper Clark Fork are the probable causes.

Rock Creek, located between monitoring stations 12 and 13, is a large tributary that normally carries low concentrations of suspended sediment. Clark Fork median suspended sediment concentrations downstream of the Rock Creek confluence were measurably decreased (Figure 3-23) at all times, except during the February 1986 flood. Concentrations were also significantly more favorable from the standpoint of fisheries protection.

Downstream from station 13, the Blackfoot River joins the Clark Fork. This large stream equals the Clark Fork in size, and its suspended sediment concentrations average a quarter to half those in the Clark Fork above the Blackfoot. Its inflow, plus the Milltown Reservoir which is a large sediment trap, decrease Clark Fork sediment concentrations. However, during high-flow events and during past operational drawdowns and construction activities, the settled sediments in the reservoir were mobilized and transported downstream. The reservoir is a significant sediment source in those instances.

Organic suspended sediment concentrations were generally low throughout the upper Clark Fork and averaged a small fraction of the total suspended sediment concentration. The Deer Lodge sewage discharge appeared to cause measurable though small increases in Clark Fork organic suspended sediment concentrations for several miles downstream of the discharge.

Middle Clark Fork. Suspended sediment concentrations in the middle Clark Fork from Missoula to the Flathead River (Figure 3-23), can be described as generally decreasing in a downstream direction as a result of additional dilution from cleaner incoming tributaries, such as the Bitterroot River. Concentrations normally fall within the range that would afford a high level of protection to freshwater fisheries.

Although Bitterroot River suspended sediment concentrations are lower than the mainstem, suspended sediment load

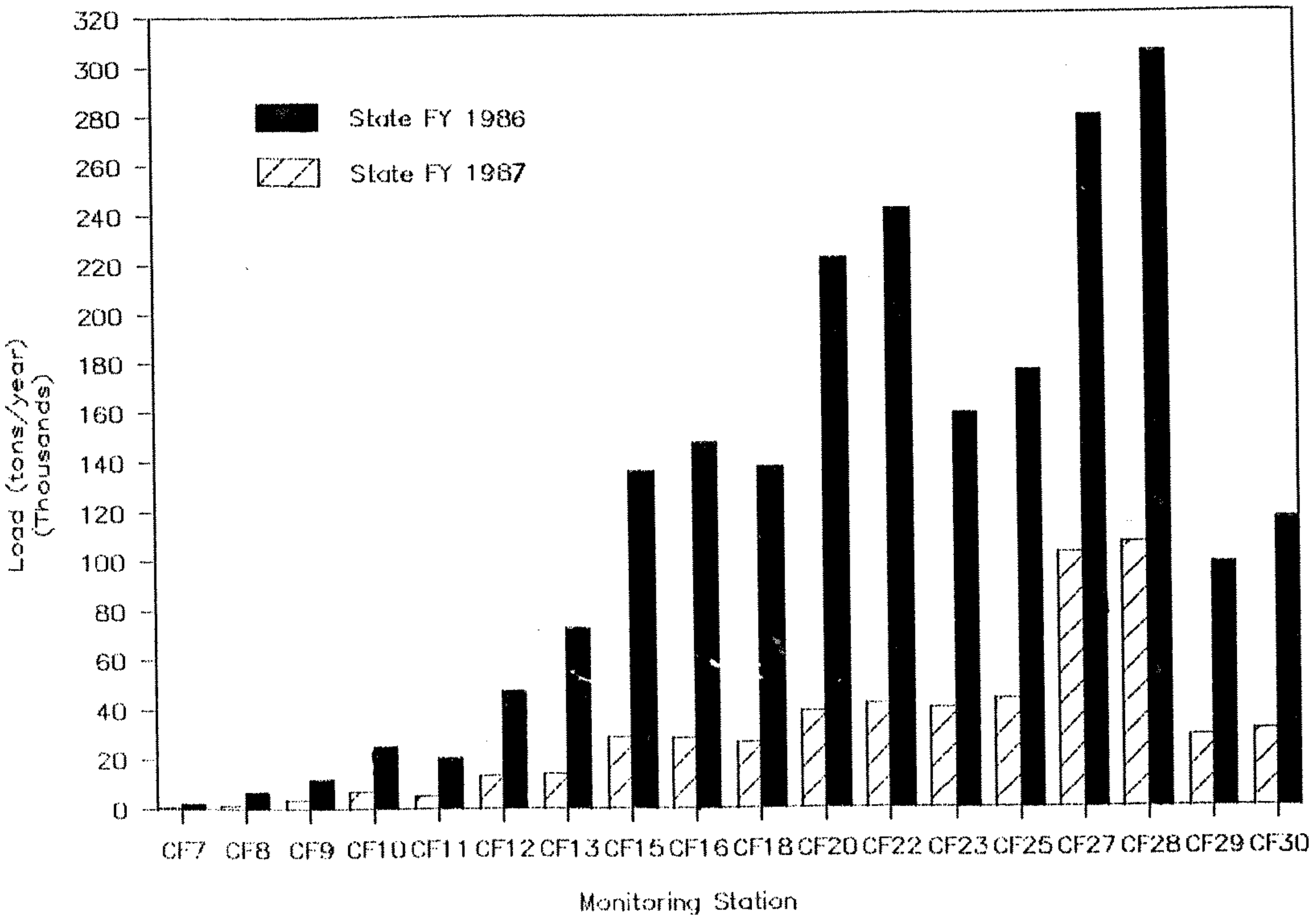


FIGURE 3-24. TOTAL SUSPENDED SEDIMENT LOAD IN THE CLARK FORK, DHES-WQB FY 86-87 DATA (ESTIMATES BASED ON 14-17 SAMPLINGS/YEAR). SEE FIGURE 3-13 FOR STATION LOCATIONS.

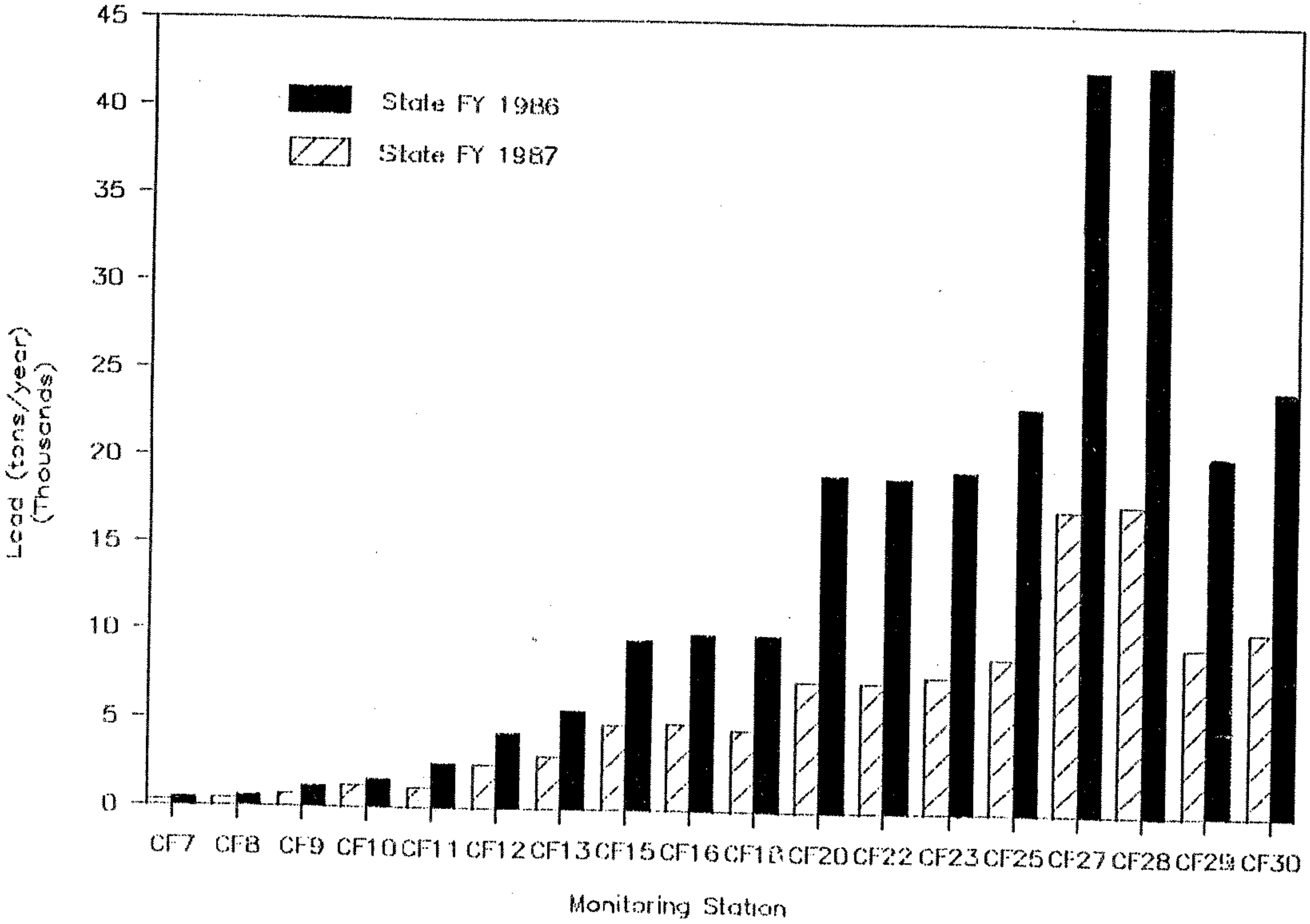


FIGURE 3-25. VOLATILE SUSPENDED SEDIMENT LOAD IN THE CLARK FORK, DHES-WQB FY 86-87 DATA (ESTIMATES BASED ON 14-17 SAMPLINGS/YEAR). SEE FIGURE 3-13 FOR STATION LOCATIONS).

plots (Figures 3-24 and 3-25) indicate that the Bitterroot River is the most significant source of sediment loading to the middle Clark Fork. Both the Missoula WWTP and Stone Container Corporation wastewater discharges contributed sizeable, largely organic suspended sediment loads to the middle Clark Fork. However, their influences on river concentrations and load were not measurable.

Lower Clark Fork. Suspended sediment concentrations in the lower Clark Fork are shown in Figure 3-23. The Flathead River more than doubles the volume of the Clark Fork and routinely carries a lower suspended sediment concentration than the Clark Fork. As a result, suspended sediment concentrations measured in the Clark Fork downstream of the Flathead are reduced and nearly always fall within the highest category for fisheries protection. Farther downstream, the Noxon Rapids Reservoir acts as a settling basin and is responsible for an even more significant reduction in Clark Fork suspended sediment concentration. The last reservoir in the system, Cabinet Gorge, has no apparent effect, presumably because most of the settleable solids have already been trapped upstream. In general, the lower Clark Fork can be described as excellent from the standpoint of suspended sediment concentrations, largely as a result of dilution by the Flathead and the influences of the reservoirs.

Suspended sediment load plots point to the Flathead River as the only significant additional source of sediment to the lower Clark Fork. The reservoirs are responsible for reducing Clark Fork suspended sediment loads to less than those carried by the Clark Fork above the Flathead River.

Other Water Quality Parameters

A number of parameters or conditions other than metals and sediment cause degradation of surface water quality in the Clark Fork, including ammonia, elevated temperature, dissolved oxygen, toxics, foam, and color. These are discussed in the following sections.

Ammonia. Ammonia is a form of nitrogen that is frequently associated with wastewater discharges. Ammonia or its degradation products are readily available for algal uptake and can contribute to nutrient enrichment problems. However, the primary concern with ammonia is that it can be extremely toxic to aquatic life under certain conditions of stream pH and temperature (EPA chronic ammonia toxicity criterion varies depending on pH and temperature). The potential for ammonia toxicity downstream of wastewater discharges in the Clark Fork Basin has been closely monitored in the past and will require continued scrutiny.

The Butte sewage effluent is a source of ammonia to Silver Bow Creek. During WQB FY 85-87 sampling, the EPA chronic toxicity criterion for salmonid species (trout) was exceeded one-third to two-thirds of the time during the monitoring period for several miles below the outfall.

Ammonia toxicity was not documented at any of the upper or lower Clark Fork stations during the monitoring period. The effluent from the Missoula WWTP is the largest source of ammonia in the middle river. Ammonia toxicity was not documented below the wastewater mixing zone during FY 85-87 WQB sampling. However, because of high levels of ammonia in the discharge and documented exceedences of the ammonia criterion within the mixing zone, further evaluation is being done by WWTP staff. The Frenchtown Mill wastewater also contains relatively high levels of ammonia. To date, exceedences of the criteria have not be documented. However, installation of the color-removal facilities has necessitated daily ammonia monitoring because wastewater dilution rates are lower when color-treated wastewater is being discharged.

Temperature and Dissolved Oxygen. Stream temperature and concentration of dissolved oxygen affect the survival of aquatic life, particularly salmonids. If a fish is exposed to increased temperatures, more energy is required for basic metabolism, and less energy is available for food acquisition, growth, and reproduction. Stream temperature is affected by many factors, including streamflow, air temperature, exposure to sunlight, the ratio of surface area to volume, ground water inflow, and topography (Braico 1973). Trout generally prefer temperatures between 52°F and 64° F, while long-term exposure to temperatures above 75° F may be lethal.

The amount of dissolved oxygen in streams is an important measure of water quality. Sufficient levels of oxygen are necessary to support a healthy and diverse community of organisms, including fish, aquatic insects, other macroinvertebrates, and plants. Severe depletions of dissolved oxygen can cause fish and insect kills. Chronically low levels can cause a decrease in diversity and quality of aquatic life (DHES 1985). Montana Water Quality Standards (DHES 1984) for most of the Clark Fork do not permit induced reductions of DO below 7 mg/l. Between Warm Springs Creek and Cottonwood Creek, DO concentrations cannot fall below 6 mg/l from June 2 to September 30 or below 7 mg/l from June 2 to September 30 or below 7 mg/l between October 1 and June 1.

The variables that affect dissolved oxygen levels include water temperature, biological activity such as photosynthesis and respiration, oxidation of inorganic compounds, decomposition of organic matter, and reoxygenation from water turbulence. These variables, along with diurnal and seasonal variations, interact in complex ways to determine instream dissolved oxygen concentration (DHES 1985). Algae and other aquatic plants release oxygen in sunlight and consume oxygen during nighttime respiration; therefore, very productive streams may have severe nighttime sags in DO (Braico 1973).

Although temperature and DO data for the Clark Fork are limited, several studies have been completed by the WQB. The first was done in August 1973, by Braico, who measured DO and temperatures at frequent intervals during a 24-hour period (called "diel" monitoring) at 12 stations along the Clark Fork and at single sampling sites on Rock Creek (near Clinton), the Blackfoot River, and the Bitterroot River. The author reported the following results:

- The greatest temperature response was observed in the Clark Fork just above the Rock Creek confluence where a high temperature of 76° F was recorded. Temperatures reached 72° F on the mainstem at Garrison, Drummond, and Turah.
- Maximum temperatures in Rock Creek, the Blackfoot River, and the Bitterroot River were 68° F, 70° F, and 74° F, respectively.
- At stations below the Bitterroot confluence, where the Clark Fork becomes quite large, stream temperatures were least affected by diurnal variations in air temperature.
- The lowest DO concentrations of 5.9 and 5.2 mg/l were observed in the Clark Fork at Deer Lodge and the Rock Creek Bridge, respectively. Conditions were critical at the latter station when high temperatures (above 68° F) and low DO levels coincided for over five hours.
- DO concentrations were generally below saturation at all other stations except during periods of maximum photosyntheses. However, minimum values did not drop below 6 mg/l at any of these stations.

Braico attributed the results of the study to a combination of factors, including extremely low streamflow (less than half of normal), loss of shade-producing bank vegetation due to highway construction, warm weather during the study, and heavy algal populations.

In 1984 and 1985, the WQB conducted a number of water quality studies in the Clark Fork between Turah and the Idaho border, partly in response to the controversy surrounding the discharge permit issued to the Champion International mill (now Stone Container Corp.). Five sampling runs provided ambient water quality data on DO concentrations. Because sampling was done at all hours of the day, the diurnal variability of DO may have masked the affects of deoxygenation caused by organic decomposition, making changes in DO difficult to interpret. However, the DO data suggested that much of the oxygen demand from the Champion discharge was satisfied within the mixing zone from the Champion outfall to Huson. The effects of instream dilution on the wastewater would diminish the oxygen demand to nearly unmeasurable levels (DHES 1985).

Diel DO monitoring runs were also conducted in August 1984 and 1985 to determine daily oxygen maximums and minimums at sites above and below the Champion mill. Results of this monitoring did not indicate a problem with DO levels in the Clark Fork. However, one run was conducted when the wastewater discharge was highly diluted, and the other was done during a period of no wastewater discharge. The data therefore represent only a narrow range of conditions (DHES 1985).

Self-monitoring data from Champion (a requirement of its permit) for the period of January 1984 to September 1985, revealed DO concentrations below 7 mg/l on 12 days. No waste was discharged on nine of those days (DHES 1985).

A study conducted in the summer of 1986 in the Clark Fork near the Missoula WWTP and Stone Container Corporation by Kerr (1987) involved two 24-hour diel surveys (July 8-9 and August 5-6). Temperature and DO were measured at regular intervals at six stations on the Clark Fork. The objective was to determine whether wastewater discharges from the WWTP and Stone Container Corporation had a measurable effect on DO concentrations in the Clark Fork. The first survey was conducted during a period of high wastewater discharge, while the second occurred during a period of low wastewater discharge.

Average DO concentrations varied considerably by site and survey. During low wastewater discharge, DO tended to increase in a downstream direction; during high wastewater discharge, it tended to decrease in a downstream direction. The largest change between two adjacent sites during high wastewater discharge occurred between Shuffields and Harper Bridge and Huson and Alberton. The theoretical net oxygen loss during high wastewater discharge relative to low wastewater discharge was greatest at Alberton. Because the flow of the Clark Fork and weather conditions during the two surveys were quite different, the estimated losses of dissolved oxygen during high wastewater discharge could not necessarily be attributed to the volume of wastewater discharged by Stone Container.

A diurnal DO survey was also conducted by the WQB in the upper and middle Clark Fork from July 29 to July 30, 1987. In the upper river, the lowest DO levels (about 70 percent of saturation) of the day occurred between midnight and two a.m. (Watson 1988a). The author concluded that the upper river is at high risk for DO levels below the state standard of 7 ppm when nighttime temperatures rise above 16° C and flows fall below 1,000 cfs at Turah and below 200 cfs at Deer Lodge. In the middle river, the lowest DO levels (about 70-80 percent of saturation) were observed between four and six a.m. (Watson 1988b) concluded that the middle river would be at high risk for DO levels below the state standard when predawn temperatures rise above 18.3° C, and would be at even higher risk in extremely low flow years.

<u>Color and Foam</u>. Wastewater discharges to surface water can cause increases in river color, particularly under low flow conditions. Kraft pulping processes generate wastewater that contains compounds that are known as foaming agents. Both increased color and foam are potential aesthetics problems in the Clark Fork (DHES 1985).

Aesthetics monitoring (color, foam, sludge deposits, slime growth, odor, etc.) was conducted in the Clark Fork near Missoula during the 1984-85 WQB investigation. Results of analyses for river color indicated a general compliance with Champion's allowable five-color unit increase stipulated in their discharge permit. Color was the single most important factor controlling the rate at which Champion could discharge wastewater to the river. Although it reported occasional violations of the color standard, Champion considered it a high priority to reduce the volume and color of its effluent (DHES 1985).

Stone Container Corporation, which acquired the mill in 1986, installed a color-removal plant at the facility in February 1988. The technology, developed by the corporation, reduces color of the effluent by about 85 percent. This will allow the mill to meet color standards if it discharges during low-flow conditions. The chemical process also reduces the total suspended solids and nutrients (Stone Container Corp. 1988). The new plant is operated seasonally only, due to the high cost of the additional treatment.

During the 1984-85 WQB aesthetics reconnaissance, considerable quantities of surface foam were observed on the Clark Fork above and below Champion's discharge, in the Bitterroot River near its mouth, and in the Clark Fork from St. Regis to the confluence of the Flathead River. The problem was especially bad in the backwater areas below Champion's discharge in the fall and early spring. Steps were being taken to reduce foaming agents in Champions effluent (DHES 1985).

Toxins. Substances in this category include organics such as PCP, PCB, oil and grease, and organic resin acids. PCP and PCB are of particular concern in the headwaters area. Silver Bow Creek has received waste oil containing PCP in the vicinity of the Montana Pole Superfund site (discussed earlier in this chapter), and PCB is a potential contaminant from the Butte urban area (MultiTech 1987a). During the Phase I Superfund studies for the Silver Bow Creek site, selected stations were monitored for PCP, PCB, and oil and grease. MultiTech (1987a) reported detectable concentrations of PCP at the monitoring station below the Montana Pole and Treatment site.

Stone Container Corporation's wastewater contains organic resin acids, which are potentially toxic. However, acute or chronic toxicity problems in the Clark Fork are unlikely, because its discharge permit stipulates a minimum river water to waste dilution ratio of 200:1 (if color-treated wastewater is discharged, the minimum dilution is 100:1).

Chronic bioassay tests on rainbow trout and *Ceriodaphnia* were conducted from May 31, 1985 to June 12, 1985 at the Champion mill site by EPA (Nimmo et al. 1985). A 30-day flow-through bioassay on the rainbow trout (button-up stage) and a seven-day daphnid life-cycle test were conducted using a series of wastewater dilutions. Mortality of fish in both series of dilution waters and waste was extremely low and there was no evidence of reduced growth, indicating that the test dilutions were not chronically toxic to trout. The daphnids survived and reproduced in ambient water from nine locations on the Clark Fork and no indication of toxicity was found at any of the stations.

As a whole, little is known about the sources, fate, and transport of organic substances in the Clark Fork Basin, as most monitoring efforts have focused on inorganic pollutants. Further investigation of these potentially toxic organics is probably warranted.

EUTROPHICATION AND NUTRIENTS

Excessive Algal Growth

Algae and other aquatic plants are natural components of most aquatic environments. Individual species have different habitat requirements, but in general, their abundance is controlled by environmental factors such as available light, temperature, and nutrients. In most instances, nutrient availability, especially nitrogen and phosphorus, is the factor that limits algae growth and abundance. In the presence of nutrient enrichment, such as domestic wastewater effluents, algae growth can be excessive and a nuisance to other beneficial uses. Excessive algae growth can also modify existing water quality by depleting oxygen, modifying pH, imparting taste and odor, and releasing toxic substances.

The process of nutrient enrichment and accelerated biological productivity is called eutrophication. In undisturbed watersheds, eutrophication is a natural aging process. Where nutrient enrichment is accelerated by human activity, "cultural eutrophication" results.

Evidence of excessive algae growth in the upper Clark Fork basin has been reported since 1974 (Casne et al. 1975). Aerial surveys in 1973-74 showed dense growths of algae occurring between Deer Lodge and the mouth of the Blackfoot River. These growths were attributed in part to insufficient stream flows during the spring months to scour the previous year's algae growth. Very heavy growths of algae have occurred again during the summers of 1984 to 1988, again associated with periods of below-normal spring runoff.

Several studies have been conducted in recent years to describe and quantify algae growths in the river and to define the factors contributing to them. Bahls (1987) has described the species composition and species diversity for composite algae samples taken in 1986 at 28 stations located between Silver Bow Creek and the Idaho border. Cladophora sp. was the most consistently abundant green algae with peak occurrences in the reaches from Gold Creek to Missoula and from Superior to the confluence of the Flathead River. Excessive algae growths did not occur in Silver Bow Creek and the Clark Fork above Deer Lodge, presumably due to metal toxicity. Diatoms were the dominant algae at the Turah and Harper Bridge stations. These sites were characterized by low species diversity and a very small percentage of pollution-tolerant species. In 1987, EPA (1987b) characterized the abundance of algae attached to natural and artificial substrates in the upper and lower river. Chlorophyll and biomass were especially high in the upper river stations.

Increases occurred below the municipal wastewater treatment plants and below the Stone Container Corp. discharge. Algal biomass and chlorophyll decreased downstream from Stone Container Corporation to the town of Plains (Ingman, 1985).

Nuisance quantities of algae have not been reported in the lower Clark Fork reservoirs. Water level fluctuations and relatively rapid flushing rates in the reservoirs probably prevent the establishment of nuisance-level algae blooms or rooted aquatic macrophytes.

Algae and macrophytes are a major concern in Lake Pend Oreille, Idaho. In recent years, residents and recreationists have reported an increase in littoral-zone (near-shore) algae and macrophytes. A 1986 study of periphyton growth in Lake Pend Oreille suggests that eutrophication of the lake is accelerating (Falter and Kann 1987).

Analysis of Lake Pend Oreille waters has indicated relatively low nutrient concentrations in the open water areas but significantly greater evidence of eutrophication in developed and confined bays. Relatively little information is available regarding nutrient sources in Lake Pend Oreille other than the Clark Fork which contributes 90 percent or more of the annual inflow. Less is known about the contribution of nutrients from other tributaries and from near-shore developed zones.

Nutrient Concentrations and Loading

Of the many nutrients required by algae and other aquatic plants, nitrogen and phosphorus are the two elements usually in the shortest supply in natural waters. This means that the growth of algae is often controlled by the concentration of nitrogen or phosphorus, or both, in the water column. The EPA has established criteria values for total inorganic nitrogen and total phosphorus that should not be exceeded in order to prevent excessive developments of attached algae in rivers and to prevent eutrophication in lakes that are fed by rivers. These values are 1,000 ug/l for nitrogen and 50 ug/l for phosphorus. The criteria may not apply equally well in all situations, and they do not account for other limitations to algal growth.

WQB data demonstrate that the major sources of nutrients in the Clark Fork Basin are municipal and industrial wastewater discharges. During low-flow years, there is less river water available to dilute the wastewater. This is especially problematic for municipal dischargers, whose discharge rates are relatively constant from year to year. It is less important for some industrial facilities, such as the Stone Container Corporation kraft mill, because their allowable discharges are largely limited by river flow.

The following summary of FY 85-87 WQB data on river nutrient concentrations and loads may very well represent a near worst-case scenario because of the low streamflow conditions that prevailed during the monitoring period. The generally higher nutrient loading in 1986 probably reflects a greater contribution from nonpoint sources.

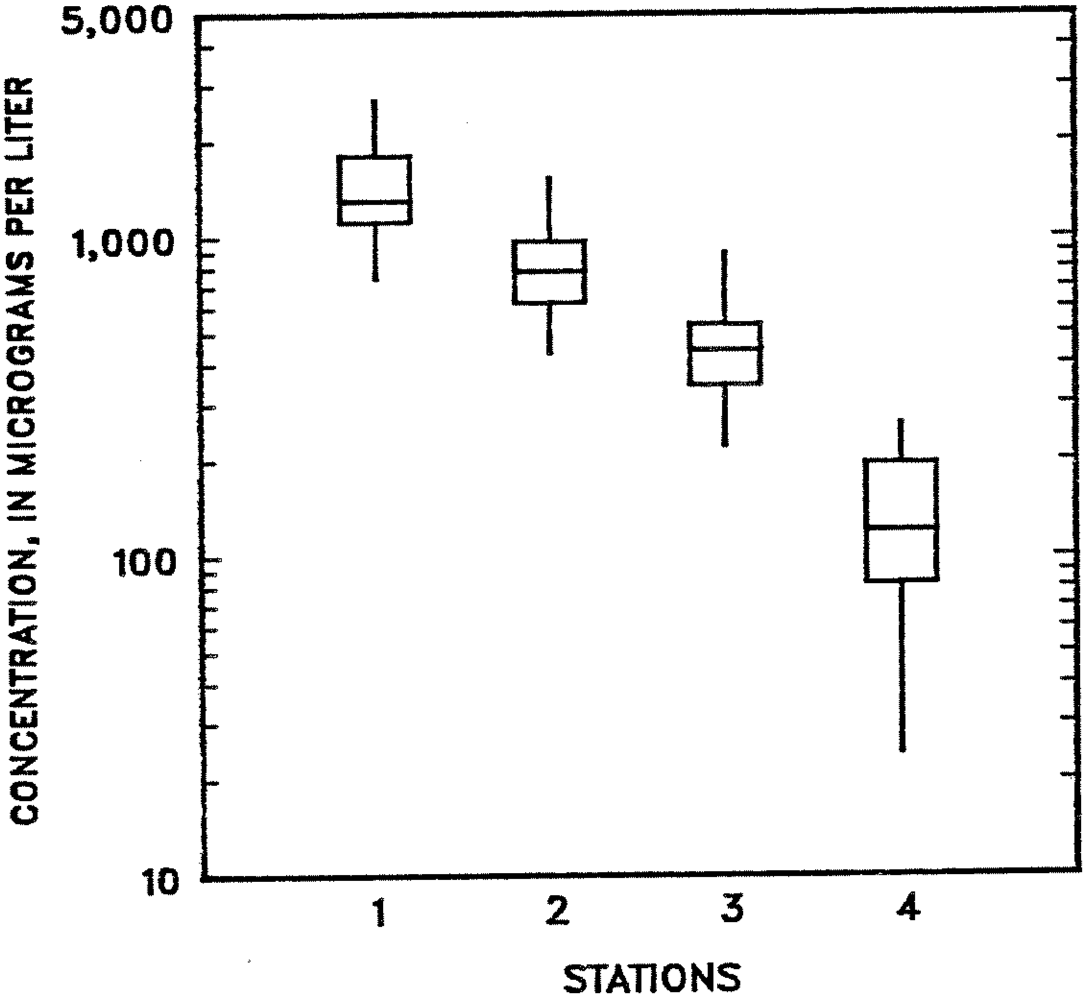
Silver Bow Creek

Silver Bow Creek from Butte to the Warm Springs treatment ponds suffered from serious nutrient pollution problems on a year around basis during FY 86-87. Measured concentrations of total phosphorus (Figure 3-26) and total inorganic nitrogen in Silver Bow Creek were an order of magnitude higher than any other stream monitoring station in the Clark Fork Basin. The EPA nitrogen (1,000 ug/l) and phosphorous (50 ug/l) criteria were routinely exceeded by a large margin--up to 32 times for phosphorus and up to four times for nitrogen--at most monitoring locations on the creek.

The highest nutrient concentrations in Silver Bow Creek occurred at monitoring station 1, Silver Bow Creek below the Colorado Tailings. The station is located a short distance downstream of the Butte municipal wastewater discharge, which is the principal source of nutrients in the creek. During periods of low streamflow, more than half the Silver Bow Creek flow consists of sewage effluent. From monitoring station 1 downstream to the Warm Springs Ponds, nutrient concentrations (Figure 3-26) and loads declined somewhat, presumably as a result of dilution from cleaner tributaries or ground water inflows or both, and probably to a lesser extent from biological uptake. However, concentrations remained sufficiently high to categorize the stream as grossly polluted. Silver Bow Creek does not harbor extensive developments of algae despite its excessive nutrient concentrations. Algal bioassays conducted several years ago for DHES (Greene et al. 1986) indicated that the potential for algal growth in Silver Bow Creek was limited by toxic metals, most likely copper. Copper is phytotoxic at relatively low concentrations and is widely used as an algicide, e.g., copper sulfate.

Warm Springs Ponds

The Warm Springs Ponds were very effective at decreasing Silver Bow Creek phosphorus concentrations (Figure 3-26,



CLARK FORK BASIN STUDY
SAMPLING LOCATIONS

1 SBC below Colorado Tailings
2 SBC at Miles Crossing near Ramsay
3 SBC above Warm Springs (ACM) treatment ponds
4 ACM Pond #2 discharge (Silver Bow Creek)

FIGURE 3-26. TOTAL PHOSPHORUS CONCENTRATIONS IN SILVER BOW CREEK, DHES-WQB FY 85-87 DATA. (SEE FIGURE 3-13 FOR STATION LOCATIONS).

monitoring station 3 versus 4) and loads during FY 86-87. Reductions in both nitrogen and phosphorus concentrations and loads were comparable and averaged about 3.5-fold less in the pond outlet as compared with Silver Bow Creek above the ponds. Biological assimilation, denitrification, and settling of suspended solids with adsorbed nutrients were presumably the responsible factors.

The ponds effectively reduced nitrogen concentrations to levels below the EPA criterion, on the average. Only infrequent, small-scale exceedences of the nitrogen criterion in the pond discharge were documented in FY 86, and no exceedences were measured in FY 87. Although phosphorus concentrations were significantly reduced, they rarely fell below the problem level. Measurements of total phosphorus in the pond discharge exceeded the EPA criterion 80 to 90 percent of the time in FY 86-87, with mean concentrations averaging nearly three times the threshold value.

Upper Clark Fork

Measured total phosphorus concentrations and estimated annual phosphorus loads for the Clark Fork from its headwaters below Warm Springs Creek (station 7) to below Milltown Dam (station 15) are presented in Figures 3-27 and 3-28, respectively. Estimated annual loads for total inorganic nitrogen are given in Figure 3-29.

Nutrient concentrations in Warm Springs Creek and in the Mill-Willow Bypass were significantly lower than those in Silver Bow Creek. Each of these tributaries helped to reduce the nutrient concentrations in the mainstem Clark Fork at its headwaters.

Nutrient concentrations in the upper Clark Fork mainstem, in general, decrease below incoming clean tributaries and increase below municipal wastewater discharges. In Figure 3-27, notable increases in median total phosphorus concentrations were observed between monitoring stations 9 and 10 and between stations 11 and 12. The primary point sources of phosphorus in those reaches are the Deer Lodge, Philipsburg (via Flint Creek), and Drummond wastewater discharges. The ground water system is also a possible source of phosphorus. However, in 30 water samples collected during 1985 to 87 from 28 wells in the area between Deer Lodge and Drummond, most concentrations of dissolved phosphorus were less than 0.1 mg/l and the maximum concentration was 0.3 mg/l (USGS unpublished data). The phosphorus load plot (Figure 3-28) confirms that these reaches contain significant phosphorus sources. Comparing the measured phosphorus concentrations with the EPA criterion indicates that concentrations in the upper Clark Fork frequently exceed

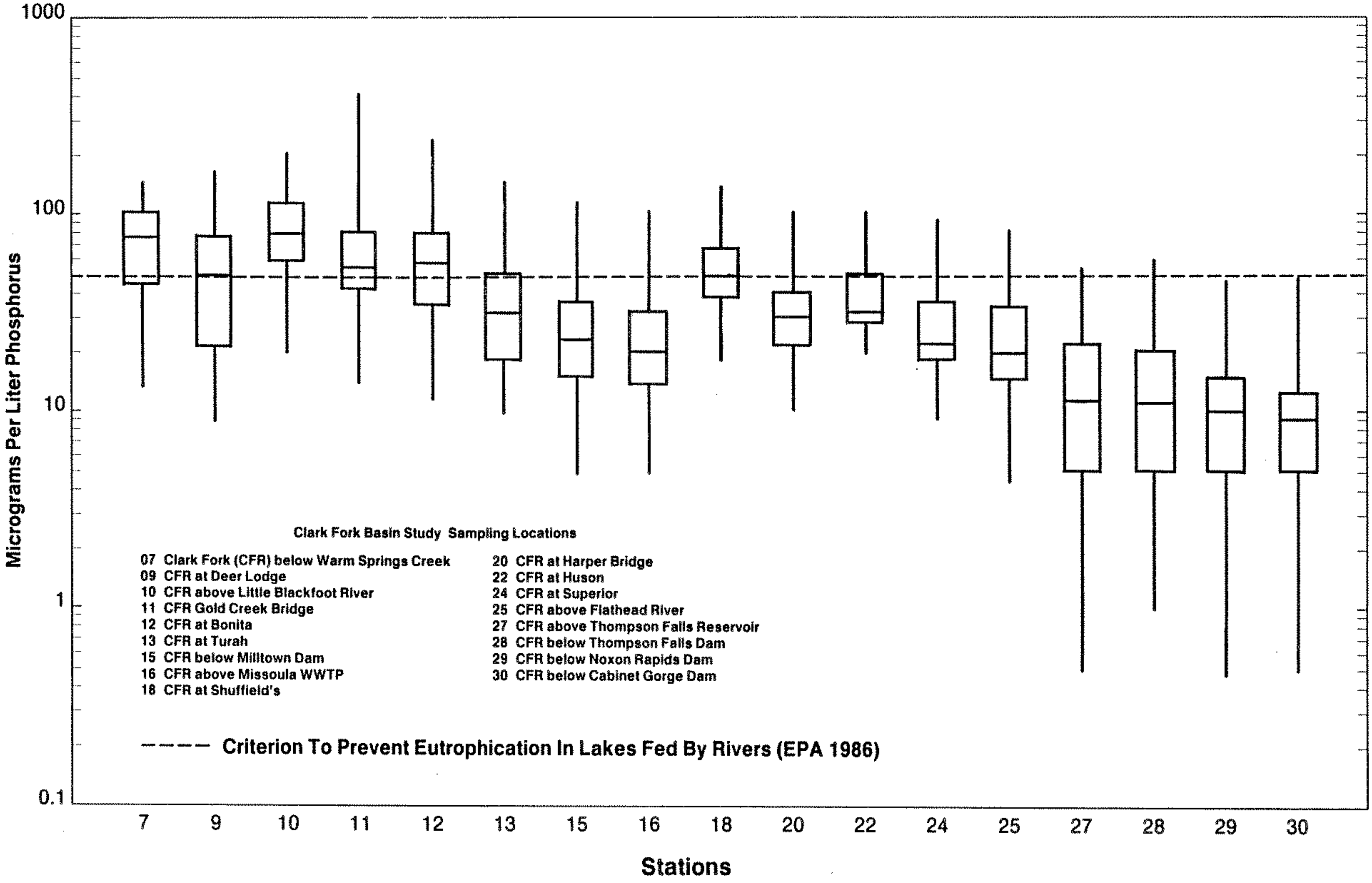


FIGURE 3-27. TOTAL PHOSPHORUS CONCENTRATIONS IN THE CLARK FORK, DHES-WQB FY 85-87 DATA. (SEE FIGURE 3-13 FOR STATION LOCATIONS).

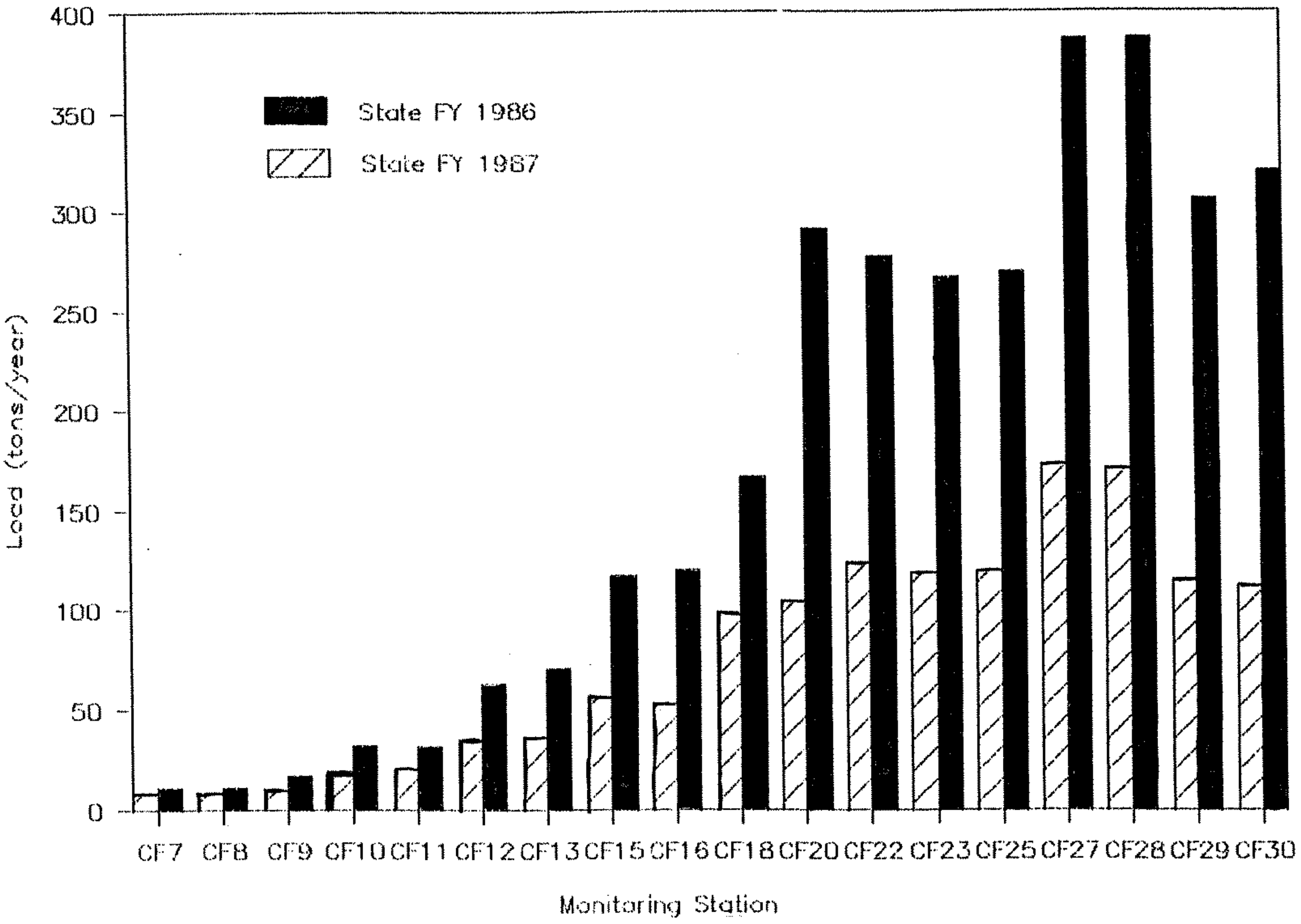


FIGURE 3-28. TOTAL PHOSPHORUS LOAD IN THE CLARK FORK, DHES-WQB FY 86-87 DATA. (ESTIMATES BASED ON 14-17 SAMPLINGS/YEAR). SEE FIGURE 3-13 FOR STATION LOCATIONS.

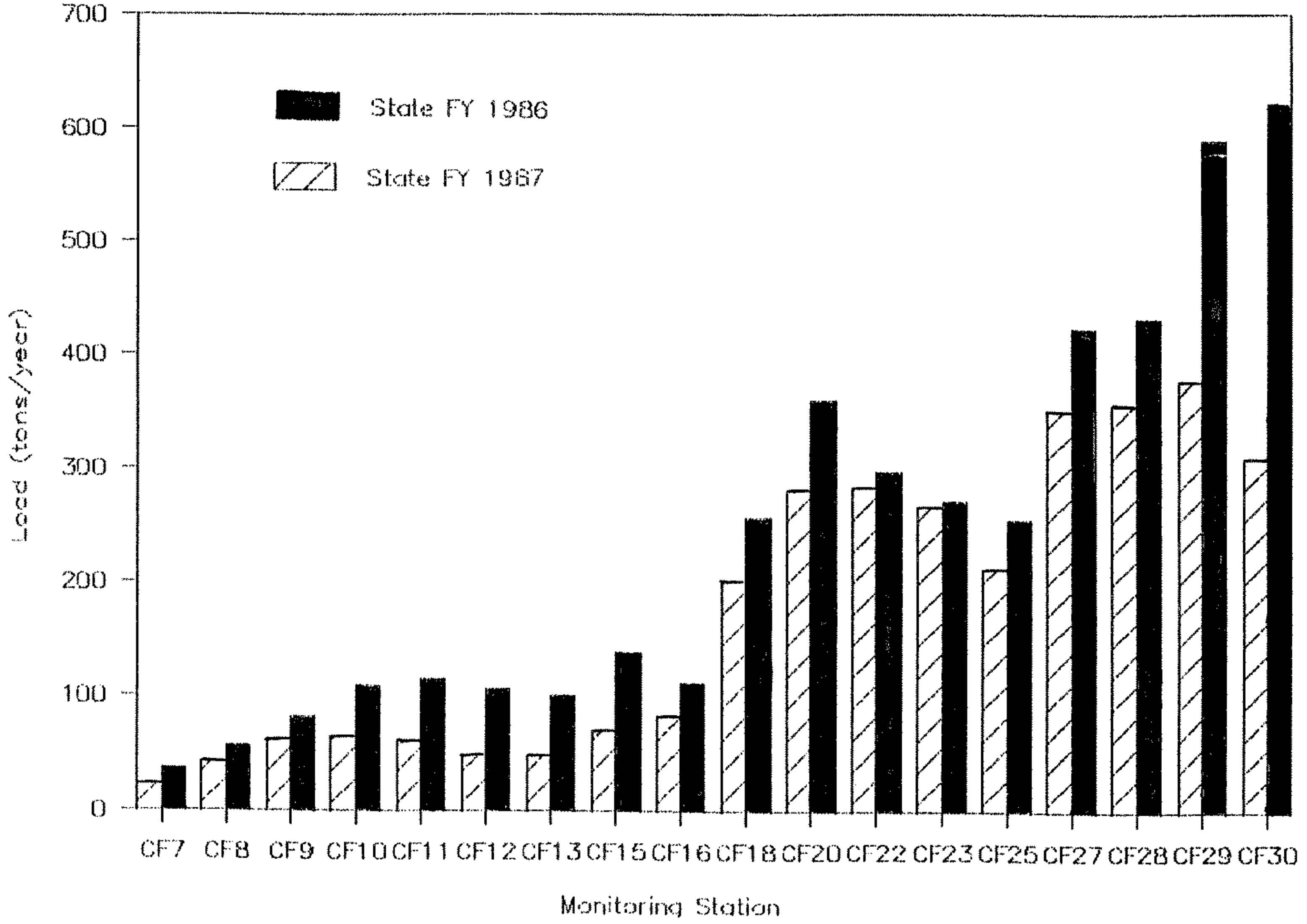


FIGURE 3-29. TOTAL INORGANIC NITROGEN LOAD IN THE CLARK FORK, DHES-WQB FY 86-87 DATA. (ESTIMATES BASED ON 14-17 SAMPLINGS/YEAR). SEE FIGURE 3-13 FOR STATION LOCATIONS.

the threshold value, but not by a large margin. The phosphorus criterion were exceeded from 60 to nearly 80 percent of the time below the Blackfoot River during the FY 85-87 monitoring period. Average concentrations ranged from 1.5 to 0.7 times the criterion. The highest frequency of exceedence of the phosphorus criterion anywhere in the mainstem Clark Fork during the FY 85-86 period consistently occurred at monitoring station 10, below the Deer Lodge sewage outfall. This area corresponds roughly to the uppermost extent of the *Cladophora* algal blooms. Rock Creek marks the downstream extent of the most serious *Cladophora* blooms. *Cladophora* is further reduced below the Blackfoot River confluence.

Nitrogen concentrations and loads showed less significant fluctuations below wastewater discharges and incoming tributaries. The EPA criterion for nitrogen was not exceeded at any time in the mainstem upper Clark Fork during the monitoring period.

Middle Clark Fork

Nutrient concentrations in the middle Clark Fork are variable as a result of dilution from incoming clean water tributaries and the influences of several major sources of nutrients. Figure 3-27 indicates a significant change in Clark Fork total phosphorus concentrations from station 16 to station 18. These monitoring locations bracket the Missoula municipal wastewater treatment plant discharge, which contributes a significant phosphorus load to the river--about 50 tons per year (Figure 3-28). The wastewater discharge contributes an even more significant nitrogen load to the river, averaging more than 100 tons per year (Figure 3-29). Exceedences of the EPA nitrogen criterion were not documented during the monitoring period in the middle Clark Fork. The frequency of exceedence of the phosphorus criterion, however, was doubled or tripled from above to below the Missoula wastewater discharge. Frequencies ranged from 8 to 18 percent in the Clark Fork above the discharge to 25 to 50 percent below for the FY 85-87 monitoring period.

The Bitterroot River joins the Clark Fork a short distance below the Missoula wastewater discharge. Its inflow is responsible for significant reductions in Clark Fork nutrient concentrations and in the frequency with which the phosphorus criterion is exceeded. On the other hand, Figure 3-29 indicates that the Bitterroot River (bracketed by stations 18 and 20) contributes a significant nitrogen load to the Clark Fork--about 75 to 85 tons per year. Some field research indicates that the lower Bitterroot River receives a considerable volume of nitrogen-rich ground water inflow from the Missoula area. The presumed source of much of this nitrogen is septic drainfield leachate (Kicklighter 1987).

The second most significant source of nutrients to the middle Clark Fork is Stone Container Corporation's Missoula kraft mill. The facility, which has been in operation since 1957, manufactures bleached pulp and unbleached kraft linerboard. The process produces about 16.5 million gallons per day (MGD) of treated wastewater that is stored in ponds and either infiltrated into the shallow ground water or discharged directly to the Clark Fork according to stringent permit limitations. Environmental Impact Statements were prepared on the facility in 1974 and 1985 (DHES 1974, 1985).

The effects of the Stone wastewater discharge on nutrient concentrations in the Clark Fork are less striking than the Missoula WWTP discharge, in part due to the additional dilution water provided by the Bitterroot River. Phosphorus and nitrogen concentrations (see Figure 3-27 for phosphorus) were marginally higher from above to below the Stone Container discharge (bracketed by stations 20 and 22), and the frequency of exceedence of the phosphorous criterion increased only slightly in FY 85-87. The nitrogen criterion was never exceeded in samples from above or below the plant in FY 85-87. Stone Container's current wastewater discharge permit specifies that it shall attempt to reduce nutrient concentrations and loading in its effluent to pre-1983 levels to meet nondegradation standards. If Stone Container is unable to meet those reductions by the end of 1991, a formal review will be conducted and the Montana Board of Health will make a final determination of appropriate loading limits for the facility. Limits will be designed to protect current and anticipated beneficial uses.

One way to accomplish this goal is to minimize nutrient additions in the wastewater treatment process, and the FY 85-87 data indicate that this approach is in fact reducing nutrient concentrations. Mean total phosphorus and total inorganic nitrogen concentrations were reduced by nearly half from FY 85 to FY 87. Reductions in nutrient loading are more difficult to assess because of the low streamflows during the monitoring period and because the mill's allowable wastewater discharge rates depend on streamflow. However, the FY 1987 estimated phosphorus and nitrogen loads from the facility were a third and a quarter, respectively, of the loads discharged in FY 85. The FY 87 phosphorus and nitrogen contributions to the Clark Fork from Stone Container are estimated to be about ten tons per year each. Clearly, the facility has made progress in its efforts to reduce nutrient discharges.

From the Stone Container mill to the Flathead River confluence, nitrogen and phosphorous concentrations decline as numerous small-to-medium-sized tributaries provide additional dilution water and as biological uptake occurs. Nitrogen and phosphorus loads remain roughly constant or decline slightly, indicating a lack of significant nutrient sources in this reach of river. The phosphorus criterion was exceeded from 13 to 36 percent of the time for the FY 85-87 period from below Stone to the Flathead River. Exceedences were less frequent with increasing distance downstream of the two point source discharges in the middle river.

Lower Clark Fork

Routinely low nutrient concentrations in the Flathead River are responsible for an average 40 to 50 percent reduction in nitrogen and phosphorus concentrations in the lower Clark Fork. Concentrations of total phosphorus (Figure 3-27) and total inorganic nitrogen gradually decline toward the Idaho border, and many measurements are at or near the analytical detection limits. Throughout the reach, the total phosphorus criterion is only infrequently exceeded (15 percent of the time in FY 86, never exceeded in FY 85 or FY 87), and the nitrogen criteria are never approached.

Figures 3-28 and 3-29 indicate that the Flathead River (bracketed by stations 25 and 27) contributes significantly to the nutrient load of the lower Clark Fork despite its inherently low nutrient concentrations. The plots also show that Noxon Rapids (bracketed by stations 28 and 29) and Cabinet Gorge (bracketed by stations 29 and 30) reservoirs act as sinks for phosphorus and reduce the Clark Fork load by approximately the amount contributed by the Flathead. The reservoirs apparently do not influence Clark Fork nitrogen loads.

Additional Monitoring Efforts

Recent monitoring programs have improved our knowledge of nutrients and algae in the basin. However, our knowledge of these issues is insufficient for regulatory decisions. Monitoring efforts must be sustained to identify long-term trends, and fundamental questions must be answered about the sources and fate of nutrients. Congress amended the Clean Water Act in 1987 to provide for a comprehensive assessment of pollution problems in the Clark Fork-Lake Pend Oreille Basin.

An interagency committee consisting of representatives from Montana, Idaho, Washington, and EPA Regions VIII and X has outlined a plan to expand studies of nutrient and eutrophication in the basin. Details of these plans are provided in Chapter 5.

NONPOINT SOURCE POLLUTION

Introduction

Nonpoint source pollution (NPS) of surface and ground water is derived from activities such as agriculture, silviculture, mining, construction, land disposal, hydromodification, and others. The sources are diffuse, and contamination usually results from overland runoff, percolation, precipitation, or atmospheric deposition rather than from a discharge at a specific, single location (EPA 1987c).

Nonpoint source pollution is the primary problem in the Clark Fork Basin, both in the tributaries and along the mainstem. The basin has a multitude of pollution sources because its economic base is rooted in agriculture, timber harvesting, mining, and hydropower production. However, because nonpoint sources of pollution are diffuse and can originate from large land areas, identifying and quantifying their effects are difficult. Effective control of NPS remains one of the most challenging issues facing resource managers in the Clark Fork Basin.

General information regarding nonpoint source pollution is provided in Table 3-18. Sediments resulting from erosion are typically the most widespread nonpoint pollutant. In many areas, agricultural practices are the most common cause of water quality problems from nonpoint sources (EPA 1985b).

Oftentimes, multiple activities in a watershed contribute the same nonpoint pollutant, resulting in cumulative effects on water bodies. Control programs are complicated by the variety of pollution sources and multiple ownership patterns that exist in a given watershed.

Best Management Practices (BMPs) are important tools in the prevention and control of nonpoint source pollution. BMPs are methods, measures, procedures, or practices used to control or reduce nonpoint source pollution. BMPs can be structural or nonstructural controls, or operations and maintenance procedures. They can be applied before, during, or after pollution producing activities. BMPs use the land in the wisest possible way, whether it be for growing crops or grazing cattle, building highways or cutting trees. BMPs are the coordinated, judicious timing of activities and use of vegetation and materials as components of a total land management system.

Categories and subcategories of nonpoint source pollution are listed in Table 3-19. A brief discussion of the major categories is followed by a summary of specific nonpoint problems and programs in the Clark Fork Basin.

TABLE 3-18. SOURCES AND EFFECTS OF NONPOINT SOURCE POLLUTANTS

Pollutant/ Cause of Impairment	Activity/Source	Potential Receptors	Effects
Sediments	agricultural practices forest practices mining construction hydromodification urban runoff	rivers, reservoirs, lakes	o Adversely affect spawning and rearing capacity for trout when deposited on stream bottoms. o Interfere with water treatment and irrigation. o Can carry nutrients, toxins, and pathogens.
Nutrients/Fertilizer	agricultural practices forest practices land disposal urban runoff mining construction hydromodification	rivers, reservoirs, lakes, ground water	o Can cause excessive nuisance algae and macrophyte growth. o Excess nitrate in drinkin water can be harmful to infants.
Toxins (primarily metals)	mining	rivers, reservoirs lakes, ground water	o Exert stress on aquatic ecosystems (can cause chronic or acute toxicity).
Pesticides	agricultural practices forest practices	rivers, reservoirs, lakes, ground water	o Can cause acute and chronic toxicity to fish and other aquatic organganisms. o Some accumulate in fish tissues; affect food chain.
Pathogens	agricultural practices land disposal marinas and boats	rivers, reservoirs, lakes, ground water	o Can be a potential source of disease.
Salinity	agricultural practices mining	rivers, reservoirs lakes, ground water	o Excess salts impair water for drinking, irrigation, stock watering, and other uses. o Saline seeps.
Acidity	mining	rivers, reservoirs, lakes, ground water	o Modifies availability of nutrients, metals, and various pollutants. o Can cause toxicity.
Physical habitat alteration	agricultural practices forest practices construction mining land disposal hydromodification	rivers, reservoirs, lakes	o Reduces available habitat for fish & wildlife. o Reduces biological production. o Can modify hydrological cycle.

TABLE 3-18 (CON'T). SOURCES AND EFFECTS OF NONPOINT SOURCE POLLUTANTS

Pollutant/ Cause of Impairment	Activity/Source	Potential Receptors	Effects
Petroleum products	marinas and boats construction, mining	reservoirs, lakes, rivers	o Cause toxicity to aquatic organisms.
Temperature	agricultural practices hydromodification	rivers, reservoirs, lakes	o Elevated stream temperatures can impair aquatic life.
Dewatering	agricultural practices	rivers	o Eliminates aquatic habitat o Causes elevated stream temperatures

TABLE 3-19. CATEGORIES AND SUBCATEGORIES OF NONPOINT SOURCE POLLUTION

Agriculture
Nonirrigated crop production
Irrigated crop production
Specialty crop production
  (e.g., truck farming and orchards)
Pasture land (grazing)
Feedlots (all types)
Aquaculture
Animal holding/management areas
Rangeland (grazing)
Streambank erosion

Silviculture

Forest management (harvesting, reforestation, residue management)
Road construction/maintenance

Construction

Highway/road/bridge
Land development
Streambank erosion

Urban Runoff

Storm sewers
Combined sewers
Surface runoff
Streambank erosion

Resource Extraction/Exploration/Development
Surface mining
Subsurface mining
Placer mining
Dredge mining
Petroleum activities
Smelting
Mill tailings
Streambank erosion

Land Disposal (runoff/leachate from permitted areas)

Sludge
Wastewater
Landfills
Industrial land treatment
On-site wastewater systems (septic tanks, etc.)
Hazardous waste

Hydromodification

Channelization
Dredging
Dam construction/operation
Flow regulation/modification
Streambank erosion
Removal of riparian vegetation
Bridge construction
Streambank modification/destabilization

Other

Atmospheric deposition
Waste storage/storage tank leaks
Highway maintenance and runoff
Spills
Natural

Source: DHES 1988b.

Agriculture

Agricultural activities can result in the addition of sediments, nutrients, pesticides, pathogens, salts, and other pollutants to natural waters. Among these activities are irrigation, poor feedlot and pasture management (overgrazing), trampling and erosion of streambanks by livestock, poor row-crop practices, improper pesticide application, alteration of streambanks and channels, and improperly designed irrigation return flows. Irrigation withdrawals can cause dewatering, which may result in elevated temperatures that adversely affect aquatic life.

Silviculture

Silvicultural practices are another important source of nonpoint pollutants to streams. Because logging activities typically occur in headwater areas, the waters that are affected are usually of very high quality. Silviculture activities that can cause nonpoint pollution include road construction, harvesting operations, use of chemicals (fertilizers, insecticides, and herbicides), removal of trees, and preparation of sites for revegetation. Sediment is the major pollutant by volume. Debris from forest operations can contribute organic matter to surface water bodies, and removal of vegetation that shades water bodies can lead to elevated water temperatures (EPA 1985b). Clear-cutting can significantly increase water yield, and a substantial increase in runoff may result in channel degradation, and increased turbidity and sediment loading.

Construction

Construction activities are not a major nonpoint source of pollution but can cause severe localized problems in some instances. Sediment is the major pollutant, and erosion rates from construction sites are generally 10 to 20 times higher than those on agricultural lands (EPA 1985b). Other potential pollutants from construction activities are nutrients from fertilizers, pesticides, petroleum products and other construction chemicals, and solid wastes.

Urban Runoff

Runoff from urban areas can cause significant water quality impacts to local surface and ground water resources. Sediments and debris are the primary pollutants, but metals, nutrients, and pathogens from animal wastes are also sometimes present. Septic tanks also contribute nutrients and pathogens to ground water (EPA 1985b).

Resource Extraction, Exploration, and Development

Nonpoint source pollution from mining activities can cause severe water quality impacts to receiving streams. The most serious NPS pollutants associated with mining are metals, acid producing materials, sediments, and radioactive materials. Many of the pollutants generated at active mines are considered to be point sources that are regulated under the MPDES and NPDES permit system. Runoff of sediment from haul roads and drainage and leachates from waste piles can be NPS problems at active mine sites. However, the mining industry in Montana is subject to water quality regulations and nonpoint problems are dealt with through monitoring and compliance. At inactive mine sites and mine waste disposal areas, drainage and leachates containing acid, metals, sediment and salts can seriously affect surface and ground water systems (EPA 1985b).

Land Disposal

Land disposal systems such as landfills, septic tanks, storage tanks, wastewater treatment areas, and hazardous waste sites can result in the release of toxins, pathogens, and nutrients to local surface and ground water systems.

Hydromodification

Sedimentation is the biggest NPS problem associated with hydromodification projects due to dredging, dam and bridge construction, flow regulation, and erosion from streambanks that are disturbed.

NPS Problems in the Clark Fork Basin

The most pervasive nonpoint source problem in the basin is sedimentation. A number of activities contribute to this problem, including intensive grazing and agriculture, silviculture, mineral exploration and development, construction activities and hydromodification. Another major problem is contamination of surface and ground water by metals derived from runoff and leachate off of floodplain mine wastes and waste disposal areas.

The severity of NPS problems varies somewhat in different parts of the basin due to diverse geology, soil types, moisture regimes, and land management practices.

Upper Clark Fork Basin

Specific nonpoint source pollution problems in the upper Clark Fork Basin are provided in Table 3-20. In this table, the upper basin includes the mainstem and tributaries to the Blackfoot River above Milltown Dam, plus the Bitterroot River. Prevailing problems in the upper basin are sediments, flow and habitat alterations, salts, pathogens and nutrients from agricultural activities; sediments, metals, acid, and habitat alteration from active and historic mines; and sediments, organics and habitat alteration from silviculture practices.

The most serious NPS problem in the headwaters and upper

TABLE 3-20. NONPOINT SOURCE POLLUTION PROBLEMS IN THE UPPER CLARK FORK BASIN.

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Bear Creek	4	Sediment	Agriculture			M	E
Beartrap Creek (below Mike Horse Adit)	0.5	Metals	Resource Extraction	Subsurface Mining Mine Tailings	Mike Horse Adit	S	M
Bitterroot River (below E. Fork)	80	Flow Alteration Sediment Temperature	Agriculture	Irrigation Streambank Erosion		M	M
Bitterroot River Alluvial Groundwater		Nutrients Bacteria	Land Disposal Agriculture	Septic Tanks/Drainfields Irrigation		T	E
Black Bear Creek (T.12N., R.13W., Sec. 22)	0.3	Sediment Habitat Alteration Bacteria	Construction Silviculture	Road Encroachment Harvesting		M	M
Blackfoot River, Anaconda Creek to Landers Fork	16	Sediment Metals Organic Enrichment	Agriculture Resource Extraction Silviculture Other	Subsurface Mining Streambank Erosion Logging Residues Natural	Mike Horse Adit Corbonate Mine 1964 Flood	M	M
Blackfoot River, Nevada Creek to Monture Creek	22	Sediment	Agriculture			M	E
Blodgett Creek	2	Sediment	Agriculture	Streambank Erosion		M	E
Braziel Creek	0.2	Sediment	Silviculture Construction	Channel Erosion Roads		M+	M

TABLE 3-20 (CON'T). NONPOINT

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Brock Creek	5	Sediment	Agriculture			M	E
Cable Creek	2	Sediment	Agriculture	Streambank Erosion		M	E
Camas Creek	1	Sediment	Agriculture	Streambank Erosion		M	E
Carpenter Creek	0.9	Sediment	Resource Extration	Dredge Mining		M	M
Chamberlain Creek	2	Flow Alteration	Agriculture	Irrigation		M	E
Clark Fork River, Warm Springs Creek to Blackfoot River	119	Metals Sediment Flow Alteration Nutrients Temperature	Resource Extraction Agriculture Hydrologic Modification	Mill Tailings Irrigation, Grazing Channelization		S	M
Cottonwood Creek	7	Sediment Flow Alteration	Agriculture	Irrigation		M	E
Cramer Creek	2	Habitat Alteration Nutrients Sediment	Agriculture Resource Extraction	Streambank Erosion Animal Wastes Mine Tailings		M	E
Dempsey Creek	10	Sediment Flow Alteration	Agriculture	Irrigation		M	E
Dog Creek	3	Sediment	Agriculture			M	E
Douglas Creek (Nevada Creek Tributary)	6	Sediment Salts	Agriculture Resource Extraction			M	E
Douglas Creek (Flint Cr. Tributary)	5	Metals	Resource Extraction			M	M

TABLE 3-20 (CON'T) NONPOINT

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Dry Cottonwood Creek	4	Sediment Flow Alteration Habitat Alteration	Agriculture			M	E
Elk Creek	12	Sediment Temperature	Resource Extraction Agriculture Silviculture	Placer Mining Grazing		S	M
Elliston Creek	2	Sediment Flow Alteration	Agriculture	Irrigation		M	E
Flat Gulch (T.7N., R.16W., Sec. 14)	3(Est.)	Sediment	Agriculture	Grazing		M	M
Flint Creek	44	Metals Sediment Flow Alteration	Resource Extraction Agriculture	Subsurface Mining Irrigation		M	M
Frazier Creek	2	Flow Alteration	Agriculture	Irrigation		M	E
Gallagher Creek	2	Flow Alteration	Agriculture	Irrigation		M	E
Gold Creek	17	Sediment Habitat Alteration Flow Alteration	Agriculture Resource Extraction	Irrigation Placer Mining	Master Mine	M	E
Granite Creek		Sediment	Silviculture	Harvesting Roads		M	E
Groundwater at the Anaconda Smelter CERCLA Site		Metals	Resource Extraction	Smelting	Anaconda Smelter		

TABLE 3-20 (CON'T) NONPOINT

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Groundwater at the Milltown CERCLA Site		Metals Arsenic	Resource Extraction	Mill Tailings	Milltown Reservoir Sediments		
Groundwater at the Montana Pole CERCLA Site -- Butte		Pentachlorophenol Petroleum	Other	Hazardous Waste Storage	Montana Pole and Treating		
Halfway Creek	3	Sediment	Agriculture			M	E
Hoover Creek	8	Sediment Flow Alteration	Agriculture			M-S	E
Hughes Creek	10	Sediment Habitat Alteration	Resource Extraction	Dredge Mining		M	E
Jefferson Creek	4	Sediment	Agriculture Resource Extraction	Placer Mining		M-S	E
Keno Creek	2(Est.)	Sediment	Silviculture Construction	Harvesting Roads		M	M
Little Blackfoot River	39	Habitat Alteration Flow Alteration Sediment Nutrients	Agriculture Hydrologic Modification	Irrigation, Grazing Riparian Removal		M	M
Lolo Creek	32	Sediment	Silviculture Other	Harvesting, Roads Highway Maintenance and Runoff		M	E
Lost Creek	7	Sediment Flow Alteration	Agriculture			M	E
Lost Horse Creek	5	Sediment	Agriculture	Streambank Erosion		M	E

TABLE 3-20 (CON'T) NONPOINT

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Marcum Creek (T.14N., R.11W., Sec. 13)	1(Est.)	Sediment Bacteria	Agriculture Silviculture	Grazing Harvesting		M	M
McElwain Creek	2	Sediment Flow Alteration Bacteria	Agriculture	Irrigation, Grazing		M	M
McManus Gulch (T.12N.,R.14W., Sec. 2)	1(Est.)	Sediment	Construction	Roads		M	M
Mill Creek	33	Sediment Metals Habitat Alteration	Resource Extraction			M	E
Mill-Willow Bypass	4	Metals Sediment	Resource Extraction	Mill Tailings		S	M
Miller Creek	4	Sediment Habitat Alteration	Silviculture			M	E
Modesty Creek	9	Sediment Flow Alteration	Agriculture			M	E
Monarch Creek	3	Metals Acid	Resource Extraction			S	E
Mulkey Creek	4(Est.)	Sediment	Agriculture Construction	Grazing Roads		M	M
Nevada Creek	37	Sediment Flow Alteration	Agriculture Silviculture	Irrigation		M	E

TABLE 3-20 (CON'T) NONPOINT

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
O'Brien Creek	9	Sediment	Silviculture			M	E
Peterson Creek	4	Sediment Flow Alteration	Agriculture	Irrigation		M	E
Poorman Creek	8	Sediment	Agriculture	Streambank Erosion Channelization		M	E
Racetrack Creek	9	Sediment Flow Alteration	Agriculture	Irrigation		M	E
Roaring Lion Creek	4	Sediment	Agriculture	Streambank Erosion		M	E
Rock Creek	2	Sediment	Agriculture			M	E
Schwartz Creek	8	Sediment Habitat Alteration	Silviculture Agriculture Construction			M	E
Scotchman Gulch (T.7N., 16W., Sec. 12)	3(Est.)	Sediment	Construction	Road		M	M
Sheep Creek	2	Sediment	Agriculture			M	E
Silver Bow Creek above Warm Springs Ponds	26	Metals Sediment	Resource Extraction	Mill Tailings		S	M
Silver Bow Creek below Warm Springs Ponds	1	Metals	Resource Extraction	Mill Tailings		M	M

TABLE 3-20 (CON'T) NONPOINT

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Silverbow Creek -- Clark Fork River Alluvial Groundwater (CERCLA Site)		Metals Arsenic	Resource Extraction	Mill Tailings			
Sixmile Creek	2	Flow Alteration	Agriculture	Irrigation		M	E
Sleeping Child Creek	11	Sediment	Silviculture			M	E
Snowshoe Creek	3	Sediment Flow Alteration	Agriculture	Irrigation		M	E
Spotted Dog Creek	3	Flow Alteration	Agriculture Silviculture	Irrigation	Clearcuts	M	E
Telegraph Creek	11	Metals Sediment Acid	Resource Extraction Silviculture	Subsurface Mining		M	E
Threemile Creek (Little Blackfoot River Drainage)	2	Flow Alteration	Agriculture	Irrigation		M	E
Threemile Creek (Bitterroot River Drainage)	4	Sediment	Agriculture			M	E
Tin Cup Joe Creek	5	Sediment Flow Alteration	Agriculture	Irrigation		M	E
Twin Lakes Creek	2	Flow Alteration	Agriculture	Irrigation		S	E

TABLE 3-20 (CON'T) NONPOINT

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Unnamed Tributary to Upper Willow Creek (T.7N.,R.15 W., Sec. 6)	2(Est.)	Sediment	Construction	Roads		M	M
Wales Creek	2	Flow Alteration	Agriculture	Irrigation		M	E
Ward Creek	3	Flow Alteration	Agriculture	Irrigation		M	E
Warm Springs Creek (near Anaconda)	15	Metals Sediment Flow Alteration Habitat Alteration	Resource Extraction Agriculture	Mill Tailings Irrigation		M	M
Warm Springs Creek (near Garrison)	2	Sediment	Agriculture			M	E
Warren Creek	2	Flow Alteration	Agriculture	Irrigation		M	E
Washington Creek	5	Sediment	Agriculture Resource Extraction	Placer Mining		M-S	E
West Fork Bitterroot River	44	Sediment	Silviculture Resource Extraction	Placer Mining		M	E
West Ashbey Creek (T.12N., R.16W., Sec. 9)	3(Est.)	Sediment	Silviculture Construction	Harvesting Roads		M	M

TABLE 3-20 (CON'T) NONPOINT

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Willow Creek (Blackfoot River Drainage)	3	Sediment	Resource Extraction			M	E
Willow Creek (Near Anaconda)	10	Sediment	Agriculture			M	E
Yourname Creek	2	Flow Alteration	Agriculture	Irrigation		M	E

SOURCE: DHES 1988b

river reach is probably erosion of heavy metals-contaminated sediments into the system. Large waste disposal areas (such as the Colorado Tailings and Ramsay Flats) and floodplain mine wastes are major sources of metals during snowmelt runoff and thunderstorms. The principal problem metals in the upper basin are arsenic, copper, cadmium, lead, and zinc.

Middle and Lower Clark Fork Basin

Specific nonpoint source pollution problems in the lower and middle portions of the basin are provided in Table 3-21. It includes the mainstem and tributaries below the confluence with the Blackfoot River, excluding the Bitterroot River. This section of the basin has some of the same NPS problems as the upper basin, except that there are fewer inactive mine waste sources. Other problems include elevated stream temperatures due to dewatering; nutrients and other pollutants from septic tanks or drainfields (in the Missoula area and possibly along the reservoirs and Lake Pend Oreille); and sediments, metals, flow alterations, and elevated temperatures from hydromodification. These effects occur during construction of hydroelectric power plants, during operational drawdown and maintenance periods, and during the course of normal flow regulation.

Current NPS Programs

A number of local, state, and federal programs have been developed to identify and control nonpoint source pollution problems in the state. These programs, many of which include the Clark Fork Basin, are listed in Table 3-22.

Most recently, a comprehensive NPS management program has been initiated by the DHES Water Quality Bureau. The framework for this program was provided by Section 319 of the Federal Clean Water Act, and it is considered the state umbrella program for NPS pollution control. This and other recent programs are discussed below.

DHES-Water Quality Bureau

The Federal Clean Water Act of 1987 established a new direction for the control of water pollution. Because nonpoint source pollution was recognized as a serious impediment to meeting the goals of the act, it was amended to include a new Section 319, entitled Nonpoint Source Management Programs. This section provides the legal basis for implementing nonpoint source programs and sets forth certain requirements that the states must meet to qualify for assistance under the act. An assessment report and a management program must be completed by a state to be considered for Section 319 grants. The assessment report is

TABLE 3-21 NONPOINT SOURCE POLLUTION PROBLEMS IN THE MIDDLE AND LOWER CLARK FORK BASIN

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Camas Creek	10	Sediment Nutrients Bacteria Temperature	Agriculture			M	E
Cedar Creek	20	Sediment Habitat Alteration	Resource Extraction	Dredge Mining		M	E
Clark Fork River, Blackfoot River to Flathead River	120	Nutrients Sediment Temperature Metals	Upstream sources plus: Land Disposal	Septic Tanks/Drainfields Industrial Wastewater	Missoula Area Stone Container	M	M
Clark Fork River, Flathead R. to Idaho State Line	95	Flow Alteration Temperature Nutrients	Upstream sources plus: Hydrologic Modification	Flow Regulation	Kerr Dam Noxon Rapids Dam	M	M
Crow Creek	16	Sediment Nutrients Temperature Bacteria	Agriculture	Irrigation Grazing/Animal Holding Areas		M	M
Fish Creek	4	Habitat Alteration	Silviculture			M	E
Fishtrap Creek	12	Sediment Habitat Alteration	Silviculture			M	E
Flathead River below Kerr Dam	72	Flow Alteration Temperature	Hydrologic Modification	Flow Regulation	Kerr Dam	M	M

TABLE 3-21 (CON'T) NONPOINT

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Grant Creek	0.25	Sediment		Streambank Erosion		M	E
Groundwater at the BN Paradise Site		Creosote	Other	Hazardous Waste Storage	BN Tie Treating Plant		
Groundwater at Stone Container		Organics Nutrients Salts	Land Disposal	Industrial Wastewater	Stone Container Kraft Paper Mill		
Hot Springs Creek	7	Sediment Nutrients Bacteria Salts	Agriculture			S	M
Issac Creek		Sediment	Agriculture	Irrigation Grazing		M	E
Kennedy Creek	5	Sediment Metals	Agriculture Resource Extraction			M	E
LaValle Creek	8	Toxics	Other	Gasoline Spill		M	E
Little Bitterroot River	35	Sediment Nutrients Bacteria Salts Flow Alteration	Agriculture	Irrigation		S	E
Little Joe Creek	14	Sediment Habitat Alteration	Silviculture Resource Extraction				

TABLE 3-21 (CON'T) NONPOINT

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Lyhch Creek	6	Sediment Nutrients	Agriculture			M	E
McCormick Creek	10	Metals	Resource Extraction			M	E
Mission Creek	18	Sediment Nutrients Temperature Bacteria	Agriculture	Irrigation Grazing/Animal Holding Areas		M	M
Missoula Valley Groundwater		Nitrates Bacteria	Land Disposal	Septic Tanks/Drainfields		T	M
Mud Creek	14	Sediment Bacteria	Agriculture			M	E
Ninemile Creek	25	Sediment	Agriculture Resource Extraction Construction	Grazing/Irrigation Streambank Erosion Placer Mining		M	E
Petty Creek	12	Sediment	Agriculture Silviculture			M	E
Post Creek	8	Sediment Nutrients Bacteria	Agriculture	Irrigation Grazing/Animial Holding Areas		M	M
Prospect Creek	10	Sediment	Construction			M	E
Quartz Creek	6	Sediment Habitat Alteration	Resource Extraction	Placer Mining		M	E

TABLE 3-21 (CON'T) NONPOINT

Waterbody	Miles of Stream, Acres of Lakes or Groundwater	Pollutant or Cause of Impairment	Source Category	Source Subcategory	Specific Source	Severity	Method
Randolph Creek	3	Habitat Alteration	Silviculture			M	E
Sabine Creek	11	Sediment Bacteria	Agriculture			M	E
St. Regis River	11	Habitat Alteration	Construction	Highway	Interstate 90	M	E
Spring Creek	5	Sediment Nutrients Bacteria	Agriculture			M	M
Sullivan Creek	11	Sediment Nutrients Bacteria Salts	Agriculture			M	E
Trout Creek	15	Habitat Alteration	Resource Extraction			M	E
West Miller Coulee	8	Sediment Bacteria	Agriculture			M	E
West Fork Thompson River	5	Sediment Habitat Alteration	Silviculture	Road Construction		M	E

SOURCE: DHES 1988b

TABLE 3-22. CURRENT NPS PROGRAMS IN MONTANA

	Administering Agencies			Program		NPS Activities
Program	Local	State	Federal	Type	Extent	
State Water Quality Management Program (Section 208, 303e, 319)	Conservation Districts	DHES-WQB DNRC-Conservation Districts Division (CDD)	BLM USFS EPA	Voluntary	Statewide	Agriculture Silviculture Construction Resource Extraction
Abandoned Mine Land Reclamation Fund		DSL	OSM	Other	Statewide	Resource Extraction
Cumulative Watershed Effects Cooperative		DSL		Voluntary	Regional	Silviculture
Hazardous and Solid Waste Management Programs and Superfund		DHES-SHWB	EPA	Regulatory	Statewide	Resource Extraction Land Disposal Storage Tanks Hazardous Waste Storage
HJR 49 Forest Management and Watershed Effects Study		EQC			Statewide	Silviculture
OSM Active Mining Regulatory Responsibilities		DSL	OSM	Regulatory	Statewide	Resource Extraction
Watershed Protection and Flood Prevention Program-SCS (PL566)			SCS	Incentive	Statewide	
Natural Streambed Land Preservation Act Permits (310)	Conservation Districts	DNRC DFWP		Regulatory	Statewide	Hydromodification
Stream Protection Act Permits		DFWP		Regulatory	Statewide	Hydromodification

TABLE 3-22 (CON'T). CURRENT NPS PROGRAMS IN MONTANA

	Administering Agencies			Program		NPS Activities
Program	Local	State	Federal	Type	Extent	
BLM's Land Management Responsibilities-Interior			BLM	Regulatory	Statewide	Agriculture Silviculture Construction Resource Extraction
USFS Forestry Land Management			USFS	Regulatory	Statewide	Silviculture Resource Extraction
BOR Activities Interior			BOR	Other	Statewide	Hydromodification
Cooperative Extension Service Activities			USDA	Voluntary	Statewide	Agriculture Silviculture
Agricultural Conservation Program			ASCS	Incentive	Statewide	Agriculture
Pesticide Application Licensing Program		MDA	EPA	Regulatory	Statewide	Agriculture
US Fish and Wildlife Service Programs			USFWS	Other	Local	Habitat Management
State Certification pursuant to Section 401 of Clean Water Act		WQB	Corps USFS	Regulatory	Statewide	Hydromodification Agriculture Silviculture Resource Extraction
Renewable Resource Development Funds and Water Development Program Funds		DNRC		Incentive	Statewide	Agriculture Silviculture Resource Extraction
233 Program for funding conservation projects through Conservation Districts	Conservation Districts	DNRC-CDD		Incentive	Statewide	Agriculture Silviculture

Source: DHES 1986.

intended to be an analysis of nonpoint source water quality problems. The management program sets forth a process for correcting these problems. For the state of Montana, these two items will be produced separately but will be considered together as the basis for nonpoint source decision-making.

The state assessment report must include the following:

- Identification of navigable waters that require additional action to control NPS so that water quality standards and the mandates of the act can be met
- Identification of categories, subcategories, or specific nonpoint sources that contribute significant pollution to those navigable waters
- Description of the process for identifying best management practices and measures to control NPS and to reduce pollution levels
- Identification and description of state and local programs for controlling NPS pollution.

The state management program must specify the BMPs and measures that will be used to reduce pollution and describe the programs that will be utilized to implement those BMPs. The management program must also provide an implementation schedule, certification by the state attorney general, and a discussion of available funding.

The assessment and management programs for the state of Montana must be submitted to EPA by August 4, 1988.

Silviculture Programs and Activities

Environmental Quality Council. House Joint Resolution 49, enacted by the 1987 Montana Legislature, directed the Environmental Quality Council (EQC) to conduct an interim study on the relationship between forest management and watershed effects in Montana. Specific objectives of the study are to evaluate:

- How current forest management practices affect Montana watersheds
- The range of management practices that both conserve watersheds and maintain the economic viability of forestry operations

- The existing administrative framework (regulatory and voluntary)
- Actions that would achieve both watershed and timber goals if determined that such actions are needed.

The EQC has established a Best Management Practices Technical Committee and a Watershed Effects Working Group to assist them in this effort. The Best Management Practices Technical Committee is responsible for developing a set of forest management practices that will conserve watershed values during the process of accessing, harvesting and regenerating timber. Committee members have reviewed forestry BMPs used in Montana and other states, and are developing a set of BMPs that can be readily understood by Montana landowners and timber operators. A new draft version was issued in July 1988. Management practices for riparian zones, the final topic on the committee's agenda, will be addressed in early fall 1988.

The Watershed Effects Working Group has developed a written questionnaire that seeks to identify areas in Montana where forest practices have caused watershed damage and areas where logging has been conducted in environmentally sensitive sites without affecting watershed values. This questionnaire was mailed to about 1,000 foresters, water quality specialists, biologists, and other professionals involved in forest/watershed management in Montana. This group is also coordinating a series of on-site audits of forest management practices on private industrial, private nonindustrial, state, and federal lands. The audits will be conducted by teams of four or five specialists who will visit a total of 30 to 40 randomly selected timber sales, some of which will be in the Clark Fork Basin. Team members will evaluate whether best management practices were used and how effective these practices proved in preventing soil erosion into adjacent streams. Evaluation of BMPs has been used successfully by a number of other states to indicate the degree of compliance by operators and to determine where to focus limited state resources to avoid watershed damage. Both the questionnaire return and the on-site audits should be completed by the end of August 1988. Results will be tabulated during September and discussed by the committee at a fall 1988 meeting. The Watershed Effects Working Group is also scheduled to consider cumulative watershed effects of forest practices at this meeting. The committee will focus on the work of the Cumulative Watershed Effects Cooperative, a voluntary state-private-federal group that is developing a method to assess and respond to potential cumulative effects in multiple ownership watersheds. A study report and recommendations from EQC's study will be submitted to the 1989 Legislature.

Cumulative Watershed Effects Cooperative. The Cumulative Watershed Effects Cooperative was formed in 1986 under the direction of the Montana Department of State Lands, Division of Forestry. The cooperative is composed of the major landowners involved in forest management in the Lower Clark Fork and Flathead Basins, including U.S. Forest Service (Region 1, Lolo, Flathead, and Kootenai national forests), Bureau of Land Management (Garnet District), Bureau of Indian Affairs (Flathead Indian Reservation), Champion International, Plum Creek Timber, Department of State Lands, and the Conservation District Division (DNRC) as well as the Water Quality Bureau (DHES).

In April 1987, the members of the cooperative signed a memorandum of understanding (MOU) adopting a set of minimum best management practices on their lands. In November 1987, the Montana Association of Conservation Districts also approved the MOU's Best Management Practices. The Conservation Districts are responsible for implementing the Natural Streambed and Land Preservation Act of 1975 (310 Law). More recently, members of the cooperative have been developing a three-step process to identify, verify, and respond to cumulative watershed effects.

Clark Fork Coalition. In 1987, the National Wildlife Federation and the Clark Fork Coalition began working on strategies to control nonpoint sources of pollution on forest lands in Montana. A paper published by the Coalition in October, 1987 (Knudson 1987) reviewed nonpoint water quality problems associated with forest practices, discussed the value of clean water and recreational resources, and suggested possible management strategies. Volume II of the report was released in draft form in March 1988 (Knudson 1988). This report includes suggested best management practices and a set of water quality conservation regulations to guide these forestry practices that can adversely affect water quality. These draft standards have been submitted to EQC for use in their NPS work on forest practices. The Coalition is also considering submitting some form of these standards in a rule-making petition to the Montana Board of Health and Environmental Sciences.

Agriculture programs

Conservation Districts. Conservation districts are legal subdivisions of state government responsible under statute for soil and water conservation activities within their boundaries. They develop and carry out long-range programs that result in the conservation and improvement of our soil and water resources, provide assistance in the planning and application of conservation measures, and encourage maximum participation of the general public and all local public and private agencies to fulfill this purpose. Although the districts deal with a variety of NPS problems, their efforts have been primarily directed at those related to agriculture.

Conservation districts are the designated local management agency for nonpoint source pollution control programs in Montana, and they have been involved in water quality improvement programs for many years. Districts will again play a vital role in the state NPS program proposed under Section 319. They will provide guidance and assistance in the implementation of selected BMPs by district cooperators, sponsor projects on selected watersheds, and cooperate in a water quality education program. Several districts have independently expressed interest in developing local NPS control programs on selected streams or watersheds within their boundaries, in addition to the initial activities proposed under the Section 319 programs.

Resource Extraction Programs

EPA-Superfund. The Superfund law requires EPA to identify, investigate, and clean up uncontrolled hazardous waste sites not regulated under other programs. There are nonpoint source problems at many of the Superfund sites in the Clark Fork Basin, which were discussed earlier in this chapter. Effective management of these sites by EPA and the DHES Solid and Hazardous Waste Bureau is crucial to controlling NPS pollution in the upper basin and in improving water quality in the Clark Fork.

State Agencies. Montana's mining laws and regulations are administered by a variety of agencies led by the Department of State Lands. The DSL Reclamation Division is comprised of the Coal and Uranium Bureau, Hard Rock Bureau, Open Cut Bureau and Abandoned Mine Lands Bureau. The DHES-WQB administers the Water Quality Act that includes the Montana Pollutant Discharge Elimination System permit program addressing surface and ground water quality and maintenance of water quality standards. The DNRC administers the Water Use Act dealing with water rights.

Abandoned Mine Lands Reclamation. This program expends funds received from the federal Office of Surface Mining (OSM) for reclamation of lands disturbed by the mining of coal, uranium, hard rock minerals, and open cut minerals. The program is crucial to the control of NPS pollution associated with historical mining in the basin (at sites other than those designated under Superfund law).

GROUND WATER QUALITY

Introduction

Ground water is used extensively in the Clark Fork Basin, primarily for domestic purposes, irrigation, livestock, and industry. It also supplies base flow to the Clark Fork and its tributaries. Although the ground water resource has not been studied as intensively as the surface water system, a fair amount of ground water data exists for portions of the basin. The headwaters, Deer Lodge Valley, and Milltown-Missoula areas have been characterized in some detail. However, very little if any work has been done to describe the ground water system between Garrison and Milltown and in the basin below Missoula. This section of the report describes ground water quality in the Clark Fork Basin. The discussion focuses primarily on recent investigations (1983 or later), although it addresses historical studies briefly.

Historical Ground Water Quality Studies

The earliest investigator to describe the ground water resources of the Butte area was probably Meinzer (1914), who studied the alluvial aquifer in the Blacktail Creek Valley. Botz (1969) also examined ground water quality and hydraulic characteristics in the Blacktail Creek alluvium, which is the principal aquifer in the upper Silver Bow Creek Basin. Botz described the aquifer as relatively thick with a large quantity of water stored in the interlayered fine gravels, sand, and silty and clayey sand. He reported that ground water quality was generally good except along Silver Bow Creek, where the flow of poor quality surface water to the ground water system resulted in degradation of the aquifer.

A number of studies were also conducted to evaluate the ground water system near the Berkeley Pit and AMC's former Butte operations, including: Stout (1961), Botz and Knudson (1970), and Hydrometrics (1980).

Konizeski et al. (1968) conducted an in-depth study of the geology and ground water resources of the Deer Lodge Valley, from the headwaters to Garrison. However, the study was primarily a physical characterization of the valley rather than an assessment of ground water quality. Some of these findings were discussed briefly in Chapter 1.

Boettcher and Gosling (1977) described the water resources of the Clark Fork Basin upstream from St. Regis. Their report included general information on the quality (common constituents) and availability of ground water, surface water-ground water interrelationships, and ground water use. The authors noted degraded water quality in the valley fill aquifer in the southern Deer Lodge Valley, but in most areas water from the Quaternary valley fill was of excellent quality. Water derived from Tertiary age sedimentary rocks was excellent to good, with localized areas of high total dissolved solids. They also indicated that water use in the basin was low in comparison to the size of the area and the amount of water available. With proper management, the authors said, the aquifers could be developed to ten times their use in 1975 without severely affecting the water resource regimen in the area.

McMurtrey et al. (1965) studied the geology and ground water resources of the 180 mi^2 Missoula Basin, including the Missoula Valley from Missoula to Huson and the Ninemile Valley. They reported that the ground water was generally of good quality and suitable for most domestic, irrigation, and industrial uses. The Quaternary deposits were the most important aquifer in the Missoula Basin, and large yields could be expected from wells in the floodplain of the Clark Fork and the low terrace bordering the floodplain. An estimated 30 million acre-feet of water is stored in the Tertiary and Quaternary sediments, of which about 8 million acre-feet is available to wells.

Geldon (1979) also studied the Missoula Basin. He identified three types of geologic units that furnish water to wells, with the Quaternary-Tertiary alluvium supplying the largest yield from unconfined sand and gravel layers. Geldon also described the ground water in all units to be generally of good quality. He predicted that continuing reliance on ground water to supply an expanding population and agricultural base would likely lower the water table in some areas, causing some shallow wells to go dry.

Juday and Keller (1978) conducted a study of the ground water serving the Missoula Valley in 1978. Several hundred wells were sampled in this study, and only three of these had nitrate levels that approached or exceeded the federal drinking water standard of 10 ppm. Coliform bacteria was a problem in about 25 percent of the wells sampled. However, the authors concluded that overall the ground water supply serving the Missoula Valley was of high quality. Data generated in their study is considered baseline water quality data for the area (Missoula City-County Health Department 1987).

Current Ground Water Quality

The Clark Fork Basin contains a number of contaminant sources that degrade or have the potential to degrade the ground water system. Many of these sources, including tailings ponds, floodplain tailings, reservoir sediments, pole treatment facilities, and wastewater treatment plants, were described earlier in this chapter.

Solid waste sites in the basin are another source of a variety of pollutants that may cause localized ground or surface water problems. Solid waste sites in the basin licensed by the DHES Solid and Hazardous Waste Bureau are listed in Table 3-23. Some of these landfills are thought to be causing contamination of both ground water and surface water. The effects of others are unknown.

Several industries in the basin are permitted by the DHES Water Quality Bureau under the Montana Ground Water Pollution Control System (MGWPCS) program. These are listed in Table 3-24.

The following sections present the results of several recent investigations that describe the physical and chemical characteristics of ground water in the Clark Fork Basin. These studies include:

Summit and Deer Lodge Valley studies (Hydrometrics 1983a)
Sludge injection site study (Duaime and Moore 1985)
Hydrogeology of the Colorado Tailings (Duaime et al. 1987)
Phase I Silver Bow Creek RI studies (MultiTech 1987-a,b,d)
Stage I studies for Anaconda Smelter RI (Tetra Tech 1986b)
Remedial action study for Milltown Reservoir (Woessner et al. 1984)
Sole source aquifer petition, Missoula Valley Aquifer (Missoula City-County Health Department 1987)

Several studies are also on-going, including Butte mine flooding monitoring, phase II Silver Bow Creek RI investigations, and a USGS study of the shallow aquifers in the upper basin.

Upper Silver Bow Creek Area

The upper Silver Bow Creek area has received a tremendous amount of attention in the last five years, and a fairly large ground water database has now been established. These data are discussed below.

Although the series of reports by Hydrometrics (1983a) dealt primarily with rehabilitation options in the headwaters, it generated or discussed some ground water data as

TABLE 3-23. LICENSED SOLID WASTE SITES IN THE CLARK FORK BASIN

Drainage	Effect	Solid Waste Facility
Clark Fork		Heron Class II Landfill
		Trout Creek Class II Landfill
	unk	Thompson Falls Class II Landfill
	*	Plains Class II Landfill
	unk	Felstet-Superior Class II Landfill
	**	BFI Missoula Class II Landfill
	*	Eko-Compost Class II Compost Site
		City of Missoula Class III Landfill
		Norm Close Class III Landfill
		Washington Construction Class III Landfill
		William Wheeler Class III Landfill
	**	Frank Bauer Class III Landfill
		Powell County/Deer Lodge Class II Landfill
	*	Butte-Silver Bow Class II Landfill
Blackfoot/Clark Fork	**	Lincoln Class II Landfill
Little Bitterroot/Flathead		Hot Springs Class II Landfill
Warm Springs Creek/Clark Fork	*	Anaconda/Deer Lodge Class II Landfill
Flint Creek/Clark Fork		Philipsburg Class II Landfill
		Charles Parke Class II Landfill
Clearwater/Blackfoot/Clark Fork		K. G. Drew Class II Landfill
Bitterroot/Clark Fork	*	Sula Class II Landfill
	**	Darby Class II Landfill
	**	Bitterroot Valley Class II Landfill
Flathead River/Flathead Lake	unk	Polson Class II Landfill
	unk	William Ingram Class III Landfill
	unk	Plum Creek Timber Class III (Pablo)
	unk	Plum Creek Timber Class III (Columbia Falls)

unk unknown

* Indicates sites highly suspected of contributing to contamination of adjacent surface water resources, either through surface runoff or through direct ground water connection.

** Indicates sites that are suspected of contributing to ground water contamination to some degree. Might be indirect source of surface water contamination.

Source: DHES 1988c.

TABLE 3-24. ACTIVE MGWPCS PERMITS IN DEER LODGE, GRANITE, MINERAL, MISSOULA, POWELL, AND SILVER BOW COUNTIES AS OF 2-18-88

Permittee	County	Date Issued	Date Expires
CSC Mining Company P. O. Box 1086 Wallace, Id 83873	Granite	03-11-85	01-31-92
Contact Mining Company, Inc. P. O. Box 337 Philipsburg, MT 59858	Granite	10-19-83	12-31-90
MCM Development Corp. 120 West Park Street Butte, MT 59701	Granite	08-14-87	07-31-92

Source: DHES 1988a.

well. Hydrometrics reported degraded ground water quality in the following areas:

- the alluvium east of the Berkeley Pit and west of the South Dump
- near the Clark Tailings and City-County Landfill
- along Silver Bow Creek from Texas Avenue to the downstream end of the Colorado Tailings
- near the Ramsay Flats and other floodplain areas
- beneath and peripheral to the Opportunity Ponds.

Phase I of the Silver Bow Creek Superfund hydrogeologic investigations were conducted from January to July 1985 to determine general contamination sources, evaluate the extent and severity of ground water contamination, and examine ground water-surface water relationships. As a result of Phase I studies, specific geographic areas were selected for a more detailed Phase II study, conducted from December 1985 to January 1986.

Ground water contamination sources identified during the Superfund investigations of Silver Bow Creek are summarized in Table 3-25. Contaminants are likely entering the surface and ground water via several mechanisms, including: infiltration of water through tailings, upward movement of metallic salts to the surface via capillary action and entrainment by surface runoff, and direct erosion and entrainment of streamside tailings (MultiTech 1987a).

MultiTech (1987a) concluded that ground water in the Silver Bow Creek study area is a severely degraded resource that may pose hazards to human health, aquatic life, and the environment. Present and future use of the ground water resource in upper Silver Bow Creek would be limited.

Samples from several monitoring wells in the study area exceeded federal drinking water standards for a number of metals and other trace elements. Several domestic wells showed exceedences of secondary drinking water standards.

<u>Butte Mine Flooding</u>. When the Anaconda Minerals Company ceased operations in Butte in 1982 and stopped pumping water out of the Kelley Shaft, the water level in the shafts rose to the level of the Berkeley Pit bottom within one year. The water level in the pit is now rising at a rate of about 72 feet per year. Water levels have also risen in various mine workings in the Butte area. Water samples from the Berkeley Pit and the Kelley Shaft have been collected by the MBMG and CDM. Laboratory analyses for selected parameters are provided in Table 3-26. Values for arsenic, cadmium, copper, and zinc are very high, and there is concern that con-

TABLE 3-25. SUMMARY OF POTENTIAL GROUND WATER CONTAMINATION SOURCES FOUND DURING THE SBC RI

Potential Source	Type	RI Findings
Upper MSD (Parrot)	Buried Tailings	Subsurface material has extreme levels of metals. Ground water in, beneath, and downgradient from tailings is degraded.
Weed Concentrator	Discharge of Process Waters	Not evaluated, but a potential source, and may have amplified problems from buried tailings in Metro Storm Drain (MSD) area.
WWTP Vicinity (Butte Reduction Works)	Buried Tailings	No site-specific tailings analysis. Ground water beneath and downgradient is severely degraded.
Colorado Tailings	Surface Tailings	Tailings have elevated metals and contaminated soils and ground water beneath (MBMG data). Metals concentrations in ground water increase to the northwest.
Anaconda Pole Treatment	Surface Soil Contamination	Surface soils have extreme levels of arsenic. Ground water was not characterized.
Ramsay Flats	Surface Tailings	Tailings contain up to 60 times background metals. Surface efflorescence contains extreme concentrations of metals (up to 15 percent). Underlying shallow ground water is degraded but, due to low gradients and transmissivity, does not move away from the site significantly.
Fluvial Tailings along SBC and CFR	Surface Tailings	Tailings have elevated metals. Ground water may be locally affected but no significant contamination was found.

Source: MultiTech 1987a.

TABLE 3-26. CHEMICAL ANALYSES FOR SELECTED PARAMETERS, BERKELEY PIT AND KELLEY SHAFT SAMPLES.

Sample Location	Sampler	Date	Approximate Depth Below Surface (ft)	Total Concentration (ug/l)				
				As	Cd	Cu	Pb	Zn
Berkeley Pit	MBMG	11-21-84	1.0	54	1,230	89,600	170	196,000
Berkeley Pit	MBMG	11-21-84	62.0	197	1,540	164,000	160	255,000
Berkeley Pit	MBMG	06-18-85	1.0	21	1,000	63,000	---	134,000
Berkeley Pit	MBMG	06-18-85	100.0	426	1,620	229,000	---	329,000
Berkeley Pit	MBMG	10-17-86	0.5	16	1,000	114,000	---	178,000
Berkeley Pit	MBMG	10-17-86	110.0	33	1,620	196,000	---	375,000
Berkeley Pit	MBMG	10-17-86	220.0	41	1,740	204,000	---	460,000
Berkeley Pit	MBMG	10-17-86	330.0	50	1,800	214,000	---	472,000
Berkeley Pit	MBMG	10-17-86	390.0	123	1,690	213,000	---	477,000
Berkeley Pit	CDM	10-16-87	0.0	10	1,040	135,000	134	208,000
Berkeley Pit	CDM	10-16-87	3.0	10	1,060	138,000	130	215,000
Berkeley Pit	CDM	10-16-87	10.0	49	1,310	159,000	134	276,000
Berkeley Pit	CDM	10-16-87	49.0	58	1,740	214,000	187	392,000
Berkeley Pit	CDM	10-16-87	102.0	699	1,880	218,000	646	496,000
Berkeley Pit	CDM	10-16-87	216.0	1,290	1,850	213,000	343	500,000
Berkeley Pit	CDM	10-16-87	328.0	1,200	1,900	214,000	663	503,000
Berkeley Pit	CDM	10-16-87	426.0	1,380	1,860	209,000	576	505,000
Kelley Shaft	MBMG	05-30-85	1235.0	1,210	490	10,600	---	457,000
Kelley Shaft	MBMG	05-30-85	1475.0	1,870	830	10,900	---	596,000
Kelley Shaft	MBMG	05-30-85	1788.0	16,580	1,280	6,200	---	1,590,000
Kelley Shaft	MBMG	05-30-85	2200.0	16,130	1,170	6,480	---	1,550,000
Kelley Shaft	MBMG	10-30-86	1090.0	3,390	<2	700	---	232,000
Kelley Shaft	MBMG	10-30-86	1400.0	3,590	<2	540	---	234,000
Kelley Shaft	MBMG	10-30-86	2200.0	7,000	12	1,670	---	510,000

Sources: Sonderegger et al. 1987.
CDM 1988a.

taminated water from the pit and mine workings may eventually discharge to the alluvial aquifer and further impair an already degraded ground water system. Because of strong hydrologic connection between the ground water and surface water in some areas, Silver Bow Creek and ultimately the Clark Fork could also be adversely affected. If the pit or shaft water were to intrude into the alluvium, there could be multiple violations of federal and state water standards.

Although EPA has conducted preliminary studies to address the mine flooding issue (Camp, Dresser and McKee 1987, 1988a,b), additional work is on-going to refine predictions and to develop strategies to deal with potential problems.

Colorado Tailings Area. Studies of the Colorado Tailings area have documented degraded ground water quality in the vicinity of the tailings. Duaime et al. (1987) reported that water quality generally deteriorates from south to north and from east to west in the tailings area and that ground water quality within the tailings is worse than that outside the deposit. The wells closest to Silver Bow Creek had the worst water quality. Ground water flows from southeast to northwest through the tailings and then discharges into Silver Bow Creek.

Several researchers (Rouse 1977; Beuerman and Gleason 1978; Botz and Karp 1979; Peckham 1979; Hydrometrics 1983a; Duaime et al. 1987) have documented the effects of degraded ground water quality in the Colorado Tailings area on Silver Bow Creek surface water quality. Although all of these studies reported worse water quality in Silver Bow Creek below the tailings than above, there was disagreement on the percentage of metals load actually contributed by the tailings. It is clear, however, that the Colorado Tailings are a source of metal contamination to both ground and surface water and some remedial action will be required.

Metro Sewer Sludge Injection Site. The Butte-Silver Bow Metro Sewer Sewage Treatment Plant pipes sludge from its plant in Butte to storage lagoons at the injection site seven miles west of Butte at Silver Bow, Montana. The site covers 80 acres and is directly east of the Stauffer Chemical Company phosphate plant. Since 1980, sludge that averages 2-3 percent solids has been injected from late spring to late October. The estimated life of the operation is 20 years (Duaime and Moore 1985).

A total of eight monitoring wells were installed at the site in 1982 and 1983 by the Montana Bureau of Mines and Geology. Twenty-one of the 23 samples collected between 1982 and 1984 from these wells, plus an existing site well, met established primary or secondary drinking water standards. The lead limit was exceeded in two preliminary samples, but subsequent samples from those wells were below detection limits. Water quality was generally consistent and similar among the wells, although some had higher chloride and TDS values than others.

Duaime and Moore (1985) concluded that there was no significant degradation of local ground water from the sewage sludge injection site, but suggested that monitoring be continued on a yearly basis.

Warm Springs and Opportunity Ponds

Superfund investigations have documented degraded ground water in the vicinity of the Warm Springs Ponds and the Opportunity Ponds (MultiTech 1987d; Tetra Tech 1986b).

Ground water downgradient of the ponds systems is contaminated, frequently exceeding federal drinking water standards for arsenic, fluoride, iron, and sulfate. This contaminant plume extends at least one-half mile downstream of the Warm Springs Ponds. However, no domestic wells are in the vicinity of the contaminated ground water, therefore, there is no apparent or immediate threat to public health. No measurable effects of contaminated ground water inflow to the Clark Fork were found during the RI study periods. Ground water from both the Opportunity Ponds and the Warm Springs Ponds areas were the main sources of contaminant inflow to the Mill-Willow Bypass (MultiTech 1987a).

Warms Springs Ponds. Extensive phase II Superfund work for the Warm Springs Ponds system is now underway by CH_2M Hill. One of the objectives is to thoroughly evaluate ground water contamination around the ponds. The feasibility study for the ponds is expected to be complete near the end of 1988. A number of corrective or control options for the ponds will likely be considered, including site abandonment (and possibly construction of a new treatment facility), structural modifications, and others.

Opportunity Ponds. A plume of ground water enriched in sulfate exits the Opportunity Ponds area to the northeast. Highest concentrations of trace elements measured by Tetra Tech (1986b) were 24 ppb arsenic, 37 ppb copper, and 166 ppb zinc. At present, a ground water mound exists over a large portion of the tailings ponds, and the water table is above the base of the tailings in over 70 percent of the area. However, it is estimated that ground water levels will approach equilibrium in approximately 30 years, and the steady-state water table should be about 15 feet below the base of the tailings in the center of the pond system. As the ponds have been drying out, an oxidizing front has been moving very slowly down through the tailings. Geochemical modeling of the pond system has predicted that the oxidizing zone will reach the bottom of the tailings ponds in 10,000 to 20,000 years. This oxidizing zone could serve as a source of solutes to ground water for a long time. However, if there is a sufficient thickness of unsaturated, calcareous alluvium beneath the tailings to neutralize the acidity they release, most of the metals would likely be attenuated rapidly. The model predicted that worst-case future ground water concentrations (thousands of years from now) at a distance of 1,000 meters downgradient of the ponds are expected to be 3 ppb cadmium, 34 ppb copper, <1 ppb lead, 4 ppb zinc, and 80 ppb arsenic. Although sufficient data were not available to accurately predict the effect of tailings leachate on the Clark Fork, a preliminary analysis indicated that future low-flow solute concentrations in the Clark Fork might be:

Arsenic	16-20 ppb
Cadmium	<1-1 ppb
Copper	24-61 ppb
Lead	<2 ppb
Zinc	32-33 ppb
Sulfate	230-330 ppm

These concentrations are only slightly higher than existing concentrations in the Clark Fork below the Warm Springs Ponds (Tetra Tech 1986b).

Floodplain Mining Wastes

As discussed earlier in this chapter, mining wastes are deposited in the channels and floodplains of Silver Bow Creek, Warm Springs Creek, the Mill-Willow Bypass, and the Clark Fork. These materials are found in large quantities for over 100 miles and have significant potential to contaminate the ground water resource. Sulfide oxidation of these wastes may release soluble metals into the ground water, and preliminary modeling indicates the possibility that the deposits could contribute significant amounts of trace metals to local ground water during a wet season.

Warm Springs to Milltown Data

In 1987, the USGS initiated a study of the shallow aquifers along the Clark Fork between Warm Springs and Milltown, Montana. The project was designed to assess the physical and chemical characteristics of ground water, seasonal changes in the systems, and ground water-surface water interrelationships.

Fifty-six samples were collected from 50 wells (Figure 3-30) completed in a variety of geologic formations. The dominant ions in the ground water sampled were calcium and bicarbonate. Twenty-seven of the samples from 21 of the wells contained at least one constituent or characteristic in concentrations that equalled or exceeded either the primary or secondary drinking-water standards established by the EPA (1986a,b). Constituent concentrations that exceeded these standards include sulfate, dissolved solids, iron, manganese, and nitrate. One well had a pH value outside the acceptable range. Exceedences for iron and manganese were most common in water from wells less than 50 feet deep, and exceedences for sulfate and dissolved solids were most common in water from wells more than 50 feet deep. Most of the wells sampled are located near the mainstem Clark Fork. Therefore, the general water chemistry derived in this study may not be representative of the Clark Fork Valley as a whole.

Clark Fork streamflow was measured at 16 sites from Warm Springs to Turah in October 1986. No significant losses in streamflow were measured throughout the reach. However, gains in streamflow, presumably from ground water inflow, were measured from Racetrack to Deer Lodge.

A final report on this study will be published in 1989.

Milltown Area

The principal ground water system in the vicinity of the Milltown Reservoir is the unconfined valley fill alluvial aquifer, composed of well-sorted sand, gravel, and boulders. The aquifer thickens from about 40 feet near the reservoir to over 100 feet north of Milltown. Ground water flow direction is generally parallel to the Blackfoot River and the Clark Fork. Recharge to the system is derived from the Clark Fork and Blackfoot River just above the reservoir and from the reservoir itself. Discharge is to the Clark Fork below the dam (Woessner et al. 1984).

Woessner et al. (1984) conducted a study of the ground water in the Milltown area to identify the source of arsenic contaminating wells in Milltown (discussed earlier in this chapter) and to locate a new water supply. Many of the existing wells sampled before this project was started (August-September 1983) were contaminated with arsenic, iron, and manganese, and nearly all other constituent concentrations exceeded background levels. Samples collected in November and December 1983 from project monitoring wells, sand point wells in the reservoir sediments, and selected existing wells showed high levels of arsenic, iron, manganese, and TDS at a number of sites. The highest concentrations occurred in the southern Milltown area and in the

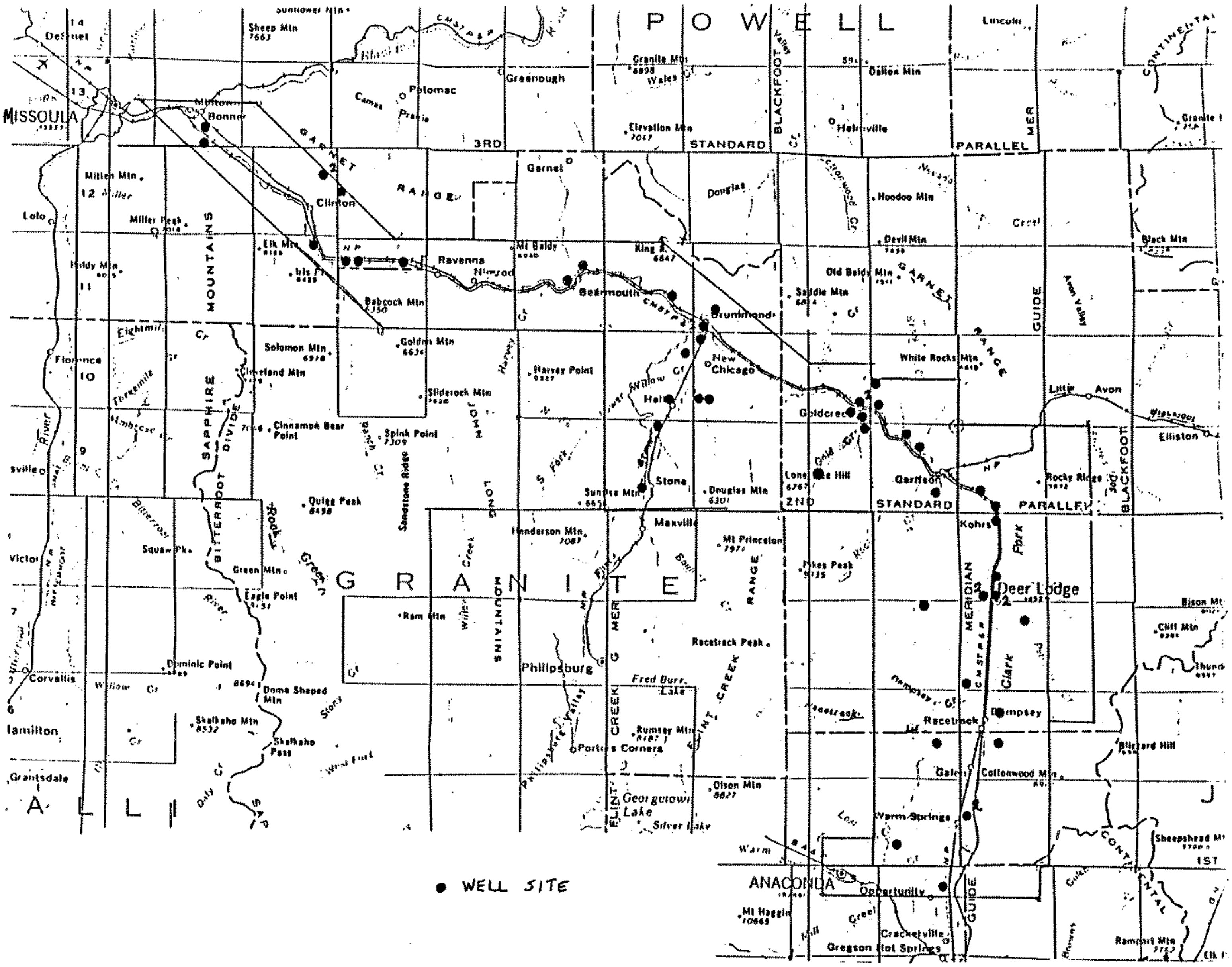


FIGURE 3-30. USGS GROUND WATER STUDY -- WELL SITES IN THE UPPER CLARK FORK WHERE WATER CHEMISTRY WAS SAMPLED. SOURCE: USGS UNPUBLISHED DATA.

reservoir sediment ground water. The lowest concentrations were found in the northern portion of the study area, reflecting high-quality recharge water from the Blackfoot River (Woessner at al. 1984).

The authors concluded that the distribution of metals in the ground water and ground water flow patterns proved that reservoir sediments were a likely source of contaminants to the alluvial ground water system. The sediments contain very high concentrations of heavy metals that are extremely enriched above natural levels and rival many severely contaminated sediment systems. Because the reservoir contains approximately 3.4 million cubic meters of sediment, it represents a huge source of metals to the surface and ground water systems (Woessner et al. 1984).

In January 1987, the Montana Power Company installed three monitoring wells within ten feet of each other on the containment side of Milltown Dam. The wells were completed in three different lithologic units at depths of 45, 30, and 15 feet. The wells were sampled in February and March of 1987. Results of these water analyses are summarized below in Table 3-27.

TABLE 3-27. RESULTS OF MPC SAMPLING OF MONITORING WELLS AT MILLTOWN DAM (FEB. - MARCH 1987)[a]

		Well	
Total Recoverable Metals	15A (45') (ppb)	15B (30') (ppb)	15C(15') (ppb)
Arsenic	<5 to 22	<5 to 58	42 to 102
Cadmium	<1 to 4	<1 to 1	<1 to 7
Copper	<10 to 210	<10 to 70	<10 to 180
Lead	<10 to 150	<10 to 40	<10 to 80
Zinc	10 to 600	<10 to 200	<10 to 1570

a Range of values from three samplings 1987.

Source: Montana Power Company 1987.

Some of these values are quite high relative to drinking water standards and aquatic life toxicity criteria and provide further evidence of the effect of contaminated sediments on the ground water system in this area.

Missoula Area

Aquifers in the Missoula area were discussed briefly in Chapter 1. The most productive of these, the Missoula Aquifer, is the major source of ground water in the Missoula Valley and the sole source of drinking water for area residents.

Recent chemical data for the Missoula Valley Aquifer are available from the Mountain Water Company and the Missoula Aquifer Study, which is being conducted in cooperation with the Missoula City-County Health Department (MCCHD) and the University of Montana. Data from 1984 to 1986 indicated no violations of State of Montana primary drinking water standards, with many of the trace metals below detection limits. The Missoula Valley Aquifer Study did show some coliform bacteria contamination, although Mountain Water Company monthly samples showed no such contamination. Small community water supplies are sampled once every five years for chemical parameters, and data from 33 such supplies indicate no exceedence of Montana primary or secondary standards (Missoula City-County Health Department 1987).

Maintaining the high quality of the Missoula Aquifer is of the utmost importance, as it supplies individual wells, two municipal water systems, over 30 small community systems, and several large industrial users (including Stone Container Corporation). The MCCHD submitted a petition to EPA in December 1987 for a sole source aquifer designation for the Missoula Aquifer to ensure a reliable high quality source of water for current and future users. The EPA granted the petition in June 1988.

Much of the Missoula Aquifer is overlain by thin, coarse soils, and depth to ground water is generally shallow. Natural attenuation of contaminants by adsorption, neutralization, ion exchange, biodegradation, and other processes is limited; therefore, the aquifer is quite susceptible to contamination. Potential sources of direct contamination identified by the MCCHD are listed below.

Yellowstone Pipeline (high-pressure gasoline pipeline)
Milltown Reservoir sediments
Pesticides from the Missoula County Weed Control Program
Browning-Ferris municipal waste landfill and historic landfills
Burlington Northern Railroad diesel refueling site
Sewage disposal seepage pits
Underground fuel and chemical storage tanks
Urban storm water
Septic systems
Industrial waste ponds

Burlington Northern Railroad and Interstate 90 transportation corridors (transportation of hazardous materials and wastes)

Because the Clark Fork provides 46 percent of the total recharge to the Missoula Aquifer, surface water quality of the Clark Fork is obviously very important. Upstream activities in the streamflow source area are of major concern, although there is a decreasing gradient of potential impact to the aquifer from surface water contamination in the upstream direction (MCCHD 1987). The petitioners have defined the project review area as the designated area and the portion of the streamflow source area within a 15 mile radius of Missoula. This represents the area where major development projects would likely have the greatest effect on the quality of the Missoula Aquifer.

Lower Clark Fork Basin

Little information has been published on ground water quantity or quality in the Clark Fork drainage basin between Huson and the Montana-Idaho border. The lack of knowledge regarding the ground water resources in the lower drainage basin suggests that it might be prudent to conduct at least a reconnaissance ground water study of the area, particularly in light of the potential mining development in this portion of the basin. Recommendations for ground water studies are outlined in Chapter 5.

FISHERIES, RECREATION, AND AESTHETICS

Effects of Surface Water Quality Degradation

In the mainstem Clark Fork, trout populations appear to be severely affected by a variety of water quality factors, including dewatering, temperature elevations, excessive nutrients, and siltation. However, the major factor suppressing trout populations appears to be metals.

Recruitment of brown trout to the mainstem Clark Fork above Milltown Dam is limited primarily to tributaries and perhaps the river itself in the Warm Springs area. Among the tributaries currently known to support major spawning runs from the river are Warm Springs, Gold and Rock creeks, and the Little Blackfoot River. The contribution from Flint Creek is currently unknown but will be assessed in the fall of 1988.

All tributary flows are probably significant in improving water quality but increases in trout abundance appear to be significant only below the mouth of Rock Creek.

Fish kills have been observed frequently in the upper Clark Fork over the last several years. State agencies have documented kills that occurred on August 9, 1983; August 1, 1984; June 18, 1987; and July 22, 1987. All four kills were associated with thunderstorms and are believed to be a result of metals entering the river due to rainfall on streamside mine tailings. Although documentation has been more thorough for some kills than for others, it has included photographs of red water immediately after storms, water samples indicating that a slug of metals entered the stream during the storm, high concentrations of metals (particularly copper) in the gills of fish that were killed, extremely high concentrations of metals in pools of water adjacent to the stream, and other subjective evidence pointing to the conclusion that the fish were killed by metals (Department of Fish, Wildlife and Parks files).

In response to concerns that tailings present in the Mill-Willow Bypass have been the origin of several fish kills, the Anaconda Minerals Company is currently modifying the bypass to divert water from the upper portions of the bypass into the Warm Springs Ponds during summer. This change is expected to isolate some of the more immediate sources of metals from the upper river but will not entirely eliminate the possibility of tailings entering the river during thunderstorms.

High concentrations of metals are also present in the river during spring runoff. No documentation shows that metals present in the river during spring runoff kill adult trout. However, metals present during runoff events are believed to chronically stress populations and may cause acute toxicity, especially to sensitive, early life stages. Such occurrences could easily go unnoticed. Many biologists also believe that the absence of rainbow trout from much of the upper river is due to their lower tolerance to metals compared to ~~than~~ brown trout's.

Several investigators have evaluated the toxicity of river water in the Clark Fork drainage (Table 3-28). Bionomics (1979) tested the toxicity of water discharged from Warm Springs Pond 2 to early life stages of rainbow trout (eggs and fry) and to Daphnia middendorffiana, which is a native daphnid, or water flea. Rainbow trout survival and hatchability were not reduced by exposure to pond water, but all fry, including those exposed to dilutions of 50 and 75 percent pond water, experienced reduced growth. Copper and zinc concentrations in a 50 percent dilution of pond 2 water averaged 25 and 65 ug/l, respectively. Additionally, Daphnia middendorffiana reproduction was significantly impaired by exposure to 100 percent pond water but not by exposure to 50 percent pond water (Bionomics 1979). Copper

TABLE 3-28. SUMMARY OF BIOASSAY RESULTS IN THE CLARK FORK DRAINAGE

Date	Location	Test Species and Life Stage	Mean Metal conc. (ug/l)		Mean Hardness mg/l as $CaCO_3$	Response Observed	Author(s)
			Cu	Zn			
August 26-October 6, 1977	Pond 2 discharge	*Daphnia magna*, life cycle	27	31	624	fewer young/female	Bionomics (1978)
July 21-October 21, 1977	Pond 2 discharge	rainbow trout, eggs and fry	29	36	642	no response	Bionomics (1978)
May 16-July 4, 1979	Pond 2 discharge 50% dilution	rainbow trout, eggs and fry	25	65	270	reduced growth fry	Bionomics (1979)
May 16-July 4, 1979	Pond 2 discharge	*Daphnia middendorffiana* life cycle	33	77	310	reduced survival offspring	Bionomics (1979)
1982	Clark Fork, near ponds	bluegill	30	101	---	acetylcholinesterase inhibition	Janik and Melancon (1982)
May 7-June 6, 1985	Clark Fork, Deer Lodge	rainbow trout, green eggs	28	33	179	no response	Parrish and Rodriguez (1986)
May 7-June 6, 1985	Clark Fork, Deer Lodge	rainbow trout, eyed eggs	28	33	179	14.5% mortality (control 5.5%)	Parrish and Rodriguez (1986)
May 16-22 1985	SBC, near Colorado Tailings 18% dilution	*Ceriodaphnia*, life cycle	22	132	138	LOEL	Lazorchak (1986)
May 16-22 1985	SBC, near Ramsay Flats 32% dilution	*Ceriodaphnia*, life cycle	45	220	138	LOEL	Lazorchak (1986)
May 16-22 1985	SBC, above ponds 75% dilution	*Ceriodaphnia*, life cycle	55	197	115	LOEL	Lazorchak (1986)
May 16-22 1985	Pond 2 discharge	*Ceriodaphnia*, life cycle	21	58	185	no response	Lazorchak (1986)
May 24-June 6, 1985	Clark Fork, Deer Lodge	rainbow trout, fingerling	39	43	172	20% mortality (control 7%)	Parrish and Rodriguez (1986)
May 25-June 1, 1987	SBC, above ponds 50% dilution	*Ceriodaphnia*, life cycle	195	390	---	LOEL	Nimmo (1987)

LOEL = lowest observable effect level.

and zinc concentrations in 100 percent pond water were 33 and 77 ug/l, respectively. Identical tests with Daphnia magna produced a similar result (Bionomics 1978); numbers of young per female were reduced by exposure to 27 ug Cu/l and 31 ug Zn/l (measured as total recoverable).

Janik and Melancon (1982), during a site specific water quality assessment of Silver Bow Creek and the upper Clark Fork, completed a few bioassay tests with Daphnia and bluegill. In these tests, Daphnia were not adversely affected by Clark Fork water nor was ventilation rate in bluegill. However, bluegill in Clark Fork water showed evidence of acetylcholinesterase inhibition. Total and dissolved copper and zinc concentrations during the survey averaged 30 and 22 ug/l of copper, and 101 and 91 ug/l of zinc. The report did not include specific information on metals concentrations that were present in the bioassay water.

Parrish and Rodriguez (1986) tested the chronic toxicity of Clark Fork water in the Deer Lodge vicinity to early life stages of rainbow trout, including separate tests using green eggs, eyed eggs, and fingerlings. Tests were conducted in May and early June 1985 to coincide with runoff; however, unusually dry spring conditions resulted in lower-than-normal stream flows and concomitantly low metals concentrations. Percentage mortality of both eyed eggs and fingerlings was higher in 100 percent Clark Fork water than in various dilutions, but results were not conclusive. During the test, acid soluble copper concentrations ranged from 10 to 78 ug/l. For the water hardnesses that were present, EPA chronic and acute criteria for copper were calculated to be approximately 20 and 31 ug/l, respectively. Most of the mortality occurred during the last week of the tests, when copper concentrations exceeded the acute criteria (weekly average concentration reached 78 ug Cu/l).

Phillips et al. (1987) conducted in situ tests with fingerling rainbow trout in the Clark Fork drainage from mid-April until late July 1986. Fish were held in the river at seven locations between Anaconda and Clinton, including a control site in Racetrack Creek. Over the course of the test, nearly 90 percent mortality occurred in Silver Bow Creek, where acid-soluble copper averaged about 200 ug/l and acid-soluble zinc 400 ug/l. Cumulative mortality at mainstem sites included 25 percent at Warm Springs, 15 percent at Deer Lodge, 7 percent at Gold Creek, and 21 percent at Bearmouth (Table 3-29). Only 3 percent mortality occurred below the confluence with Rock Creek (Clinton). No mortality occurred at the control site in Racetrack Creek. Mortality in Silver Bow Creek and in the Clark Fork at Warm Springs, Deer Lodge, and Bearmouth was statistically higher than at

TABLE 3-29. RESULTS OF INSTREAM BIOASSAYS IN THE CLARK FORK DRAINAGE USING FRY AND FINGERLING RAINBOW TROUT

Location	Copper (ug/l) mean	Copper (ug/l) range	Zinc (ug/l) mean	Zinc (ug/l) range	Hardness (mg/l as $CaCO_3$) mean	Hardness (mg/l as $CaCO_3$) range	Cumulative % Mortality fry	Cumulative % Mortality fingerling
1986								
Racetrack Creek (control)	5	(5-10)	7	(3-15)	83	(28-116)	---	0
Silver Bow Creek	201	(90-690)	381	(154-770)	84	(64-96)	---	89[b]
Clark Fork at Warm Springs	48	(5-160)	141	(35-693)	128	(80-200)	---	25[b]
Clark Fork at Deer Lodge	59	(20-140)	67	(24-130)	177	(96-224)	---	15[b]
Clark Fork at Gold Creek	55	(10-160)	60	(19-163)	145	(94-170)	---	7
Clark Fork at Bearmouth	55	(5-170)	83	(24-223)	155	(110-184)	---	21[b]
Clark Fork at Clinton	28	(5-70)	44	(9-105)	103	(70-124)	---	3
1987								
Racetrack Creek (control)	6	(5-10)	12	(6-24)	110	(98-122)	8	2
Silver Bow Creek	219	(70-520)	478	(32-994)	116	(104-124)	92[b]	88[b]
Clark Fork at Warm Springs	28	(10-50)	99	(27-430)	169	(140-216)	18	7
Clark Fork at Deer Lodge[a]	25	(10-50)	38	(17-68)	197	(130-210)	---	---
Clark Fork at Gold Creek	14	(5-30)	35	(19-57)	172	(124-204)	36[b]	24[b]
Clark Fork at Bearmouth	15	(5-40)	31	(4-54)	192	(100-228)	55[b]	12
Clark Fork at Clinton	8	(5-20)	17	(2-30)	113	(64-148)	10	8

[a] The bioassay vessels were stolen three weeks into the test at Deer Lodge before significant mortalities were observed at any of the sites.

[b] Significantly different from controls at the 95 percent confidence level.

Source: Phillips et al. 1987.

the control site. Copper and zinc concentrations present during the test are summarized in Table 3-29.

Additional bioassays were conducted during May and June of 1987 (Phillips and Hill, unpublished data), including tests of both rainbow and trout fingerlings and swim-up-stage fry. Test sites were the same as those used during 1986. Tests began on May 4 and were completed by July 1. The test vessels were equipped with an automatic feeding system that provided hatchery food to the fry four times per day. Fry were less tolerant than fingerling during these tests. Rates of mortality for fry were: Warm Springs (18 percent), Gold Creek (36 percent), Bearmouth (55 percent), and Silver Bow Creek (92 percent). Mortality at the latter three sites was significantly higher than the 8 percent observed at the control site and the 10 percent observed at Clinton (downstream of Rock Creek). A pair-wise multiple comparison technique was employed using Bonferroni adjusted confidence intervals. Fingerlings were less sensitive than fry. Rates of mortality for fingerlings were: Warm Springs, 7 percent; Bearmouth, 12 percent; Gold Creek, 24 percent; and Silver Bow Creek, 88 percent. Mortality at the control site was only 2 percent. Mortality at both Gold Creek and Silver Bow Creek was statistically higher than the control.

The Warm Springs bioassay location is on the east side of the river and is in the plume of Pond 2 discharge water. During both the 1986 and 1987 bioassays, maximum and average zinc concentrations were higher at this site than at downstream sites. High metals concentrations below the ponds occurred during periods of high winds that stirred up particulate materials in the Warm Springs Ponds. Unlike resident fish in this vicinity of the river, our bioassay fish were unable to seek refuge from the higher metals concentrations by moving into water originating from either Warm Springs Creek or the Mill-Willow Bypass. Such movements may allow resident fish to escape high concentrations of metals.

In summary, the instream bioassays indicate that early life stages of rainbow trout are adversely affected in Silver Bow Creek and in the mainstem Clark Fork. Statistically significant mortality has been documented from Warm Springs to near Bearmouth. This occurred even during years when metals concentrations were relatively low because of modest runoff. Tributaries that contribute good-quality water to the river may provide potential refuges from high metals concentrations, but the extent to which these are utilized by resident fish has not been documented. Use of refuges may partially explain why trout densities are sustained immediately downstream of the Warm Springs Ponds.

It is difficult in a natural environment such as the Clark Fork to gauge the conditions that fish and other aquatic organisms are exposed to because metals concentrations may fluctuate greatly over short intervals of time. For example, even frequent sampling such as that conducted by Phillips and Hill (three times per week) may not describe conditions that are present during short, intense thunderstorms. In any case, various authors have documented that Silver Bow Creek and Clark Fork waters are sometimes toxic to some invertebrates and early life stages of fishes. Toxic responses have been observed when metals concentrations were as low as 20-50 ug Cu/l and 30-80 ug Zn/l and when water hardnesses ranged from approximately 100-200 mg/l (as $CaCO_3$). At water hardnesses of 100 and 200 mg/l, federal criteria documents recommend that metals concentrations should not exceed 12 and 21 ug Cu/l and 37 and 66 ug Zn/l to prevent occurrence of chronic toxicity. Toxicity information for the Clark Fork indicates that these criteria are not overly protective and at times may provide only a very narrow margin of safety.

Some preliminary metal speciation work has been done by researchers at the University of Montana. They hypothesized that because trout populations in the upper Clark Fork decline downstream from the sources of metals near Butte and Anaconda, water chemistry changes might result in a greater prevalence of toxic metal species downstream. To test this hypothesis, the researchers applied several approaches to modelling metal speciation to water chemistry data from the upper Clark Fork (Caciari and Watson, in review). These approaches ranged from a simple model developed by the EPA's Western Fish Toxicology Station (WFTS) at Corvallis, Oregon, which predicts the percentage of free copper from alkalinity and pH, to a complex multiequation equilibrium model (MINTEQ).

The different modeling approaches predicted a similar amount of free copper, but the MINTEQ model predicted much higher levels of copper hydroxide and lower amounts of copper carbonate than the other approaches. None of the approaches showed any substantial downstream trend in metal speciation, largely because there was no substantial downstream trend in pH or alkalinity. Seasonal trends cannot be discerned based on one year of data. Because the simple WFTS model is in good agreement with more complex models, it should be applied to the Clark Fork's past and future data sets to determine if seasonal or longer-term trends emerge.

Effects from Hydropower Development

Historically, the Clark Fork was a major spawning ground for fish migrating out of Lake Pend Oreille, Idaho.

Some historical records suggest that fish may have travelled as far upstream as Missoula, a distance of 211 miles from Lake Pend Oreille (Malouf 1974). The three dams on the lower Clark Fork modified the habitat and blocked access to spawning grounds for fish migrating out of the lake. The Thompson Falls Dam, constructed in 1916, blocked migrations for all but the lower 70 miles of river, and the Cabinet Gorge Dam, constructed in 1953, eliminated the remaining fishery for migratory westslope cutthroat trout, kokanee salmon, and bull trout.

Although the reservoirs have been in operation from 35 to 72 years, significant game fish populations have not been established in them, despite the expenditure of many thousands of man hours and hundreds of thousands of dollars.

Each of the lower river reservoirs is a run-of-the-river impoundment, constructed for the primary purpose of hydroelectric power production. The operations of the power plants, including drawdowns and the physical characteristics of the reservoirs, combine to create adverse conditions for fish production. The relatively rapid water exchange, or flushing rate, in each reservoir limits the plankton production needed to sustain fish populations. Fish food availability (aquatic insects and other benthic organisms) are also severely affected by water level fluctuations and reservoir drawdowns. Spawning beds within the reservoir and access to tributary spawning areas are severely diminished by reservoir drawdowns. Testing has also shown that large numbers of fish are flushed downstream during spring drawdown.

During the period of 1953 to 1963, large numbers of trout and kokanee salmon were stocked in Cabinet Gorge Reservoir, but a fishery was not established. Since 1963, fish stocking in Cabinet Gorge has been suspended except for some limited plants of catchable-size rainbow trout and plants of brown trout eggs in Elk Creek, a tributary to the reservoir. The egg plants are an attempt to establish a self-sustaining brown trout population.

More attention has been focused on Noxon Rapids Reservoir in recent years, because a successful fishery in Noxon will have a positive influence on the Cabinet Gorge Reservoir fishery. Like Cabinet Gorge, early attempts to establish a fishery at Noxon Reservoir were unsuccessful. Remnant populations of brown trout, bull trout, and lake whitefish are found in each reservoir, but the numbers are insufficient to maintain an acceptable fishery.

In 1986, a new operation plan for Noxon Rapids Reservoir was put in effect by the Washington Water Power Company.

Prepared through joint efforts of WWP, the Montana Department of Fish, Wildlife and Parks, and the Northwest Power Planning Council, the plan is an attempt to reduce the extent and frequency of reservoir drawdowns, especially at critical times of the year. The four major points of the agreement are as follows:

1. Maximum drawdown will be limited to ten feet, except that in the second and succeeding years of a critical water period, as defined by the Pacific Northwest Coordination Agreement, drafting may reach 36 feet, but only on a pro-rata basis with all other reservoirs in the coordinated system.

2. Reservoir level will be within one foot of full pool by May 15 each year, and the reservoir will be operated within four feet of full pool thereafter until September 30. This restriction should protect most in-reservoir fish spawning activities, reduce effects of drawdown on aquatic plant and animal communities, and assure recreational access during major use months.

3. The rate of drafting will be limited to two feet per day and ten feet per week. This limitation is designed to reduce bank erosion.

4. WWP reserves the right to deviate from the operational criteria in the event of an emergency, such as project maintenance, system power failures, or an extended period of weather extremes.

In addition to this agreement WWP is continuing to support the state's effort to establish fish populations in the Cabinet Gorge and Noxon Rapids reservoirs.

Test netting in Cabinet Gorge Reservoir indicates lake whitefish, largemouth bass, yellow perch, and brown trout populations are possibly increasing. Evidence of brown trout spawning in reservoir tributaries has also increased during the past seven years.

Sampling of fish populations in Noxon Rapids Reservoir show fairly stable results from 1960 through 1982, followed by a marked increase in 1987. The increase was largely suckers and yellow perch, but brown trout populations show some signs of increase. Improved habitat resulting from the new reservoir operations policy is expected to result in increased fish numbers and improved growth rates.

Effects from Irrigation Projects

This section discusses the effects of irrigation on the fisheries, recreation, and aesthetics of the Clark Fork. The discussion addresses large irrigation storage projects as well as smaller, individual projects and uses of water for irrigation purposes.

Large Storage Projects

Nevada Creek Reservoir. The Nevada Creek Reservoir is located on Nevada Creek ten miles southeast of Helmville in the upper Blackfoot River drainage. The project supplies water to irrigate approximately 13,000 acres of hay land. The full storage capacity is used for irrigation.

Nevada Lake provides mediocre fishing for rainbow trout that are stocked annually. Because of the extreme annual irrigation drawdown, little if any natural reproduction occurs. Limited amounts of both summer and winter fishing currently occur. Any improvement in fishing quality under the current operation and use of the stored water is unlikely. The lake waters are usually turbid, and the extreme drawdowns by late summer are aesthetically unpleasing. The reservoir does have the potential to produce a decent fishery if water level fluctuations could be minimized.

Nevada Creek flows through private ranchland along its entire length below the dam and is used to convey water from the reservoir. A large state ditch, the Douglas Canal, distributes a major share of the water. The North Canal and other private ditches take out additional water.

Nevada Creek has good physical habitat in some areas, but the trout fishery is limited by low flows during the winter months when the dam gates are shut down. Also, siltation in the stream bottom limits spawning potential. A limited brown and rainbow trout fishery occurs, mostly of a local nature. The DFWP is currently studying the stream in cooperation with the Nevada Creek water users to determine minimum flows required below the dam. Low flows reduce the otherwise reasonably good aesthetic qualities of the stream.

Flint Creek Project (East Fork Reservoir). The Flint Creek Project is located on the East Fork of Rock Creek 20 miles southwest of Philipsburg in Granite County. East Fork Reservoir is a somewhat isolated lake, receiving only moderate recreational use. The fishery consists primarily of rainbow trout stocked annually. However, there is a small bull trout population that reproduces naturally in the East Fork above the reservoir. These fish do occur in the fisherman's catch. Fluctuation in water level limits fishery production, and the aesthetics are not good during late season drawdowns. It is, however, a rather scenic lake at full pool.

The project diverts water from the Rock Creek drainage. Without the project, this water would be available for the main Rock Creek "Blue Ribbon" trout fishery. The impacts of this loss of flow on Rock Creek have not been quantified.

Flint Creek receives some benefit from irrigation return flows. Leaky delivery canals in Flint Creek Valley also contribute East Fork water to Flint Creek. However, the return flows are reused along Flint Creek. Flint Creek suffers from dewatering, siltation from streambank erosion, and higher-than-desirable water temperatures in the lower reaches.

The fishery in Flint Creek is composed primarily of rainbow and brook trout in the upper reach and mostly brown trout below Maxville. It is a popular fishery but has limitations due to the environmental consequences of land uses and irrigation. The stream flows through a scenic agricultural valley. Low flows due to irrigation withdrawals reduce the aesthetic qualities in some reaches. The DFWP has applied for an instream flow reservation in Flint Creek from the dam on Georgetown Lake to the mouth. However, this alone will only preserve the status quo of the current low-flow conditions.

<u>Painted Rocks Lake</u>. Painted Rocks Lake is located on the west fork of the Bitterroot River about 30 miles south of Darby in Ravalli County. Stored water purchased by the DFWP is used to improve low stream flows in the Bitterroot River. Extensive irrigation in this major river valley depletes natural flows and in most years causes the stream to go nearly dry at Bell Crossing near Stevensville.

Since its original purchase in 1958, the DFWP has released water from the reservoir for instream purposes. However, it was unusual for those releases to reach dewatered downstream areas because the water was diverted by the irrigators along the way.

In 1985, 1986, and 1987, the DFWP reached an agreement with the irrigators that would allow a major portion of the released water to reach Bell Crossing. A water commissioner was appointed by the court to monitor and enforce diversions of water. This was a satisfactory program during those low-water years, but the agreement was not fully implemented due to summer rains which increased streamflows (see the attached agreement between the irrigators and the DFWP).

Painted Rocks Lake contains primarily westslope cutthroat trout and is a limited fishery maintained by

Montana Department
of
Fish, Wildlife & Parks

Draft Water Exchange Proposal on the Bitterroot River

May, 1987

The Department of Fish, Wildlife and Parks wishes to extend to those who irrigate from the Bitterroot River a water exchange proposal similar to the agreement of 1986. The exchange consists of:

1. A quantity of water up to 3,000 acre feet would be made available by DFWP, early in the irrigation season, for irrigation use at any flow rate from Painted Rocks Reservoir.

2. DFWP could request participating irrigators to reduce irrigation diversion to maintain instream flows of 402 cfs (16,080 inches) at Bell Crossing after September 15.

3. DFWP would keep flow records at Bell Crossing and monitor reservoir releases.

4. DFWP would pay costs associated with the river commissioner to protect water purchased for instream flow. In years when irrigators also buy water costs for the commissioner would be shared.

In return, irrigators would agree to the following:

1. Pay DNRC to have the dam gates opened and closed when water is released for irrigation.

2. Sign the petition for the appointment of a river commissioner in years when the DFWP needs one to deliver stored water to Bell Crossing.

3. A water commissioner would deliver sufficient water to provide a flow of not less than 100 cfs (400 inches) at Bell Crossing.

4. Fall shutdown of irrigation ditches will be done in a manner to stimulate fish movement out of canals back to the river.

One person would be appointed to represent the department and one person to represent the irrigators in matters concerning the management of Painted Rocks water. At a minimum 15 percent of the water right holders must be party to this agreement.

stocking. Rainbow and brook trout occur in fewer numbers. There is, however, considerable other recreational use of the lake, such as boating, camping, waterskiing, and swimming. These activities become limited as the pool level drops. In low-water years, there is sometimes no pool at all in late fall and winter. When it appears the lake will not contain adequate water during a low-water year, it is DFWP policy to not stock fish during that year. The reservoir lies in a very pleasing scenic mountain area and is an extremely aesthetic spot when the water level is adequate.

The Bitterroot River flows 80 miles from the junction of the east and west forks to its confluence with the Clark Fork at Missoula. It is a very popular fishery for rainbow and brown trout as well as mountain whitefish during the winter. Other species include westslope cutthroat, brook trout, and bull trout. It is a floatable stream when flows are adequate, and local guides provide some services to fishermen. The stream flows through the beautiful Bitterroot Valley and is a major aesthetic attraction along with the high mountains and riparian lowlands.

Dewatering is the principal problem that must be continuously monitored. DFWP has filed a claim for instream flows at the request of the Ravalli County Fish and Wildlife Association under Section 85-2-223 of Senate Bill 76. The claim is currently pending in the water court.

<u>Georgetown Lake</u>. Georgetown Lake is located on the North Fork of Flint Creek in Granite and Deer Lodge counties about 18 miles west of Anaconda. Under an old decreed water right, a minimum of 30 cfs is released from the dam for irrigation in the Flint Creek Valley. The irrigators in the valley have been trying to obtain additional water from the project but have been unsuccessful. MPC has filed a FERC application to abandon use of the project for hydropower purposes, and they are negotiating with interested parties to take over the project. Granite County is pursuing this option.

Out of date

Georgetown Lake is a very important recreational lake. It lies in a high-elevation scenic area and is one of the most-fished lakes in the state. Numerous species of fish have been stocked over the years, including rainbow, westslope cutthroat, and brown trout, grayling, and coho and kokanee salmon. The lake currently contains primarily rainbow trout, brook trout, and kokanee salmon.

Depending on what happens with MPC's application to FERC, historical water use could be altered. If irrigation interests gain control of the water supply, changes could occur in lake levels as well as flows in both Flint Creek and

Warm Springs Creek. The State of Montana is currently not interested in assuming responsibility for the old dam. Extensive repairs are needed to maintain and improve the power production system. However, state agencies and local residents are interested in preventing any degradation to the lake's fishery and recreational values.

Montana Resources, Inc., which bought the Butte mining properties from AMC in 1984, holds extensive water rights in the Warm Springs Creek drainage. AMC used this water for copper refining in Butte. The Butte operation under MRI is smaller and does not require the former quantities of water. There is some indication (and concern) that some of these water rights may be sold. If this occurs, there may be impacts to irrigation interests as well as to instream flows in Flint Creek and Warm Springs Creek. Some of the Warm Springs Creek water was temporarily stored in Georgetown Lake prior to being pumped back over into Warm Springs Creek for transfer via pipeline to Butte.

Lower Willow Creek Reservoir. Lower Willow Creek Reservoir near Hall provides water to lands in the lower Willow Creek and lower Flint Creek valleys. The reservoir has a limited westslope cutthroat fishery, and fishery potential is poor because of extreme reservoir drawdown and poor water quality. Willow Creek above the reservoir contains a genetically pure strain of westslope cutthroat trout, a "Species of Special Concern" in Montana.

The Granite County Conservation District has applied for a water reservation to construct another dam upstream from the present reservoir to provide new supplemental water for lower Willow Creek and Flint Creek. This new storage facility is not expected to have a significant adverse impact on Clark Fork streamflows but would eliminate local cutthroat stream fishing in a portion of Willow Creek.

Lake Como. Lake Como is located on Rock Creek in Ravalli County between Hamilton and Darby. The project is located on the east slope of the scenic Bitterroot Mountains and supplies water for irrigators in the Bitterroot Irrigation District. The aesthetic qualities are excellent when the reservoir is full, or nearly so, but decrease with increased drawdowns. With sufficient water, recreational uses include fishing, boating, water skiing, and swimming. It provides a limited fishery for rainbow and westslope cutthroat trout. The project affects flows into Rock Creek below the dam. A canal one mile below the reservoir diverts the flows released and dries up Rock Creek during the irrigation season. Only during spring runoff, when the project spills, is there adequate flow in most of the stream below the dam. Therefore, the stream provides only a limited rainbow trout fishery even though the aesthetic qualities of the area are otherwise quite good.

Other Irrigation Projects

According to the Montana Registry of Dams, published in 1968 by the old Montana Water Resources Board, there are 80 dams with reservoirs holding 50 AF or more water in the Clark Fork Basin. These include the large projects previously discussed. Most are privately owned, and many of them lie in the Selway-Bitterroot, Anaconda-Pintlar, and Flint Creek mountain ranges. Table 3-30 lists the number of dams by county and the number used for irrigation. There are also numerous smaller reservoirs (less than 50 AF) throughout the basin used for irrigation, stock water, and fish and wildlife.

TABLE 3-30. INVENTORY OF DAMS BY COUNTY WITH 50 AF OR MORE CAPACITY IN THE CLARK FORK BASIN

County	No. Dams	No. Used for Irrigation
Deer Lodge	3	1
Granite	15	14
Mineral	0	0
Missoula	17	11
Powell	16	11
Ravalli	23	23
Sanders	6	2
Total	80	67

Source: Montana Water Resources Board 1968.

Ravalli County has the highest number of small storage projects, which were constructed many years ago. Most lie on the west side of the Bitterroot Valley. Almost all of them utilize existing high mountain lakes in the Selway-Bitterroot Mountains. Dams were built on the outlets to store additional water for late-season irrigation use.

The impacts of these small projects is not completely known. Many of the mountain lakes provide fishing for persons who hike into them, since many are in roadless and wilderness areas. Dams at some lakes have been breached for safety reasons, creating water too shallow for fishery production. Other dams are still in place but unused, and the higher water levels of those lakes produce better fisheries. Lakes with adequate depth provide moderate fishing opportunities for various trout species. There is minimal natural reproduction in inlet and outlet streams in some lakes, and most are maintained by periodic stocking. These lakes are extremely aesthetic, but drawdowns detract from this pleasantness in some cases.

Because the projects store snowmelt and the stored water is released after spring runoff, there is probably a beneficial effect on the flow of tributary streams in late season, at least up to the first point of diversion. However, most of these tributaries are partially or totally dewatered by the time they reach the Bitterroot River. Return flows from use of the stored water may help hold up flows in the lower Bitterroot.

Other Water Uses

Other water users in the Clark Fork Basin also cause individual as well as cumulative impacts on stream flows. In the upper basin, the main Clark Fork and most of its tributaries are affected by irrigation diversions. Warm Springs Creek, the Little Blackfoot River, and Flint Creek are major tributaries with fisheries affected by diversions. Portions of the Clark Fork above Deer Lodge suffer from extreme dewatering, as do most of the smaller tributaries, such as Lost, Rock, Dempsey, and Racetrack creeks. These streams all provide fishing for trout, but their potential is limited by reduced flows for irrigation.

The Clark Fork upstream of Drummond shows the effects of dewatering to a greater extent than downstream reaches (tributaries excluded) because there is less irrigable land downstream of Drummond relative to the water supply. Hence, the effects of dewatering are less apparent.

The dewatering problems occur in July and August in most years but begin earlier or last longer in dry years. Nearly all diversions are for agricultural use.

Dewatered streams occur because of the cumulative effects of both old and new water rights. Many rights have priority dates before the turn of the century. Since 1973, when Montana implemented the new water law, water users have had to apply for and be issued a permit to appropriate water. Practically all permits in the basin are issued with few conditions that will help the dewatering problem.

The effects of dewatering streams with fish populations are all generally the same--loss of physical habitat, higher water temperatures, lower food production, and decreased dissolved oxygen. The extent of these impacts depends on the degree of dewatering, the most severe being actual loss of a fish population when a stream stops flowing.

Fishing opportunities are reduced, aesthetic qualities are poorer, and floating (where the stream is large enough) becomes difficult or impossible when insufficient flows occur, resulting in fewer recreational opportunities.

Instream flows are a partial solution to the dewatering problem. However, because instream flow rights cannot affect senior diversionary water rights, they only preserve the status quo of stream depletion. They do not prevent dewatering, but can reduce future demands on the streams once they are acquired. Rewatering of streams that have severe flow problems can only be accomplished through new strategies, such as purchasing and leasing senior water rights, building new storage projects, and conserving water to free up additional water for instream uses. Some of these strategies will require new legislation, but if they can be implemented, they will help improve the stream fisheries as well as their recreational, and aesthetic values.

CHAPTER 4

FUTURE WATER NEEDS AND ACTIVITIES IN THE BASIN

The Clark Fork Basin is blessed with an abundant natural resource base that supports the forest products industry, mining, hydropower, agriculture and ranching, recreation, and many other uses. However, because these interests often compete for land and water, careful and informed resource management decisions must be made, particularly with regard to future development in the basin.

This chapter describes real and potential future water needs in the basin and examines the question of how much water is available for future development. One issue currently in the forefront is that of instream flow. Maintaining enough water in the Clark Fork at all times to protect aquatic resources, water quality, public water supplies, and hydropower needs is of vital concern. Another issue is the resurgence of mining in the basin, touched off by the current favorable market price of gold. Such a boom could place more water demands on the Clark Fork and its tributaries, not only for the mines themselves, but also for the towns that may grow as a result of mining activity. These issues and others are discussed below.

WATER RESERVATIONS

Introduction

As discussed in Chapter 2, Montana's 1973 Water Use Act allows public entities, such as conservation districts, municipalities, counties, and state, and federal agencies to reserve water for future uses. These include diversionary and consumptive uses as well as instream flows for the protection of fish, wildlife, and water quality. Some of these public entities may seek water reservations to satisfy future demands for water in the Clark Fork Basin. Potential consumptive and instream flow needs in the basin are discussed below.

Consumptive Water Needs

Potential future consumptive water needs in the Clark Fork Basin include water for domestic and municipal supplies, waste disposal, agricultural uses such as stock watering and irrigation, and for industry (such as mining). At this writing, none of the communities in the basin has filed plans to expand either its municipal water supply system or its waste disposal system. However, if growth should occur in some areas of the basin, additional surface and ground water demands could be placed on the Clark Fork system. Potential future irrigation and mining water needs are discussed separately following the sections on instream flow needs.

Instream Flow Reservation Needs in the Basin

In addition to the flows already requested by DFWP in the upper river, the following streams and stream reaches within the Clark Fork Basin need instream flow protection:

River Mile	
150.4	Montana - Idaho Border
157.1L	Elk Creek (tributary to Cabinet Gorge Reservoir)
162.5R	Bull River (tributary to Cabinet Gorge)
	9.7L East Fork Bull River
	25.9L South Fork Bull River
	26.3R North Fork Bull River
167.0L	Pilgrim Creek (tributary to Cabinet Gorge)
168.7R	Rock Creek (tributary to Cabinet Gorge)
175.7R	Marten Creek (tributary to Noxon Rapids Reservoir)
	9.5R South Fork Marten Creek
185.9R	Vermilion River (tributary to Noxon Rapids)
207.5L	Prospect Creek
	2.6L Clear Creek
212.7L	Cherry Creek (tributary to Thompson Falls Reservoir)
214.6R	Thompson River (tributary to Thompson Falls Reservoir)
	6.9R West Fork Thompson River
	15.7R Fishtrap Creek
	17.9L Little Thompson River
245.0R	Flathead River (Probably will not include river or tributaries below Kerr Dam, since all are on Indian Reservation)
249.3R	Seigel Creek
265.9L	Tamarack Creek
270.7L	St. Regis River
	1.6R Little Joe Creek
	4.5R Two Mile Creek
	8.2R Ward Creek
	13.0L Twelve Mile Creek
	18.7L Big Creek
	30.2L Randolph Creek
286.6L	Cedar Creek
289.6L	Trout Creek
305.0L	Fish Creek
	8.6L West Fork Fish Creek
	8.7L South Fork Fish Creek
319.7L	Petty Creek
325.1R	Ninemile Creek
328.2R	Sixmile Creek

River Mile	
334.1R	Mill Creek
350.5L	Bitterroot River and major tributaries that are unspecified at this time.
358.2R	Rattlesnake Creek

Rock Creek tributaries: unspecified at this time--above Milltown Dam

Blackfoot River tributaries: unspecified at this time--above Milltown Dam

In addition, the mainstem Clark Fork from Milltown Dam to the Idaho-Montana line (excluding the reservoirs) will be divided into reaches for the reservation request.

To date, no community in the Clark Fork Basin has applied to reserve instream flows for future municipal needs.

Forest Service Instream Flow Needs

The U. S. Forest Service has the authority and responsibility to regulate occupancy and use of national forest lands, to prevent environmental degradation, and to protect national forest resources. When a project is proposed in a national forest that requires the use of water, instream flow needs are made a condition of occupancy and use of national forest land. To be approved by the U.S. Forest Service, all construction projects in the national forest must provide for achieving and/or maintaining the stability of channel systems (16 USC 551). Also, projects must minimize damage to scenic and aesthetic values and fish and wildlife habitat and otherwise protect the environment.

IRRIGATION

The Water Resources Division of the DNRC uses a land classification system to determine the suitability of land for irrigated agriculture. The system separates arable lands into three classes based on soil type and climate. Class 1 represents land with the highest potential productivity; Class 2 lands are of intermediate potential; and Class 3 represents irrigable lands of the lowest value. Table 4-1 lists the arable acres in each class for seven subbasins of the Clark Fork drainage.

TABLE 4-1. ESTIMATED ARABLE LAND IN SUBBASINS OF THE CLARK FORK

Subbasin	Land Class 1 (acres)	Land Class 2 (acres)	Land Class 3 (acres)	Total Arable Acres
Upper Clark Fork	950	48,722	160,752	210,424
Flint-Rock Creeks	---	-----	45,893	45,893
Blackfoot	---	4,386	121,614	126,000
Middle Clark Fork	---	6,471	51,442	57,913
Bitterroot	---	12,419	60,807	73,226
Flathead	27,531	44,754	180,065	252,350
Lower Clark Fork	---	7,186	111,666	118,852
Total	28,481	123,938	732,239	884,658

Source: DNRC Land Classification System Database

These figures represent the upper limit of irrigation development imposed by soil, topographic and climatic factors. The number of potentially irrigable acres is reduced when economic factors, such as water delivery costs, are considered. For example, Elliott (1986) estimated that only about 13,300 acres could actually be irrigated profitably in the upper Clark Fork, which is approximately 6 percent of the arable acreage shown in Table 4-1 for that subbasin. Further study is required to determine if economic factors would have the same effect on other parts of the Clark Fork Basin.

Water availability is another major constraint on future irrigation development in the basin. The DNRC (1988a) evaluated the irrigable lands identified by Elliott (1986) and found that water was not available throughout much of the irrigation season for lands that would have been supplied from tributary flow. Water availability considerations further pared the number of acres of irrigable lands in the upper Clark Fork to about 8,400.

MINING

A number of companies have recently submitted plans to DSL to mine gold, silver, and copper in various tributaries of the Clark Fork. These proposed projects must be closely scrutinized to ensure that environmental degradation is minimized and that water quality is not further impaired. Some of the larger operations propose to utilize a cyanide heap leach process to recover gold from the ore deposit. In this process, crushed ore is placed on a leach pad and sprayed with a dilute cyanide solution to dissolve the gold and silver values in the ore. This solution percolates down through the ore and collects on the pad liner. The gold- and silver-bearing solution is pumped to a process plant for removal of the gold and silver. The solution is then pumped back onto the ore pile, and the process is repeated until recovery of metals from the ore falls below acceptable economic levels (Sunshine Mining Company 1988). Because the cyanide heap leach process has the potential to cause environmental problems, new mine plans proposing to use it will be reviewed very closely. Comprehensive water monitoring programs for leach pad facilities will be necessary to ensure protection of the water resources.

New mines proposed in the Clark Fork Basin are discussed briefly in the following sections. More detailed information can be obtained through the DSL, the agency responsible for administering the state's hard rock mining rules and regulations.

New Butte Mining, Inc.

In October 1987, Butte Mining Plc was listed on the London Exchange and it purchased two major mining claim blocks in the Butte district from Montana Mining Properties. New Butte Mining, Inc. (NBMI), was formed as the operating entity for Butte Mining Plc and will develop and operate the mines as a Montana corporation. The company hopes to develop underground operations along various vein systems in the Butte Hill for gold, silver, lead, and zinc. Work has begun on several blocks of claims to verify tonnages and grade, and metallurgical research is underway. The company is also exploring the possibility of metal recovery by reprocessing existing mine dumps in the area.

NBMI would likely use a technique called "slot mining" to remove oxide ores from the surface. Oxide vein material would be selectively extracted by powerful hydraulic excavators down to the sulfide zone. In profitable veins, long narrow benches would permit ore removal to depths of 75 feet. The excavated slots would be backfilled immediately behind mining, covered with soil, and revegetated. NBMI is evaluating the feasibility and profitability of reopening more than one underground mine.

NBMI estimates that there are enough precious metals left in the Butte district to provide employment opportunities and profit potential for many years to come, depending on the price of base and precious metals and environmental and operational considerations. The company expects to create employment for over 100 people in future mining and metal processing operations.

NBMI is considering several processing options, including using the Weed Concentrator, building a new processing facility, or transporting the material to a custom milling facility. NBMI believes that its mining and metal processing operations will result in few environmental problems (Montana Mining Properties 1987).

Pegasus Gold Corporation

The Pegasus Gold Corporation submitted an application in February 1988 to mine gold and silver in the German Gulch drainage, located about 18 miles southeast of Anaconda and 18 miles southwest of Butte. Pegasus acquired the property from Montoro, which withdrew its application after encountering difficulties during the permitting process. Pegasus Gold is a Canadian corporation with headquarters in Spokane, Washington. Pegasus also owns the Montana Tunnels and Zortman/Landusky projects.

The proposed mine plan for the Beals Mountain Project calls for open pit mining methods with a cyanide heap leach facility on the Beals Hill saddle (7,600 feet). The operating permit boundary would encompass 1,182 acres. The ore deposit contains low grade gold, silver, and various other elements. The ore would be crushed to one-half inch, and no fine tailings would be generated. The heap leach facility would have two clay liners and a 40 ml/PVC liner to prevent ground water contamination. There would be cyanide destruction capability on site (Pegasus Gold Corporation 1988).

Activities near German Creek would be limited to a road and a freshwater pipeline. The operation would require 1.0 cfs from the creek, which is about 15 percent of low flow. Although there is some moisture perched in the subsoil, the site as a whole is fairly dry (Pegasus' most productive well yields only 8 gallons per minute [gpm]).

The expected life of the mine is ten years, but the area has not been completely explored. The total resource is 11.8 million tons of ore, with 8.7 million tons of mineable reserve. Average annual gold and silver production are expected to be 33,000 and 25,000 troy ounces, respectively. The operation would be seasonal (March to October or November) and would employ approximately 65 people. Every attempt would be made to hire locally and to use local suppliers.

Extensive baseline environmental data were collected by Montoro, and Pegasus has collected additional data on ground water, cultural resources, wildlife, and air quality that are included in the permit application.

Cable Mountain Mine, Inc.

Cable Mountain Mine, Inc., submitted an application to the Montana Department of State Lands in February 1988 for a placer gold mine about 12 miles west of Anaconda. The proposed mine is in the Cable Creek area of the Flint Creek Range, near the historic Cable Mine. The proposed mine permit boundary encloses about 94 acres with a disturbance area of about 51 acres (Cable Mountain Mine, Inc. 1988).

The company proposes to employ 13 people to mine and process approximately 1.8 million tons of gold-bearing sand and gravel over a three-year mine life, and to reprocess about 18,000 tons of existing stamp mill tailings. The design mining rate is 3,000 cubic yards/day, and the operation would utilize standard hydraulic/gravity separation methods for placer gold recovery. Coarse waste rock would be placed on a waste dump or backfilled in the pit. Fine tailings material would be routed to a settling pond. About 2,000 gpm of process water would be required to operate the plant. This water would be derived from pit inflow, adit discharge, and if needed, dewatering wells (Cable Mountain Mine Inc. 1988).

The mine site and historically disturbed areas would be reclaimed to provide erosion control and stabilization. All disturbed areas would be recontoured, regraded, and planted with trees and shrubs. The final open cut would be left as a small lake.

Sunshine Mining Company

The Sunshine Mining Company of Kellogg, Idaho, submitted an application in January 1988 to mine gold and silver at the Big Blackfoot Mine three miles west of Lincoln. The proposed mine area is located on private lands controlled by Sunshine Mining and on portions of federal land (Helena National Forest). The project site is in the southwest portion of Lincoln Gulch, which is tributary to the Blackfoot River. The mine pit would be directly north and west of the Blackfoot River, and the ore processing facility would be in the basin of an intermittent drainage that flows east to Lincoln Gulch. The operation would utilize standard open pit mining methods, including topsoil salvage, ripping and blasting of rock, and a truck-shovel operation for loading and hauling. The open pit would be developed in four sections, with the first two sections of the pit backfilled with waste rock and overburden from the last two sections. Waste and overburden from the first section of the pit (about 660,000 tons) would be placed in a waste rock dump, which would be revegetated along with the backfilled portion of the pit during the life of the mine (Sunshine Mining Co.

1988).

The proposed operation would produce approximately 2.3 million tons of ore. The ore would be transported to a crusher, located at the leach pad facility about 1.5 miles from the Blackfoot River, where it would be crushed to three-inch minus. The leach pad would be a total containment facility with a double liner system and a net precipitation storage pond. A specialized water monitoring program for the leach pad facility would be maintained during the operational and post-operational phases of the project. Reclamation of this facility would include a procedure to neutralize the residual cyanide in the ore pile.

The project would require approximately 60 gpm of water, which would be derived from two wells and the precipitation pond. After the first year, most of the water would come from the pond. Potable water would be obtained from on-site wells.

The operation would employ a maximum of 55 people. The project is expected to have a seven-year life; however, if the leaching process proved economical beyond year seven, it might be extended.

The primary aim of the reclamation plan for this project is reforestation. All disturbed areas would be revegetated with tree seedlings and bunch grasses.

Montana Mining and Timber Company

The Montana Mining and Timber Company (MMTC) submitted an application for a gold placer operation on Gold Creek to the Department of State Lands and the U.S. Forest Service in February 1988. The proposed mine area is located along the upper reaches of Gold Creek on both patented land and land administered by the Deer Lodge National Forest. The mine area includes the Pineau and Master mines, both of which are previously disturbed, unreclaimed placer mines. (Montana Mining and Timber Company 1988).

The total mine area for the proposed Gold Creek project is about 244 acres, with a disturbance area of 109 acres. Approximately 1.2 million to 1.5 million tons of gravel would be processed at a rate of 3,000 to 4,000 tons/day. The life of the mine is expected to be two years, with year-round operations requiring a work force of 39 people.

The company would use standard hydraulic/gravity separation methods for processing at the Master Mine Camp. Separators and a thickener tank system would be used to remove suspended sediment from the tail water. The sediment would be slurried to a sediment burial site in the Master Mine area, dewatered, and buried. Runoff catchment ditches and sediment control ponds would be constructed downgradient of each mine block for erosion control. Mining would be restricted to within 100 to 200 feet of the south and middle forks of Gold Creek, and all settling ponds would be located out of the 100-year floodplains. Channel diversion or dewatering are not expected to occur (Montana Mining and Timber Company 1988).

Water requirements for the project would be about 50 gpm, which would be supplied by two wells currently in use on the site. If needed, additional water could be obtained from the Middle Fork of Gold Creek under an existing water right.

Baseline surface water, vegetation, soils, and meteorological data collected for this project are included in the application. The mine site would be reclaimed to provide erosion control and stabilization and to return the disturbed areas to wildlife habitat. Trees and shrubs would be planted for cover diversity.

Mark V Mines, Inc.

Mark V Mines, Inc., submitted a conceptual mine plan to the DSL and the U.S. Forest Service in February 1988 to mine gold in the Williams Gulch drainage of Rock Creek. The proposed underground mine, called the Bagdad Gold Project, is located about 25 miles west of Philipsburg in the Lolo National Forest (MSE, Inc. 1988).

Mark V proposes to extract the ore using standard small-scale underground methods. Milling-grade material would be removed from the mine and stockpiled, to be transported periodically to a custom mill in Philipsburg. Waste rock would be used for underground backfilling. While there is currently an access road within the Lolo National Forest, the plan calls for a new access road primarily within the Deer Lodge National Forest. This new road is proposed to avoid potential sedimentation in Williams Gulch, reduce traffic on Rock Creek Road, and reduce the effects of increased traffic on private landowners along Rock Creek (MSE, Inc. 1988).

Approximately 90,000 tons of ore reserves have been identified by exploratory drilling, and geologically-indicated reserves are estimated at one million tons. Mark V hopes to begin production in August 1988, with a minimum projected mine life of ten years. The optimum level work force would be 25 to 30 people, producing 150 to 200 tons per day (MSE, Inc. 1988).

The maximum probable water discharge from the mine is

80-100 gpm. This mine water would be treated in several steps prior to discharge to a drainage ditch next to the access road.

Because of the mine's proximity to the sensitive resource values of Rock Creek and the potential for public controversy surrounding the proposed Bagdad Project, the U.S. Forest Service has decided to prepare an environmental impact statement for the site. A draft EIS is scheduled for completion by early August 1988.

American Eagle Mining Company

The American Eagle Mining Company has been operating a placer gold mine in Quartz Gulch of Rock Creek since 1987. This mine, located about 20 miles west of Philipsburg, currently operates under the small miner's exclusion (less than five acres' disturbance, fewer than 36,500 tons of material per year). In January 1988, the company submitted an application to DSL and the U.S. Forest Service to expand its operation to 41 acres. The application was found to be deficient and incomplete by DSL, and at this writing the company has not resubmitted its application.

In March 1988, the DHES Water Quality Bureau filed suit against the American Eagle Mining Company for violating the Montana Water Quality Act. In September 1987, the company discharged wastewater from its placer wash ponds without a permit. In October 1987, multiple impoundment structure failures resulted in the deposition of significant quantities of sediment in the drainage below the mine site. The DHES-WQB has sought an injunction against further mining activity until water quality violations are permanently corrected and environmental damage repaired, and it opposes the issuance of an operating permit until these problems are resolved.

ASARCO, Inc.

ASARCO has proposed to construct a 10,000 ton/day mine and mill complex to develop its silver-copper ore deposits under the Cabinet Mountains Wilderness. The project site is located on Kaniksu National Forest land administered by the Kootenai National Forest in Sanders County, on the west fork of Rock Creek approximately six miles northeast of Noxon. The ore body would be accessed through development adits with portals located outside the wilderness boundary. The underground mining would be a large-scale, mechanized, room-and-pillar operation. The ore would be crushed and ground at the ore processing complex to liberate metal-bearing sulfides. A flotation process would then be used to remove the sulfides. The copper-silver ore concentrate (about 51,000 tons/year) would be trucked to Noxon for rail shipment to a smelter (ASARCO, Inc. 1987).

The water requirement for the mill would be approximately 3,000 gpm, which would be derived from mine water drainage, fresh water wells, wastewater from sewage treatment, plant site runoff, thickener overflow, and reclaimed water from the tailings impoundment. Domestic water needs are expected to be about 30 gpm.

Tailings generated during the operation would be slurried in a pipeline to an impoundment area located mostly on private lands with portions on federal land. The impoundment area would be continuously expanded, covering approximately 376 acres during the projected life of the mine. The utility corridor containing the tailings pipelines, water pipelines, power lines, and telephone lines would generally parallel USFS Road No. 150, which would be partly relocated and upgraded to a two lane road. ASARCO has proposed reclamation objectives and developed a plan to rehabilitate all areas disturbed during mine construction, operation, and closure.

Construction and development of the mine and processing complex would require about three years. The maximum estimated mine life at full production is 30 years, with a total production of 3.6 million tons of ore per year. Full production employment is estimated at 305 to 355 people.

ASARCO originally submitted its mine permit application to the U.S. Forest Service and the DSL in May 1987. These agencies responded with a list of deficiencies, and ASARCO submitted its responses to the deficiencies in December 1987. In January 1988, a public scoping meeting was held to discuss the project proposal, the environmental analysis process, and the numerous environmental issues that have been raised regarding this project. The major issues of concern are threatened and endangered species, wilderness, the stability of the tailings impoundment, and water quality.

U.S. Borax

The United States Borax and Chemical Corporation (U.S. Borax) submitted a conceptual plan for a silver-copper mine in the Cabinet Mountains to the Department of State Lands and the Kootenai National Forest in January 1988. The mineral deposit is located 10 miles northeast of Noxon and 22 miles south of Libby. Mineral exploration in the upper Rock Creek drainage began in 1977, and acquisition of mining claims started in 1981. The mining claims are controlled by Pacific Coast Mines, Inc., Jascan Resources, Inc., and Atlantic Goldfields, Inc. This association forms the Montana Silver Venture, of which U.S. Borax is the designated operator.

The mining claims are located on federal lands in the Kaniksu National Forest, which is administered by the Kootenai National Forest. The project area is located in both Lincoln and Sanders counties. The company is considering a number of location alternatives for the evaluation adit, production adits, processing plant, tailings disposal, and ancillary facilities. Additional engineering, environmental, and economic evaluations are required before the preferred alternatives can be selected. The major decision of whether to develop the mine in the Rock Creek drainage basin or to develop it from the east side of the Cabinet Mountains on either Libby Creek or Ramsay Creek has not been made. Either scenario would involve developing the mineral deposit under the Cabinet Mountains Wilderness.

The mining operation would involve excavating and crushing the ore underground, transporting it to the surface plant for further crushing and grinding, and processing the copper-silver concentrate by flotation. Tailings generated from the process would be thickened and piped to a tailings disposal area. Water from the tailings disposal pond would be recycled to the process plant.

The approximately 1,800 gpm of water that would be needed to slurry the tailings at 50 percent solids would be collected from the underground excavations. Potable water requirements are estimated to be about 100 gpm.

The geologic ore reserve is over 100 million tons with an average grade of 2.1 ounces of silver/ton and 0.8 percent copper. Ore production rate is expected to be about 10,000 tons/day and 3.5 million tons annually. The next phase of development would include a decline into the deposit to provide data for defining the overall mine plan. This is expected to take 2 to 3 years and employ 35 to 50 people. The construction phase for the mine and processing plant would also require 2-3 years and employ 300 to 400 people. The projected mine life is 20 years, and 300 to 350 people would be employed in this production phase (U.S. Borax 1988).

U.S. Borax will have to obtain an operating permit subject to joint review by both the Montana Department of State Lands and the U.S. Forest Service. The company has described a program to develop the necessary environmental baseline data for the permit applications in the conceptual plan. Based on the agencies' approved plan of study, U.S. Borax is proceeding with the collection of environmental baseline data for the project area. Baseline data collection and the EIS process may take up to three years.

FOREST PRODUCTS

Economic forecasters indicate that the forest products industry will continue to be the backbone of western Montana's economy. While the rapid growth of the 1970s is not likely to be repeated, sustained production is expected. Many factors can influence the industry and its future, for example: changes in the U.S. housing industry, adequacy of timber supply, future energy costs, and competition with other timber-producing areas (Keegan and Polzin 1987).

Timber harvest during the past decade has relied heavily on timber from private lands. Most projections indicate that private timber sources will be very limited or depleted during the next decade. At the same time, the demand for lumber and wood products is expected to increase dramatically.

The diminished private timber supply is expected to result in new demands for harvest in national forests. The U.S. Forest Service has completed forest plans for each of the national forests in the Clark Fork Basin. The plans show the average harvest in the past and indicate the number of acres available for timber management in the future (Table 4-2). Actual harvest in national forests in the future will be increasingly managed to meet the Forest Service's multiple-use criteria and to provide sustained yields of wood products. As timber supplies diminish and demands increase, forest management efforts will be intensified.

WATER AVAILABLE FOR FUTURE DEVELOPMENT

The following sections describe water available for future development in the Clark Fork Basin. The first section addresses those issues associated with surface water, the second with ground water, and the third with water transfers. The probability of new federal irrigation projects is discussed last.

Surface Water

There are a number of issues that affect water availability for new uses in the Clark Fork Basin. These issues include the number and magnitude of existing rights and the extent of the aboriginal fishing and cultural water rights claimed by the Confederated Salish and Kootenai Tribes of the Flathead Reservation. The water rights of the tribes is an important issue that should be analyzed beyond this report. The concerns related to existing water rights and claims include the large hydropower water rights that legally control most of the flows of the Clark Fork Basin and the water rights claims submitted as part of the statewide

TABLE 4-2. TIMBER MANAGEMENT IN NATIONAL FORESTS OF THE CLARK FORK BASIN

National Forest	Total Area[1] (millions of acres)	Average Annual Harvest (millions of board feet)[2]	Suitable Timber (acres)[3]
Deer Lodge	1.3	60.0	594,771
Bitterroot	1.6	28.0	589,000
Lolo	2.2	98.5	1,402,000
Kootenai	2.1	173.0	1,800,000
Flathead	2.3	101.3	835,747
Helena	0.975	16.8	488,000

[1] Areas include parts of drainage not in Clark Fork Basin.
[2] Based on average harvest over variable time periods.
[3] Estimated acres suitable for producing commercial timber. In some instances may include areas that are designated as wilderness.

Sources: USDA 1985b,c; 1986a,b; 1987a,b.

adjudications. These issues are elaborated in the following sections.

Hydropower Water Rights

A number of large run-of-the-river power facilities are located in the Clark Fork Basin. They include the Milltown, Kerr, and Thompson Falls hydropower facilities, which are owned and operated by the Montana Power Company, and Noxon Rapids and Cabinet Gorge, which are controlled by the Washington Water Power Company. The WWP claimed 35,000 cfs through the statewide adjudications and received a provisional permit in 1976 from the DNRC for an additional 15,000 cfs for the Noxon Rapids facility.

Analyses conducted by Fitz (1980) and Holnbeck (1987) suggest that water available to upstream users for future upstream development is severely limited because of Noxon Rapids. If WWP is certified to have a 50,000 cfs water right, then no water is available for appropriation to upstream users in two years out of ten. At least 400 cfs would be available for future use between May 25 and June 17 in five years out of ten. In three years out of ten, at least 14,000 cfs is available between May 25 and June 17. On the average, no water is available before May 25 and after June 17 in every year. The long-term average flow of the Clark Fork below Noxon Rapids is 21,020 cfs, which is considerably less than the 50,000 cfs capacity of the turbines at the Noxon Rapids facility. These data are illustrated in Table 4-3 and Figure 4-1.

TABLE 4-3. TIME PERIODS WHEN FLOWS EXCEED 50,000 CFS, CLARK FORK BELOW NOXON RAPIDS

	1961-79	1961-86
Average starting date	May 22	May 25
Average ending date	June 17	June 17
Maximum number consecutive days	65	65
Minimum number consecutive days	0	0
Average consecutive days	24	22
Average total days (consecutive plus intermittent)	30	28

Source: Holnbeck 1987.

The DNRC's policy is that before issuing any new provisional permits, the applicant must show that water is

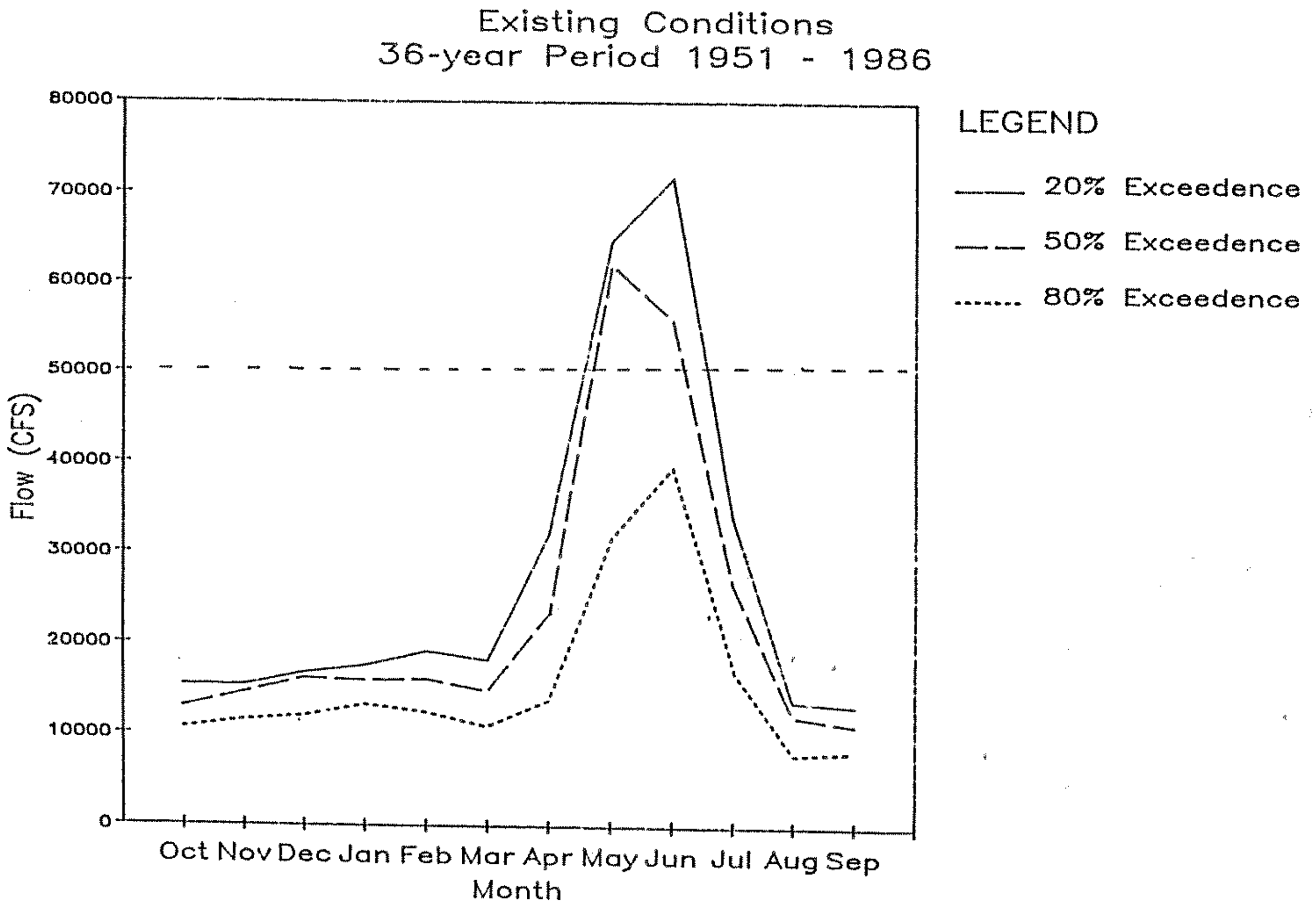


FIGURE 4-1. DURATION HYDROGRAPH FOR CLARK FORK BELOW THOMPSON FALLS DAM.
SOURCE: HOLNBECK 1987

physically available in the specific source of supply requested. The burden is also on the applicant to show that the rights of prior appropriators will not be adversely affected if the new provisional permit is granted. However, absent any objections, DNRC does not require such proof.

In the winter of 1987, the DNRC contacted WWP, MPC, BOR and Montana State University (MSU) and proposed a cooperative study to determine whether hydropower use would be unreasonably affected by the granting of additional provisional water use permits. The study began in summer 1988 and will be completed by early fall 1988. The study should help ascertain whether the basin should be closed and no new provisional permits granted, whether a block of water can still be developed before basin closure is initiated, or whether some other action, such as a negotiated reallocation of WWP's rights, is more appropriate.

The above results suggest, however, that little water is available for appropriation from the Clark Fork drainage upstream of Noxon Rapids. This includes the Flathead River drainage basin and the Clark Fork mainstem and its tributaries (e.g., Bitterroot and Blackfoot rivers, Rock Creek). Even if water is available for appropriation upstream of Noxon Rapids, it may not be available in specific tributaries where it may be most needed. The water supply, existing water rights, and public interest values must be analyzed within each subbasin to ascertain whether water may be appropriated for future beneficial uses.

Existing Water Rights

Existing water rights in the Clark Fork Basin are of two categories--those perfected after July 1973, and those in place prior to that date. Water developments after 1973 were subject to permitting or notification requirements that provided a means of assuring a reasonable correspondence between water rights and actual use. Pre-1973 water rights were not developed under such a cataloging system. The statewide adjudication program was created to recognize and confirm pre-1973 water rights in Montana, based on claims of actual water use submitted by right-holders.

Table 4-4 compares the water supply characteristics of Clark Fork subbasins with the acres, volume, and flow of irrigation claims filed for pre-1973 uses. These data are compared with calculated actual water demand for acreage under irrigation facilities in 1980.

One reason that the number of acres associated with adjudication claims is greater than the DNRC's estimate of actual acreage in use is that the same irrigated acreage has

TABLE 4-4. COMPARISON OF STREAMFLOWS WITH CLAIMED RIGHTS AND ESTIMATED ACTUAL WATER USE FOR IRRIGATION

	Average[1] Annual Flow		Adjudication[2] Claims for Irrigation (pre-1973 rights)			Estimated Actual[3] Acreage in use in 1980	
Subbasin	cfs	AF	Acres	cfs	AF	Acres	AF
Upper Clark Fork* (above Milltown)	1,633	1,183,000	210,210	3,385	996,068	28,821	413,000
Blackfoot	1,402	1,016,000	238,210	80,953	1,319,765	100,681	106,180
Bitterroot	2,486	1,801,000	510,252	106,930	2,308,270	112,755	483,710
Flathead**	12,388	8,979,000	110,210	126,354	55,677,877	174,917	711,700
Lower Clark Fork* (from Milltown past Noxon Rapids)	21,020	15,230,000	56,730	1,590	357,763	31,659	345,110

* Adjudication claim figures for these basins adjusted to eliminate most duplication of claims for the same acreage.

** Adjudication claims submitted for Flathead Indian Irrigation Project listed flow rates and volumes, but no acreages.

Sources: USGS 1987; DNRC 1988a; DNRC 1986; Elliott 1986.

been claimed under more than one water right. For example, water from two or more sources may be claimed to irrigate the same ground. However, the differences that remain between claims for pre-1973 uses and reasonable estimates of present use and available water likely reflect a substantial inflation of many claims. If the acreages and flows claimed are not verified and revised where necessary to reflect actual use, inflated claims will be incorporated into the final decree, greatly complicating future water right enforcement and water allocation efforts. For example, the final decree might grant a claimant the right to irrigate 200 acres, when in fact only 120 acres have historically been irrigated. The claimant could legally irrigate 80 additional acres under the existing water right with a corresponding increase in actual water use. Junior users could be affected with little opportunity for appeal, and water available for future use could be reduced.

Ground Water

Few aquifers in the greater Clark Fork Basin have been investigated in the detail necessary to accurately determine sustainable ground water yields. Certainly, large volumes of water reside in storage in the valley fill sediments of the Clark Fork valleys. Most of the major aquifers receive relatively abundant recharge, and several possess hydraulic and depositional characteristics that make them favorable targets for development. All, however, are integral components of the Clark Fork hydrologic system. The level of development considered acceptable in a given aquifer system should depend both upon local considerations of ground water availability and surface water sources that recharge the aquifers and that ultimately receive ground water discharge from the aquifers. Because all aquifers receive some recharge from precipitation, only other recharge factors are discussed here.

Lowland reaches of most smaller streams in the basin contain alluvial deposits that transmit ground water. The hydraulic characteristics of these deposits range from marginal to very favorable in terms of water yield to wells. They are typically limited in extent, and large well yields usually indicate nearby recharge from surface water bodies. Their location in tributary valleys frequently limits the use of such aquifers to supplying domestic and stock needs; small-scale irrigation withdrawals are occasionally possible. Local industrial operations, especially mines, derive process water from some of these aquifers and present a potential for increased withdrawals in some areas.

Secondary permeability (fracture and joint systems) controls ground water flow in most of the consolidated rocks occurring in the Clark Fork Basin. Precambrian-aged Belt-series rocks, which are widespread in the basin, usually yield only small quantities of water to wells. Exceptions to this generalization occur in areas where major fault systems provide relatively transmissive flow paths, typically along the margins of important structural basins. In these areas, well yields are occasionally adequate for community supplies and even modest irrigation. Despite their large areas of exposure throughout the region, these aquifer systems are at some risk for local overdevelopment, particularly in areas of increasing residential density, because of their storage and recharge limitations.

Bedrock aquifers featuring deep ground water circulation often express themselves as the thermal springs that are scattered throughout the basin. Some of these present the possibility of additional commercial development of geothermal water.

The important high-yield aquifers of the Clark Fork region occupy the major structural/topographic basins and are composed of unconsolidated to semi-consolidated sands and gravel deposited by fluvial and glacial processes. They vary substantially in hydraulic characteristics, their mode of interaction with surface water bodies, and their relative degree of development.

Clark Fork Basin

Missoula Aquifer. By measures of existing use and aquifer capability, the Missoula Aquifer is the most significant ground water system within the mainstem Clark Fork. Existing withdrawals are on the order of 61,000 AF/year, and an annual recharge of more than 87,700 AF was estimated for 1986. More importantly, the unusually favorable hydraulic characteristics of the aquifer material imply that very large increases in ground water withdrawals could be supported by the aquifer, as long as the Clark Fork is available as a source of natural and/or induced aquifer recharge (Clark 1986; Missoula City-County Health Department 1987). Because this relationship implies responses in Clark Fork flows to ground water withdrawal, such increases in ground water use could be incompatible with instream flow objectives or existing water rights in the Clark Fork system.

Upper Clark Fork. The aquifers of the Deer Lodge Valley and Silver Bow Creek are described in Chapters 1 and 3. These aquifers have a demonstrated record of supporting large well yields, at least locally. The existing high-yield wells serve as municipal, irrigation, industrial, and commercial water supplies. Relatively abundant recharge suggests that the aquifers could support higher levels of ground water development, ignoring for the moment any water quality concerns. Ground water leaves the upper Clark Fork through evapotranspiration or through discharge to gaining reaches of the Clark Fork.

Bitterroot Valley. Valley-fill sediments of the Bitterroot Valley cover a relatively thin mantle of Quaternary-aged alluvial gravels (generally on the order of 50 feet in thickness), which overlie at least several hundred feet of Tertiary-aged sediment of varying composition. The Quaternary gravels are generally permeable and can yield several hundred gpm to wells, depending on their saturated thickness. Bitterroot Valley aquifers generally receive recharge from irrigation losses and losing reaches of tributary streams; ground water flows toward the Bitterroot, which receives ground water discharge along most of its lowland reach (McMurtrey et al. 1972). Ground water uses from the Quaternary gravels include irrigation, municipal, and some industrial withdrawals. Less productive aquifers on the valley margins supply generally low well yields to an ever-increasing number of residential ground water users. In a number of areas, aquifers underlying elevated benches are heavily dependent on irrigation return flows and ditch seepage for recharge. Changing land uses and abandonment of some irrigation systems leave these high-elevation aquifers subject to lowered water tables and local water supply shortage.

Blackfoot River Basin. The Blackfoot River Basin contains two identifiable regions where accumulations of valley-fill sediments contain relatively large quantities of stored ground water, and where favorable aquifer characteristics are at least a possibility. One underlies the river reach beginning ten miles upstream of Lincoln and ending two miles below the town. Here sediment accumulations up to 300 or more feet thick receive recharge from the Blackfoot River. The existing withdrawals are mainly small ones from domestic supply wells. There are a few more productive wells utilizing this aquifer, and some test data indicate that well yields of a few hundred gpm may be locally possible (Coffin and Wilkie 1971). Major increases in ground water use would result in induced aquifer recharge from the Blackfoot River and/or decreased ground water discharge to downgradient gaining reaches of the river.

The extensive glacial sediments underlying the lower reaches of Nevada Creek, the North Fork of the Blackfoot, and lower Monture Creek suggest that productive aquifer material may exist in places. These aquifers currently supply mostly domestic and stock wells and little information exists regarding the potential for greater ground water uses.

Lower Flathead Basin

Little Bitterroot Valley. The Lonepine Aquifer (Donovan 1985) of the Little Bitterroot Valley stores a relatively small volume of water in comparison with the regional Kalispell Valley aquifer, but it is a locally important source of irrigation, domestic, and stock water. In addition, it has interesting management aspects to its behavior and use.

The Lonepine Aquifer consists of very permeable gravels overlain by a massive thickness of Lake Missoula silts, which provide for effective aquifer confinement and artesian flow conditions. Most large withdrawals from the aquifer are from flowing wells used for irrigation and for supplying a commercial resort dependent on the geothermal flows that contribute recharge to the Lonepine system. Approximately 1,130 AF/year currently flow past the area of irrigation use (eventually reaching the lower Flathead River or shallow alluvial aquifers). Pumping from the aquifer could allow for the capture of more of this through-flowing water and probably would induce additional aquifer recharge from the Little Bitterroot River. However, large additional withdrawals are not compatible with the maintenance of flowing wells in the area; additional development would imply the replacement of existing irrigation systems and the adoption of new modes of operation by the current water users.

The nearby Sullivan Flats-Big Draw aquifer is another system with favorable characteristics for high-yield wells but with apparent constraints on the scale of development. In this case, the aquifer discharges virtually all of its modest annual flux (1,700 AF/year) through a spring that appears to be heavily appropriated for surface water use.

<u>The Mission Valley</u>. This southern region of the Flathead Valley has a complex depositional history that accounts for a variety of known local aquifer systems, underlain by a thick sequence of glacial and glaciofluvial debris, which is a widespread regional aquifer.

Heterogeneous interstratified glacial deposits form the regional ground water flow system. It is recharged along the Mission Mountain front and at the north end of the Mission Valley. Regional flow paths are toward the south and west, discharging toward lower Mission Creek and the Flathead River (Boettcher 1982). Locally favorable aquifer characteristics allow for yields of several hundred gpm from some municipal and irrigation wells, and flowing wells are possible in several areas. Annual recharge to the system probably far exceeds withdrawals, suggesting that the area is physically capable of supporting additional ground water development. Large additional withdrawals would occur at the expense of reduced head in the aquifer and reduced ground water discharge to the surface environment.

The shallow aquifers overlying the regional flow system exhibit their own hydraulic characteristics and some degree of functional separation from the regional aquifer. Some of these are confined by surficial deposits of lakebed silts, resulting in local artesian aquifers in which wells may flow. The shallow aquifer of the Post Creek area is the most significant of these and supports domestic, irrigation, and commercial water uses often designed around flowing wells. Recharge to these flow systems may (as in the case of the Post Creek aquifer) be abundant, but at the same time, existing uses are somewhat vulnerable to well interferences because of relatively low aquifer pressures.

Jocko Valley. The Jocko Valley contains several hundred feet of valley-fill sediment, at least some of which must receive recharge from the Jocko River and irrigation systems in the area. The hydrologic characteristics of the aquifer material are not yet well described, and the aquifer's capability to support large ground water withdrawals has not been demonstrated. The existing wells are mainly small ones, used for domestic and stock water.

Water Exchanges

Water exchanges may be an option to provide for future water development in the Clark Fork Basin. Three possibilities are discussed, including: 1) contracting for water from existing storage facilities, 2) sever and sell of existing water rights, and 3) leasing by the state or private parties.

There are a number of storage facilities in the Clark Fork Basin whose releases satisfy existing water needs when the natural water supply cannot. While the storage capacity of many of these reservoirs may already be committed to supply the needs of existing users, others may have water available for purchase. For example, the state-owned Painted Rocks project on the West Fork of the Bitterroot River has had water available for purchase under contract for some time.

Water purchased from storage can be used in two ways. First, released water can be diverted directly by a user who is physically located downstream of the facility. Second, stored water can be purchased to replace water that would be depleted because of a new use higher in the drainage. The new user purchases the water and arranges for its release to eliminate the impact of the new use on a downstream right. Whether this approach can be taken depends on the existence of a storage facility above the affected senior appropriator.

New users can also buy existing water rights and change the use and source of supply. This new water development, however, cannot adversely affect any senior or junior water users. Many western states have already implemented this approach to provide for new uses after basins become fully appropriated. The large hydropower facilities in Montana may be willing to sever and sell part of their water rights. This latter option may be feasible if it is based on the power company's demand for power (e.g., surplus power) and its ability to recover the lost hydropower revenues.

The DNRC currently has the authority to lease a limited volume of water from existing and future state, federal, and private reservoirs. For most of those reservoirs, the DNRC is the only entity that can lease water if they are included in a temporary preliminary decree, a preliminary decree, or a final decree. The DNRC must also acquire the water rights in its own name or enter into an agreement with or purchase the water from the entity holding the water right. Thus, the DNRC has the ability to lease stored water for future uses. Legislative action would be required for private parties to lease their rights, and for the volume ceiling to be raised. However, at this time, it is not known whether leasing is necessary or even a viable option.

The Probability of New Federal Irrigation Projects

The Missoula Valley project, authorized in 1944, was the last federal project authorized and constructed in the study area. The probability of a new federal irrigation project in western Montana appears rather remote. The Bureau of Reclamation, in its Assessment and Implementation Plan of 1987, stressed that its primary mission as a water developer will be changed to a water resource management agency. The key finding of the study is that, "The Bureau's primary role as the developer of larger federally financed agricultural projects is drawing to a close. There have been no new construction authorizations of this type since 1968." Most U.S. Congressmen believe that the BOR has completed its primary mission of reclaiming the West. Additionally, with the surplus crops now being produced, many in Congress find it difficult to continue subsidizing new irrigation projects. However, if a very feasible project were found in the study area and the state was willing to pay a reasonable share of the cost, Congress may still be willing to authorize and fund it.

CHAPTER 5

ACTION PLAN

INTRODUCTION

The management of aquatic resources in the Clark Fork Basin is the statutory responsibility of many agencies. Although rules and statutes place some limits on their flexibility, state, federal, and local governments can maximize their effectiveness through basinwide planning and cooperation.

This chapter presents an action plan for maintaining and enhancing the quality of aquatic resources in the Clark Fork Basin. It identifies primary issues and recommends the agency or coordinated agency actions needed to resolve them. In some instances, the action may be an interim step that must be taken before final solutions are obtained. It should be clearly recognized that the plan has no ending--that the results of past efforts, as well as plans for new programs, will require continuous reevaluation. Most importantly, the responsible agencies must progress in a logical sequence to address priority issues in coordination with other agency efforts.

The action plan attempts to categorize the recommendations according to major issues, but there is clearly overlap among categories. This overlap demonstrates the critical need for coordination and continuous integration of information into a Clark Fork Basin management plan.

COMPONENTS OF THE PLAN

Data Management

Throughout the past few decades, various individuals and organizations have collected environmental data in the Clark Fork Basin. These data were often not published or were generally unavailable to other interested parties. However, through a cooperative agreement with the EPA, the DHES has developed a central Clark Fork Data Management System. The initial emphasis of this system is to store and manage data collected for CERCLA (Superfund) purposes. Other data pertaining to the Clark Fork Basin are also important to Superfund and other programs and will be added to the system as needed. The Clark Fork Data Management System is also tied to the Natural Resources Information System and the

Geographical Information System administered by the Montana State Library. It is essential that valid scientific data pertaining to the Clark Fork Basin are entered in the overall Clark Fork data file, and strong support should be given to funding this comprehensive data management system.

Public Involvement

The purpose of the Clark Fork Basin Project has been to summarize existing information and encourage coordination of agency activities. The project has been aided in this process by the strong public interest expressed throughout the basin.

Implementing the action plan and making progress on Clark Fork issues will require an informed and interested public. All phases of the planning process should be open to public participation. Government agencies should make information available to the public and should seek public involvement in decision-making.

Special interest groups, such as the Clark Fork Coalition, which represents more than 70 organizations and several hundred individuals throughout the Clark Fork Basin, and the Northern Lights Institute, are particularly important. Their efforts to inform the public on important issues and to work with all levels of government and industry on permitting issues have aided in conflict resolution. The Northern Lights Institute and the Clark Fork Coalition propose to use a community-building approach to environmental problem solving by creating a "standing forum" of citizens who are committed to improving conditions on the river.

Special interest groups are encouraged to participate in the implementation and formulation of the Clark Fork action plan.

Funding

One of the most difficult and essential components of the plan is funding. While existing state and federal funded programs can meet many requirements, most new programs will require special funding.

The Clark Fork Project was initially funded through a direct grant from the Anaconda Minerals Company and later with monies from the Resource Indemnity Trust Fund. Some funds were also available through cooperative agreements with the EPA.

Funds for many of the various agency efforts in the Clark Fork Basin have been supplied by private firms as required by federal and state permitting processes. For example, Champion International, Inc. (now Stone Container Corp.), funded the data collection required for the Frenchtown Mill discharge permit EIS, and the Montana Power Company has funded water quality data collection at the Milltown Dam site. Other firms and municipalities have funded data collection and analysis as needed for permit applications and renewals. Various special interest groups, such as Trout Unlimited, have contributed funds directly for conducting special investigations.

The EPA and the DHES have committed large sums of money to the investigation of hazardous wastes at Superfund sites in the upper basin. Recently, Congress appropriated $315,000 to the EPA to investigate water pollution problems in the Clark Fork-Lake Pend Oreille Basin. These funds have been distributed to state agencies in Montana, Idaho, and Washington to assess problems of nutrients and eutrophication.

Future funding will require diverse sources and innovative methods to derive maximum benefits. Special interest groups must continue to seek funds for their interests and states must continue to work together to obtain funding for interstate projects. Joint federal, state, and local support for long-term monitoring projects will be needed to sustain progress. Careful planning and agency cooperation should make many reclamation projects eligible for funding through the Resource Indemnity Trust Fund.

Certain projects may be funded partially or entirely through grants from foundations and industries. Successful funding in these instances will require careful coordination and integration of public interests.

Recommendations

The action plan is based on recommendations from ten technical work groups. Representatives of federal, state, and local governments and industries worked together to summarize existing conditions and to propose actions needed to correct problems and to improve aquatic resource management. Because of the widely divergent interests and responsibilities of work group members, the recommendations pertain to a wide range of topics.

In general, the following recommendations emphasize abatement of pollution and careful planning of future basin developments to minimize impacts on aquatic resources. Some recommendations require immediate agency action, while others suggest interagency investigations and planning.

RECOMMENDATIONS

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Heavy Metals and Surface Water Quality

The headwaters area of the Clark Fork has a multitude of heavy metals sources. A large part of the metals load in Silver Bow Creek is attenuated by the Warm Springs treatment ponds. However, the ponds are filling with sediment, and as their capacity diminishes, so will the level of treatment they provide. The ponds were designed to contain flows of about 700 cfs, but much smaller flows have been diverted around the ponds into the Mill-Willow Bypass because of dike failure or collection of debris on the gates. When the ponds are bypassed, untreated Silver Bow Creek water enters the Clark Fork, and metals concentrations rise, often above EPA chronic aquatic life criteria. In addition, intense summer thunderstorms can mobilize metals that have accumulated in the bypass and cause fish kills. If the pond dikes failed because of earthquake or flood damage, millions of cubic yards of toxic sludge and sediments could be released to the river. The potential threat of this problem ranks as a number one priority of the Superfund investigations on Silver Bow Creek. The ponds are currently under investigation to evaluate several alternatives for pond stabilization and maintaining or enhancing treatment of Silver Bow Creek.

As a whole, the Warm Springs Pond system has been a useful sediment trap for Silver Bow Creek and has greatly improved water quality in the Clark Fork. However, the fact that water is frequently diverted around the ponds demonstrates the need to improve the system to control and reduce the movement of dissolved and suspended toxic elements from Silver Bow Creek into the Clark Fork. Stabilizing the Warm Springs Ponds against floods and earthquakes and improving the long-term efficiency of the system are also critical.

Strategies

These goals could be accomplished in a number of ways:

1. **Renovate existing Warm Springs Pond system.**

   a. Enlarge and deepen the ponds.

   b. Modify and improve the hydraulic capacity of the pond inlet to reduce the need to bypass untreated water into the Clark Fork.

c. Enlarge and stabilize the pond dikes to prevent damage and loss of contents during floods or earthquakes.

2. **Construct a new treatment pond system.**

   a. Consider the feasibility and advantages of abandoning the old pond system and constructing a new one.

3. **Construct supplemental treatment ponds.**

   a. Consider the opportunities for and advantages of constructing additional ponds either upstream or downstream of the present system.

4. **Modify pond structures.**

   a. Modify the internal pond structures to improve the sediment settling capabilities of the ponds.

5. **Evaluate seasonal pH conditions.**

   a. Evaluate pH conditions in the ponds under different seasonal conditions to determine the need for continued lime treatments.

6. **Renovate the Mill-Willow Bypass.**

   a. Remove heavy metals contaminants from the Mill-Willow Bypass and armor the bypass channel to prevent erosion during floods.

Funding

All of the alternatives suggested above would be expensive but they would probably be cost-effective in the long term. The ponds represent a pivotal point in the Clark Fork Basin, and improvements in the system are critical to the amelioration of the heavy metals problem in the Clark Fork.

The Warm Springs Pond system is currently a top priority operable unit within the Silver Bow Creek Superfund site. A feasibility study report that will define alternatives for the system is due out in fall 1988. At that time, EPA should move quickly to choose an alternative and get work underway. Funding should be obtained from either the PRP or Superfund.

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Nonpoint Source Pollution

Nonpoint source pollution is caused by diffuse sources that are not regulated as point sources and normally is associated with activities such as agriculture, silviculture, construction, land disposal, hydromodification, and others. The primary pollutants are sediments, nutrients, toxic substances, pathogens, pesticides, acidity, and salts.

Nonpoint source pollution is a major problem in the Clark Fork drainage. The primary pollutant is sediment, derived mainly from agriculture and silviculture.

In the past, nonpoint problems in Montana have been addressed in a somewhat fragmented manner. However, baseline information does exist, and it can be used to compare future measurements of nonpoint source effects and to gauge the effectiveness of control programs. In 1985, Montana joined 55 other states, territories, and interstate water quality agencies in assembling existing information on water quality impacts caused by nonpoint sources of pollution. The effort was coordinated and the findings compiled and published by the Association of State and Interstate Water Pollution Control Administrators.

The federal Clean Water Act of 1987 established a new policy for the control of water pollution, including a directive to the states to develop and implement programs to control nonpoint sources of pollution. Section 319 of the Act provides the legal basis for implementing such programs and sets forth requirements the states must meet to qualify for assistance. The State of Montana must strive to meet those requirements. Some of the funds should address critical nonpoint source problems in the Clark Fork Basin.

Strategies

Identifying, prioritizing, and initiating programs to reduce nonpoint source pollution problems in the Clark Fork Basin should be important goals for Montanans. Strategies for achieving these goals are:

1. **Support the state nonpoint source management program.**

    a. The state should aggressively pursue actions recommended by the DHES-WQB in the state nonpoint source management program proposed under Section 319 of the Federal Clean Water Act of 1987.

2. **Create a regional water quality managers program.**

a. Solicit state and federal funding to develop a network of regional water quality managers to tackle the NPS problems in the basin. The state of Montana should choose these managers from a wide variety of agencies, including: DHES-WQB, DNRC, DSL, EPA, USFS, BLM, SCS, and Conservation Districts. These NPS water quality managers would be responsible for:

- developing nonpoint assessments and management plans in their region
- reviewing plans for activities (e.g., timber sale plans, mine plans) that may contribute nonpoint source pollutants to streams
- inspecting sites where land disturbance may occur to determine that BMPs are being employed
- conducting baseline monitoring
- holding meetings to keep the public apprised of the program and to receive their suggestions
- working with other agencies and organizations involved in regulation and abatement of nonpoint source pollution
- conducting complaint investigations.

3. **Develop a basinwide NPS management plan.**

a. Develop a comprehensive, coordinated NPS control program for the entire Clark Fork Basin. Separate NPS control programs may be generated for specific regions.

b. Identify and prioritize existing water quality problems and detail actions needed, including monitoring.

c. Draw heavily on on-going assessments of NPS problems in Montana and on plans prepared by DHES-WQB, EQC, the Cumulative Watershed Effects Cooperative, etc.

Funding

The Clean Water Act of 1987 calls for a 60/40 federal/state match for funds. The Act earmarked the following monies for NPS programs, for which the states compete:

FY 88	$ 70 million
FY 89	100 million

FY 90	100 million
FY 91	130 million

However, Congress appropriated no money for FY 88, and only $25 million of the $100 million authorized for FY 89 are being requested. EPA, Region VIII did not request any 319 funds for FY 89.

The State of Montana is seeking match money should federal funds become available. At present, the most likely source may be the 201(g)(1)B funds for wastewater treatment construction grants. The Governor has the authority to utilize up to 20 percent of these funds for nonpoint source pollution abatement. If this fund is not used, then the state would have to find some new funding source to secure match funds to implement programs developed under Section 319.

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Floodplain Tailings

Large areas of the upper Clark Fork floodplain are covered by river-borne tailings deposits or tailings disposal areas (e.g. Colorado Tailings), the result of historic mining practices in which the Clark Fork was viewed mainly as a convenient means of disposing of mine wastes. These tailings deposits are sources of contamination to soils, surface water, ground water, aquatic organisms, and other media. Once-vital riparian areas have been lost, and the tailings are considered blights on the landscape.

The floodplain of the upper Clark Fork lies within the boundaries of the Silver Bow Creek Superfund site. Theoretically, remedial or corrective actions to deal with the tailings will be implemented as part of the Superfund process. EPA has prioritized various areas within the site. Areas that pose human health hazards take precedence over those that pose environmental concern, and because the Superfund process is an arduous one, cleanup along the floodplain may be many years away.

This section contains recommended actions to address some aspects of the floodplain tailings problems in the upper Clark Fork. Reclamation of key areas along the floodplain could reduce the frequency of acutely toxic concentrations of metals in the upper Clark Fork. The cleanup actions outlined below should complement and perhaps expedite the Superfund process.

Strategies

Strategies to reduce metals inputs (especially acute toxic concentrations of copper and zinc) to the upper Clark Fork from diffuse floodplain sources are:

1. **Identify priority streamside tailings.**

   a. Review existing maps of streamside tailings in the upper Clark Fork to determine if these maps are adequate or if more mapping is needed.

   b. Conduct a detailed ground survey to identify tailings areas that are the most erosion-prone and that would be good candidates for reclamation efforts.

2. **Define the geochemistry and hydrogeologic setting at priority streamside tailings areas.**

   a. Undertake a detailed geochemical and hydrologic study of sites selected for initial reclamation work.

   b. Use existing survey data, especially that developed by the University of Montana Geology Department, to determine additional study needs.

   c. Develop a detailed map of metals distribution in the priority floodplain tailings areas.

   d. Monitor soil and ground water.

3. **Evaluate the fluvial mechanics of the Upper Clark Fork.**

   a. Conduct a detailed evaluation of the fluvial mechanics of the river prior to any major reclamation efforts. Identification, evaluation, and reclamation of streamside tailings areas could be wasted efforts if the river mechanics are poorly understood. The issues of potential sources of contamination from surface runoff, bank erosion, etc., must be set within the context of how the river functions as a physical system.

4. **Select candidate sites for reclamation.**

   a. Base selection of floodplain tailings areas for reclamation work on the geochemical, hydrogeologic and physical setting, access, and landowner cooperation. Ideally, the sites selected would represent a variety of environmental conditions so that the knowledge gained from a few sites could be transferred to other sites in the floodplain.

5. Support cleanup of large tailings deposits.

a. Direct reclamation and pollution abatement activities at major localized metals sources to reduce metals loading to Silver Bow Creek and the Clark Fork. The Colorado Tailings and Ramsay Flats areas have been studied intensively by a number of groups in the past several years. Both areas are documented contaminant sources to Silver Bow Creek and local ground water.

6. Conduct demo projects

Funding

Funding for reclamation of streamside tailings in the upper Clark Fork should be sought from a variety of sources, including the Resource Indemnity Trust Fund, the General Fund, the Coal Tax Fund, and the PRP.

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Soils and Reclamation

Large acreages in the upper Clark Fork Basin are contaminated with a variety of substances, primarily arsenic and heavy metals. Most of the soil contamination is the result of smelter emissions, use of tailings-laden irrigation water, or proximity to waste dumps. The contaminated areas pose a number of human health and environmental hazards. People who live near waste dumps or contaminated soils may be exposed to dangerous levels of pollutants. Contamination of soils has resulted in loss of productive land and reduced agricultural yields. These soils are potential sources of surface and ground water contamination.

The areas of greatest concern are in the vicinity of Butte and Anaconda within the boundaries of the Silver Bow Creek and Anaconda Smelter Superfund sites. Expedited remedial actions have been initiated by the EPA in the communities of Mill Creek (relocation of residents) and Walkerville (removal or reclamation of waste dumps; cleanup of residential yards). More of this type of work will likely be done in residential areas near the Old Works in Anaconda and Timber Butte south of Butte.

However, once the immediate health hazards are resolved, large acreages of contaminated land will still remain in both residential and agricultural areas. To date, EPA and the state have not established metals action levels for the Butte and Anaconda areas. Action levels established for other areas (e.g., the East Helena Superfund site) are likely not applicable because of natural variation in background metals levels due mainly to differences in geology. Establishment of site-specific hazard levels criteria is critical to the process of reclamation in the Butte and Anaconda areas.

In the Deer Lodge Valley, there are areas that are devoid or nearly devoid of vegetation due to contamination from either smelter emissions or historic use of tailings-laden irrigation water. The lack of perennial vegetation in these areas results in wind erosion, increased surface water runoff, increased recharge of the shallow ground water system, and possibly increased metals loading to surface and ground water. Although some reclamation projects have been initiated to address these areas, more research is needed to determine if large acreages can be cost effectively reclaimed.

Strategies

In order to establish hazard level criteria for the Butte and Anaconda areas, to support funding for reclamation projects, and to begin to establish vegetation in barren areas in the Deer Lodge Valley, these strategies are recommended:

1. **Conduct a background metals levels study in the Butte and Anaconda areas.**

   a. Determine natural concentrations of arsenic, cadmium, copper, lead, and zinc in soils in the vicinity of Butte and Anaconda. Because Butte is a highly mineralized area, background metals concentrations in soils may be higher than "typical" concentrations. The study must be carefully designed to avoid areas contaminated by smelter emissions, waste dumps, and other sources of contamination. The data will be useful in assessing the risks of heavy metals contamination and in establishing appropriate cleanup levels.

2. **Establish action levels for soils cleanup for the Butte and Anaconda Superfund sites.**

   a. Establish appropriate action levels for soils based on health risk assessments and the background soil study. The EPA and the state should develop site-specific criteria for the Butte and Anaconda sites that are sufficient to protect human health and the environment and are economically reasonable.

3. **Support funding for reclamation projects.**

   a. Make funding of reclamation projects in the Clark Fork Basin a high priority. There must be sufficient funding in place to monitor the effectiveness of various reclamation techniques and to determine if there are environmental impacts associated with those techniques.

4. **Apply reclamation techniques to larger areas.**

a. Transfer the knowledge gained from studies on small demonstration plots to larger land areas to determine if the techniques are successful, economically feasible, and environmentally sound.

b. Fund the next phase of the Headwaters RC&D project, which involves six 10 to 15-acre sites, as a first step toward reestablishment of forage on lands contaminated by mine waste. Funding of other reclamation demonstration projects will be critical in the future.

Funding

Funding for the background soils study should be provided through the Superfund process. Reclamation project funding could be derived from a number of sources, including the RIT program, Superfund, or the PRP. A cost-share program should be considered to encourage landowner participation. Without such a program to underwrite a portion of the reclamation costs, reclamation of agricultural lands would not likely be cost-effective for individual farm enterprises.

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Nutrients and Eutrophication

Excessive algae growths in the Clark Fork and Lake Pend Oreille is one of the more difficult water quality problems of the Clark Fork Basin. Except for controlling heavy metals pollution in the upper basin, the problem of nutrients and algae growth is considered the highest-priority issue.

Dense mats of filamentous green algae and diatoms, besides being aesthetically unattractive, affect water uses such as recreation and irrigation. Algae use oxygen during night time respiration, depleting oxygen needed by fish and other aquatic animals. Large quantities of algae eventually die, creating sludge deposits and oxygen demands. Rooted aquatic plants (macrophytes) found in lakes or river backwaters have similar effects when they occur in excessive quantities. In the Pend Oreille River in Washington, very dense growths of aquatic vegetation have choked out most other uses, including boat traffic.

The cause of these excessive growths is primarily due to the high concentrations of basic nutrients (nitrogen and phosphorus) found in the Clark Fork-Pend Oreille system. Despite this general knowledge, however, very little is known regarding the sources or fate of nutrients in this aquatic system. Nitrogen and phosphorus enter the water from the basin's natural geologic strata, irrigation return flows, animal wastes, domestic and industrial waste water, and the atmosphere. The relative contribution of nutrients from each of these sources is generally unknown.

Controls on nutrients to slow down or reduce eutrophication can be implemented by a variety of methods, including: treating wastewater, limiting or banning the use of phosphates in certain products (e.g., detergents), reducing soil erosion, putting voluntary restrictions on the use of lawn fertilizers, placing and maintaining septic tanks properly, treating urban stormwater runoff, and encouraging proper land use activities. Many of these control efforts require strong citizen support and voluntary participation; others require relatively expensive treatment operations.

A special program to investigate the sources and fate of nutrients in the Clark Fork-Pend Oreille Basin was initiated in 1988. The investigation is a coordinated program funded under Section 525 of the Clean Water Act Amendments of 1987. The states of Montana, Idaho and Washington, working in cooperation with the EPA, have outlined a three-year assessment of nutrient-eutrophication problems in the basin. The results of this investigation are expected to provide a measure of the eutrophication problem and sources of nutrients, and to indicate appropriate control measures. The continued close cooperation of the three states is essential in meeting the program goals and sustaining the required funding.

Strategies

The following is an outline of the three-state program:

1. Montana study objectives.

a. Conduct a critical review of all available criteria relating periphyton standing crop to beneficial uses and factors regulating periphyton standing crop in flowing waters.

b. Determine the existing standing crop and nutrient status of periphyton in the Clark Fork River (seasonally) and relate data to existing criteria.

c. Conduct an on-site study at selected locations to determine factors (e.g., sediments, nutrients, temperature, substrate, metals, macroinvertebrates) limiting periphyton growth and standing crop in the Clark Fork.

d. Identify primary nutrient sources and establish appropriate criteria for controlling periphyton growth in the Clark Fork Basin.

2. **Idaho study objectives.**

a. Develop a nutrient budget for Lake Pend Oreille, including point and nonpoint sources.

b. Assess nutrient levels and/or reductions necessary to protect lake water quality.
c. Provide a final report in the Clean Lakes Phase I Diagnostic Study format.

3. **Washington study objectives.**

a. Evaluate the trophic conditions within the Pend Oreille River system, including identification of limiting nutrients and characterization of current trophic status.

b. Develop a seasonal and annual nutrient and water budget for the reach from Albeni Falls Dam to Box Canyon Dam (R.M. 90 to R.M. 34).

c. Characterize external loading sources to the Pend Oreille River, including comparison of local tributaries, nonpoint, and point sources.

d. Evaluate potential internal loading of nutrients from macrophytes and sediments.

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Fisheries

The Clark Fork fishery has been seriously damaged by more than a century of water quality degradation and physical habitat alterations. Water pollution abatement in the past two decades has improved the fishery, but game fish are considerably less abundant in the Clark Fork than in other rivers of comparable size. The factors affecting the fishery change as the stream flows from its contaminated headwaters to its confluence with Lake Pend Oreille. Some of these factors are readily recognized, while others are less obvious and require additional investigation.

The upper river fishery continues to be damaged by the acute and chronic toxicity of heavy metals. Copper and zinc concentrations frequently exceed criteria for the protection of aquatic life at all locations in the upper river. Episodes of acute toxicity, which often occur after thunderstorms, may kill an entire population, but the survival of early life stages of trout is probably most affected by chronic metals pollution. The scarcity of trout in most of the upper river further suggests that reproduction and recruitment is limited.

Another obvious factor affecting trout production is the seasonal dewatering of the Clark Fork and its tributaries. Dewatering because of irrigation diversions results in diminished fish habitat and marginal water quality conditions. Segments of some tributaries are dewatered entirely for short times during some critical water years.

The effects of other factors on the upper river fishery are less well known. Information is needed on spawning areas and on factors (other than toxicity) that may limit recruitment of young fish into the population. Habitat degradation has occurred in several areas due to mining waste deposits, stream channelization, and heavy livestock use in riparian zones.

Less is known about the fishery from Milltown Dam to the mouth of the Flathead River. DFWP has surveyed fish populations in this reach and evaluated the importance of tributaries for spawning areas only in the past few years. Preliminary data suggest that the abundance of game fish is considerably below other rivers of comparable size. Recent water quality investigations have not documented toxic or other adverse conditions in surface water that might affect the middle river fishery.

The lower river fishery has been most affected by physical habitat alterations. The hydropower dams and reservoirs of the lower river have blocked fish migrations and created relatively poor fishery habitat. The rapid water exchange through the reservoir and fluctuating water levels limit the biological productivity needed to sustain a larger fish population. Early attempts to manage the reservoirs exclusively for salmonids have been unsuccessful, but recent introductions of cool-water species have shown some promise. The availability of spawning areas for salmonids is limited. Some tributary streams have subterranean flows in the lower reaches that block spawning migrations; other streams are scoured during spring runoff leaving poor spawning substrates.

Strategies

The goals of a fisheries program for the Clark Fork are to increase the abundance of game fish throughout the mainstem and to identify and protect the habitat required to sustain game fish production. Improving the Clark Fork fishery requires action, especially on the part of DFWP, in several separate, but related categories:

1. **Eliminate acute toxicity conditions in the upper river.**

   a. Design and implement a reclamation plan to prevent the direct entry of precipitation runoff from streamside tailings into the river. The reclamation plan should utilize existing data and new information gathered for this purpose (see "Floodplain Tailings"). Government agencies, private parties, and landowners should work together on this plan.

2. **Investigate trout fry and fingerling survival in the Clark Fork mainstem.**

   a. Continue DFWP investigations of trout fry survival at selected locations in the upper river. Live fish containers developed for this purpose should be placed to help identify specific locations where acute and chronic toxicity conditions exist. These data should be used in the development of a reclamation plan (see #1).

   b. Continue DFWP evaluations of the survival and growth of trout stocked at key locations in the river. The data gained from these test plants will be useful in assessing the relative survival rates of different trout species and better defining factors limiting trout abundance.

3. **Remove barriers to potential spawning areas.**

   a. Identify all tributary streams where spawning trout migrations are blocked by natural or man-made barriers and work with landowners and sportsmen's groups to remove such barriers or provide fish passage around them. The following tributary streams have been identified as having barriers or potential barriers to spawning trout: Gold Creek, Six-Mile Creek, Harvey Creek, Tamarack Creek, and Siegel Creek.

   b. Exercise beaver control on streams where beaver dams are affecting trout access to important spawning areas.

4. **Protect instream flows.**

   a. Complete measurements of instream flow requirements for fisheries and analysis of fish populations on the middle river and tributaries. DFWP study results should be used to support an application for water reservations needed to maintain and enhance the existing fishery.

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b. Investigate opportunities for the DFWP purchase or lease of water rights in the key tributary streams to maintain instream flows. Warm Springs Creek at the Clark Fork headwaters is an example.

c. Continue seeking a long-term DFWP lease or purchase of water rights from Painted Rocks Reservoir to maintain instream flow in the Bitterroot River.

d. Hire a state water commissioner to monitor and control legal water uses, especially on the upper Clark Fork and on the Bitterroot River.

5. **Survey spawning grounds.**

a. Conduct a systematic survey of tributary streams to identify important spawning grounds and rearing habitat. The DFWP should protect critically important areas by special regulation, riparian zone management, instream flows, and other management programs as needed.

6. **Regulate reservoir water levels.**

a. Evaluate the tradeoffs among various user groups under different flow scenarios with an integrated model utilizing data on the water requirements for irrigation, recreation, and fisheries. The model should be used to determine reservoir operations that have the least effect on other beneficial uses.

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7. **Develop a stream corridor management plan.**

a. Utilize existing information on channel instability due to natural and man-made events, riparian land uses, riparian vegetation, sediment transport, and hydrologic data to prepare a stream corridor management plan for the Clark Fork Basin. The plan should involve local, state and federal agencies, other interested parties, and landowners, and should provide for long-term management programs to stabilize riverbanks, minimize channel meander, protect agricultural lands, protect and enhance fish and wildlife habitat, and enhance water quality. The plan should identify funding requirements and sources, and outline an implementation schedule.

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These statements are in conflict.

8. **Improve reservoir fish habitat.**

a. Commission a bottom- contour map of the Noxon Rapids and Cabinet Gorge reservoirs to aid in fisheries management of the reservoirs. The map should include depth contours at least down to the level of maximum drawdown to assist fisheries and reservoir managers to minimize effects on fisheries and ~~maximize~~ optimize biological production.

b. Work with the DFWP sportsmen's groups, and the Washington Water Power Company to develop and evaluate artificial structures in the reservoir to create fish habitat and substrates for macroinvertebrates.

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Recreation

The Clark Fork Basin offers many exceptional recreational opportunities. The river and its tributaries are a focal point for many forms of recreation ranging from waterfront parks in Missoula to whitewater rafting in Alberton Gorge.

Many individuals and groups have urged the state to more actively promote recreation and tourism as a means to diversify the basin's economy. Many private and public facilities exist to meet recreational needs but it is unknown if appropriate facilities are available for future needs.

Strategies

1. **Conduct a comprehensive survey of recreation use.**

a. Conduct a comprehensive analysis of all active and passive recreational uses in the basin, especially those closely associated with the river and its tributaries. The analysis should summarize existing uses and facilities and estimate future needs.

2. **Develop and implement a basinwide recreation plan.**

a. Utilize the recreation survey data to plan for the long-term recreational needs of the basin. The plan should consider and provide for such activities and facilities such as fishing access areas, RV parks, camping, handicap parks, nature trails, bicycle paths, canoe pull-outs, boat ramps, fishing, and other water-based recreation facilities.

b. Evaluate and encourage opportunities for special community activities associated with the riverfront in communities along the Clark Fork. Local governments, special interest groups, and recreation planners should convene workshops and public information sessions to identify and encourage appropriate recreational and waterfront development programs.

Funding

Program planning and site development will require major investments. A variety of funding sources should be considered, including special revenues from gasoline sales, fishing licenses, bed taxes, state land lease fees, and tax on recreational equipment.

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Monitoring

Water quality monitoring is one of the essential tools of water quality management. Scientifically valid data collected over a long period are necessary to assess changes in water quality. The need for water quality data on the Clark Fork became most evident in 1983 when Champion International, Inc., applied for a modification of its wastewater discharge permit. The lack of adequate data to support permitting decisions resulted in delays and public uncertainty.

Since 1984, the Water Quality Bureau has maintained an intensive water quality monitoring effort at more than 30 stations located from near the headwaters to the Idaho border. This water quality sampling, supplemented with biological data, is the most comprehensive water quality record for the basin. It is essential to continue this monitoring program for at least another biennium.

In addition to the WQB monitoring, several other agencies and industries have collected valuable data from surveys and specific projects. All of these programs have improved our knowledge, but developing a long-term, comprehensive, environmental monitoring program for the Clark Fork Basin is paramount.

Such a program should provide a sufficiently detailed record of water quality and biological data to identify trends and new problems and to measure the effects of resource development, changing land uses, and reclamation and pollution control programs.

Strategies

The strategies for achieving these goals are:

1. **Continue WQB monitoring in the Clark Fork Basin.**

   a. Maintain the current WQB monitoring program to provide information for trend analysis, to refine our knowledge of certain pollutants such as nutrients, to measure progress in Superfund cleanup in the headwaters, to measure effects of new mining projects, and to define water quality over a broader range of flow conditions (FY 85-88 were relatively low-flow years).

b. Approve the WQB budget request to continue the monitoring program for another biennium.

2. **Create an interagency monitoring work group.**

a. Appoint an interagency monitoring work group or (committee) consisting of representatives from agencies or groups that have a direct interest in water quality management in the basin, such as DHES, DFWP, DNRC, USFS, USGS, MBMG, SCS, Conservation Districts, the Confederated Salish and Kootenai Tribes, local governments, and others.

3. **Develop a cooperative interagency monitoring program.**

The goals of the interagency monitoring work group or committee will be to:

a. Design a comprehensive ambient water quality and biological monitoring program that provides the sampling procedures, analytical methods, and quality control needed to satisfy all participating agency requirements.

b. Reduce overall agency costs.

c. Provide baseline data that meets agency needs and can be supplemented with project-specific investigations.

The monitoring program should:

- define goals and objectives
- define how the data will be stored and used by the participating agencies
- identify the specific monitoring needs of the Clark Fork and eliminate duplicative or nonessential monitoring
- identify data needed to meet monitoring objectives
- describe the following program components:

  -sampling stations
  -sampling frequency
  -sampling techniques

  - -analytical techniques
  - -quality assurance program
  - -data analysis and storage

- estimate annual costs associated with the monitoring needs

- define appropriate mechanisms for funding

- define appropriate roles for agencies in implementing the program

- recommend an interagency structure and cooperative agreement to manage the monitoring program, including a schedule of periodic meetings to review and interpret data and to make necessary adjustments in the program
- identify opportunities for citizen participation.

4. Initiate a long-term surface water monitoring program.

a. Maintain key monitoring stations in the Clark Fork over the long term (20 years or more) with stations at Deer Lodge, Turah, Alberton, and Whitehorse Rapids.

b. Set study parameters ~~to~~ might include:

- pH, EC, TSS, VSS, hardness, alkalinity, temperature

- Total recoverable and dissolved As, Cu, Zn, (carbon furnace)

- Daily sediment at Turah and possibly Alberton

- Biota

c. Monitor water quality 12 times per year based on flow. For biota, monitor once per year at Turah and Deer Lodge.

* d. Maintain established stream gaging stations at Deer Lodge, Turah, and Whitehorse Rapids.

e. Establish a new gaging station at Alberton.

f. Fund the program. The USGS estimates that such a program would cost $91,000 the first year and $86,000 per year thereafter.

USGS not necessarily the agency to do the work.

(19)

Water Rights

Effective management of water resources in the Clark Fork Basin in the coming years depends greatly on the resolution of a number of water rights issues. Chief among these is making a determination of the physical and legal availability of water in the basin. This determination cannot be made until the status of large hydropower companies' water rights is decided and an accurate adjudication is completed. Other issues include the water rights of the Confederated Salish and Kootenai Tribes, new water use permits, and water allocation alternatives.

Strategies

1. **Determine the status of large hydropower water rights.**

    a. Determine the status of WWP's total water right (claim for 35,000 cfs and provisional permit for 15,000 cfs) at Noxon Rapids. If the Water Court decides that WWP is certified for that right, and if WWP chooses to exercise its right to object to new uses on the basis of adverse effects, then little or no water may be available to upstream users for appropriation in most years (without storage). This could trigger an action to limit or cease issuing water use permits in part or all of the basin or during some periods of the year.

2. **Determine the physical and legal availability of water in the basin.**

    a. Complete a water-availability analysis. DNRC and other cooperators (WWP, BOR, MPC, MSU) are currently conducting a study to determine whether hydropower interests would be unreasonably affected by the granting of additional provisional water use permits. Once this water availability analysis is complete, it may be possible to reach a mutually acceptable decision regarding the physical and legal availability of water in the basin.

3. **Complete an accurate adjudication in the Clark Fork Basin.**

    a. Determine how much water has actually been appropriated, how much water is left in the basin for new consumptive uses, and how to administer water rights equitably by completing an accurate adjudication.

4. Encourage settlement of the reserved water right of the Confederated Salish and Kootenai Tribes.

a. Determine the extent of the aboriginal fishing and cultural water rights claimed by the Confederated Salish and Kootenai Tribes in the Flathead Basin. The BIA has submitted claims, on behalf of the tribes, for water rights and instream flows on streams in the Flathead system. These issues are currently in litigative status, and the outcome of the litigation could affect water availability for new uses in the Clark Fork Basin.

5. Encourage clarification of the adjudication law.

a. Clarify the adjudication law to more clearly define the role of the Water Court and judge and to ensure the accuracy of the adjudication process. The adjudication schedule should be determined by the legislature.

6. Clarify the State of Montana's position on existing water rights.

delete

a. Standardize the state's position on existing water-rights. At present, there appear to be differences in interpretation of water rights law among state agencies.

7. Seek legislation for a moratorium on issuing new water use permits.

a. Seek legislation for a moratorium on new water use permits (for purposes other than domestic uses) until some of the issues surrounding the physical and legal availability of water in the Clark Fork Basin are resolved. The legislation should specify a certain size limit for domestic uses that would allow individuals to meet their needs.

8. Formulate water allocation alternatives.

a. Develop a mechanism to deal with water needs should a decision be made to close the Clark Fork Basin to new water use permits.

b. Explore alternatives or options such as interbasin exchanges, free market exchange, and reallocation of hydropower water rights. Institutional barriers to these options should be addressed.

9. Improve public information on water rights.

a. Develop a program to increase awareness of water rights procedures and issues in the Clark Fork Basin.

(10)

Water Management Issues

Management decisions regarding water resources in the Clark Fork Basin are hampered by, among other things, the lack of an up-to-date land use database and the lack of coordination in ground water and surface water permitting processes.

Strategies

1. **Update land use data in the Clark Fork Basin.**

    a. Facilitate future water management decision by maintaining an accurate, up-to-date land use database in the Clark Fork Basin. For example, estimates of irrigated acres in the basin (given in this report) range from 230,000 to 400,000. No one knows how much land is actually under irrigation. Ideally, the database would be updated yearly in a consistent manner and the data would be made widely available.

2. **Initiate conjunctive management of surface and ground water.**

    a. Consider both surface and ground water in the basin in issuing provisional permits to appropriate water. The DNRC should identify those areas in the Clark Fork Basin where surface water-ground water relationships need to be defined. Once these relationships are understood, surface water impacts can be considered in making ground water permitting decisions. The DNRC should also identify the analytical tools needed to evaluate ground water use impacts on surface flow. Areas where future development may occur should be given a high priority. The priority site list should be used to establish funding directives for research in the basin.

(11)

Instream Flow Reservations

Instream flow reservations are needed in the Clark Fork Basin to maintain fish and other living organisms, to protect water quality and domestic water supplies, and to enhance aesthetic qualities.

Strategies

1. **Encourage the city of Missoula to file an instream flow reservation in the Clark Fork.**

middle + lower river application

a. Encourage the city of Missoula to file an instream flow reservation application to protect flows in the Clark Fork that recharge the Missoula aquifer. The Clark Fork provides approximately 46 percent of the annual recharge to the Aquifer, which supplies drinking water for Missoula residents and water for two municipal systems, many small community systems, several large industrial users, and private well owners. It would therefore be in the best interest of the city to protect instream flows in the Clark Fork.

2. **Encourage others to seek instream flow reservations in remaining portions of the basin.**

a. Seek instream flow reservations in the middle and lower Clark Fork and tributaries. Although instream flow reservation applications have been made by DFWP for the upper Clark Fork and its tributaries, there have been no such reservation applications for the remaining portions of the basin. It is important to the future of the Clark Fork that agencies such as DFWP, USFS, BLM, and others file reservation applications. DHES also

3. **Seek legislation to allow purchase of water rights.**

a. Seek legislation to allow agencies to purchase water rights for instream uses in areas where instream flow reservations cannot be met because of current flow regimes.

b. Seek legislation to allow the state to buy or lease senior water rights to use instream and to transfer water conserved through increased efficiency to instream use with compensation to the owner. This is the only way water can be obtained from senior right holders. This would be extremely important for instream flow protection in dewatered streams that are over-appropriated.

(12)

Information Needs

In the last few years, a considerable amount of data has been gathered in the Clark Fork Basin. Such information has dramatically increased our knowledge of how the river system functions and how it reacts to environmental stresses. An adequate information base now exists that can be used to take decisive remedial action and to establish preventive programs. However, a number of gaps in that knowledge remain, and some of the research has raised new questions that need to be addressed.

Many of the existing problems in the basin are focused in the upper river, where elevated levels of metals are prevalent on land and in the waters. Most future activities in the upper basin will be tied to Superfund; however, there are a few projects that should be conducted separately from that process. To improve our understanding of the Clark Fork system, specific investigations and short-term monitoring programs (to supplement basic monitoring programs now in place) should be initiated and funded.

Strategies

1. **Study ground water effects on metals loading.**

   a. Conduct a comprehensive study of the contribution of ground water to metals loading problems in the upper Clark Fork. The study should use existing wells (and possibly some new wells) and should focus on the headwaters and Deer Lodge areas.

2. **Document the extent of the carbonate zone in the vicinity of the Anaconda and Opportunity Ponds.**

   a. Determine the actual thickness of the alluvial deposits underlying the tailings contained in the Anaconda and Opportunity Ponds. Two distinct source zones for solutes have been identified in the tailings--a saturated zone just above the alluvium and an oxidizing zone in the upper part of the tailings that will slowly move downward. Modeling has predicted that many thousands of years from now, oxidation of sulfides to sulfuric acid could lower the pH at the bottom of the tailings and cause the release of metals such as arsenic, cadmium, copper, lead, and zinc. However, if there is sufficient thickness of carbonate-rich alluvium beneath the tailings, the acidity may be neutralized and the metals attenuated before reaching the ground water. The unconsolidated alluvial deposits are estimated to range from more than 100 feet thick in the western portion of the site to about 20 feet thick east of the Opportunity Ponds. However, a detailed study should be conducted in the vicinity of the ponds to document the actual thickness and percentage of carbonate in the alluvium to determine if it will afford adequate ground water protection in the future. More modeling efforts may be required to make this determination.

3. **Determine the effects of the Phosphoria Formation and phosphorus mining on water quality.**

   a. Determine the phosphorus load derived from the Phosphoria Formation, a geologic strata rich in phosphorus near Garrison, or from past and present phosphorus mining in the area. Intense surface and ground water sampling should be done to characterize these sources of phosphorus. Wells should be sampled in the Garrison area during summer when ground water is most likely to enter the river and when additional phosphorus would cause the most problems.

4. **Monitor nitrogen loading from the Bitterroot River.**

   a. Conduct intense water quality monitoring along the lower Bitterroot to pinpoint the sources contributing to elevated levels of nitrogen in the Clark Fork system. The Clark Fork should be monitored directly above and below the confluence with the Bitterroot to determine the nitrogen load attributable to the Bitterroot. Septic drainfields and irrigation return flows are suspected sources.

5. **Conduct ground water studies of the lower Clark Fork.**

   a. Further water management objectives by making long-term observations in the lower Clark Fork Basin in areas where changing land uses, increased consumptive water use, and other cultural activities may influence ground water availability and quality. Most of the ground water monitoring emphasis in the Clark Fork Basin has been focused in the upper basin. However, not all monitoring needs are tied to the areas of historic mining impact in the headwaters.

   b. Conduct a reconnaissance ground water study of the lower river (from Huson to Lake Pend Oreille) to gather basic information about the local aquifers and their relationship to the Clark Fork. A number of new monitoring wells may be required.

6. **Document the extent of the mixing zone for Clark Fork tributaries.**

   a. Conduct a rhodamine dye study to determine the extent of the mixing zone created when a tributary enters the Clark Fork. Failure to consider the extent of mixing could lead to erroneous interpretations regarding water quality and its relationship to other uses.

7. **Collect baseline monitoring data for tributaries that may be affected by proposed mines.**

   a. Maintain a database for those Clark Fork tributaries, such as German Gulch, the Blackfoot River, Gold

Creek, Rock Creek (near Clinton), and Rock Creek (near Noxon), where mining activities are currently proposed. Although some monitoring data have been collected by the mining companies, it would be appropriate for the WQB to maintain a database to assess potential effects of those projects on surface waters.

8. **Monitor the effects of early snowmelt events on Clark Fork water quality.**

   a. Develop a program that can be initiated on short notice to monitor water quality during late winter-early spring snowmelt runoff events in the upper Clark Fork. Most water quality monitoring programs on the Clark Fork are designed to monitor late spring-early summer runoff events. However, in the last couple of years, significant late winter-early spring snowmelt runoff events have occurred. Some water quality samples collected during these events have contained very high concentrations of heavy metals. Additional, systematic monitoring is needed to define the frequency, duration, and extent of these conditions. Daily or every-other-day monitoring at one or two stations may be required for short periods.

9. **Document water quality conditions during fish kills.**

   a. Establish a special monitoring program to document water quality during events such as thunderstorms. A number of fish kills have occurred near the headwaters in recent years, most of which have been attributed to mobilization of soluble metals in the Mill-Willow Bypass and the upper Clark Fork following intense summer thunderstorms. A monitoring program utilizing local residents to collect data and automatic sampling devices has been proposed by DHES and EPA. This program should be implemented as soon as possible.

10. **Monitor DO concentrations at key locations in the Clark Fork.**

    a. Initiate a special WQB monitoring program to measure late summer, early morning DO concentrations at key locations in the basin. The monitoring program should provide a systematic evaluation of DO in the river to determine if concentrations are affecting beneficial uses.

11. **Monitor water temperature regimes in the Clark Fork.**

    a. Initiate a program to characterize the water temperature regimes in critical river reaches, particularly during late summer. Temperature, like other water quality parameters, is highly variable, and a long-term database is essential to interpret changes and to establish long-term trends. Available temperature data should be completed and analyzed to establish a historical database.

⑬

Program Implementation and Continuity

During the past four years, the Clark Fork Basin has been the focus of many agency activities. The Clark Fork Basin Project initiated by Governor Schwinden has worked to coordinate these activities and to formulate an action plan for the future. The completion of this report concludes the Clark Fork Basin Project, but it should also signal the beginning of a new effort to implement the project recommendations.

It is essential to maintain the continuity of agency activities to assure progress in pollution abatement and water resource management. An organizational structure should be estabilished to accomplish the following objectives:

- Maintain a high level of communication with government agencies, special interest groups, and the general public
- Maintain coordiation and cooperation of divergent regulatory authorities and other interested parties with responsibilities for resource protection and management
- Continue to collect those data necessary to formulate and implement remedial actions and reclamation programs
- Ensure that actions recommended by this report and other investigations are implemented
- Continue to seek new approaches to government regulation that will reduce conflict and improve efficiency
- Encourage a basinwide coordination of water resource management involving issues of regional importance.

Strategies

1. **Continue the Clark Fork Basin Project.**

Continue the project in the Governor's Office as it has been structured in the past. A Clark Fork Basin Project coordinator, whose primary responsibility is the Clark Fork Project, would serve as chairman of the Interagency Task Force and the Citizen's Advisory Council.

a. Implement the actions recommended by this report.

b. Promote communication among agencies and with the general public.

c. Continue basin management planning, including joint efforts with downstream states.

d. Conduct special projects as recommended by the task force.

e. Seek funding to implement the recommended programs.

2. **Create a Clark Fork Basin Commission.**

a. Create a Clark Fork Basin Commission as a permanent governmental entity. The commission structure would include representatives of selected state and federal agencies, industries, local governments, and citizens representing local interests. The statute creating the commission would define the organization's structure, funding, and responsibilities. The commission could be staffed through the Governor's Office in a way similar to the existing Flathead Basin Commission.

3. **Create a limited-tenure Clark Fork Basin Commission.**

a. Create a Clark Fork Basin Commission identical to #2 except that it would be authorized for a limited time only, e.g., four to six years. During its existence, the commission would be expected to focus on implementing recommendations, maintaining a long-term monitoring program, and coordinating agency activities.

4. **Develop a Clark Fork Program.**

a. Create an interagency task force of state, federal, and local government agencies through the office of the Governor. A member of the Governor's staff would chair the task force and serve as a liaison to citizen interest groups and organizations. This alternative provides an informal mechanism to coordinate agency actions and to communicate with citizens of the basin.

5. Create an interstate basin organization.

a. Create an interstate basin commission to address resource issues common to Montana, Idaho, and Washington. The governors and selected representatives of the three states would establish a formal mechanism to share information, identify concerns, and formulate plans for action in the basin. The commission would work to obtain funding for the regional projects and to resolve conflicts among states.

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put w/ F-5-2

State of Montana
Office of the Governor
Helena, Montana 59620
406-444-3111

TED SCHWINDEN
GOVERNOR

RECEIVED
FISHERIES DIV.

DATE: September 7, 1988

TO: Clark Fork Interagency Task Force, Workgroup Leaders, and Interested Persons

FROM: Howard E. Johnson, Coordinator HEJ
Clark Fork Basin Project

SUBJECT: **MEETING - SEPTEMBER 13, 1988**

The Task Force meeting will be held at **9:00 a.m. - 12:00 p.m., Tuesday, September 13, 1988, in Room C-209 of the Cogswell building.** A meeting agenda is enclosed.

The purpose of the meeting is to review the Clark Fork Status Report and Action Plan. It is essential to discuss agency comments and changes suggested by the agencies before the report is released for public review. We are especially concerned about your review and comments regarding the Recommendations.

We are scheduled to release the report for public review on September 26, 1988.

Enclosure

put w/ F-5-2

L. Spence
Fish

Montana Department of Fish, Wildlife & Parks

1420 East 6th Avenue
Helena, MT 59620

August 31, 1988

RECEIVED

FISHERIES DIV.

Howard Johnson, Coordinator
Clark Fork Basin Project
Office of the Governor
Helena, Montana 59620

Dear Howard:

We have reviewed the Clark Fork Basin Status Report and Action Plan at the Montana Department of Fish, Wildlife, and Parks. All of those who reviewed it commented on the fact that it was well written and comprehensive. You and Carole Schmidt are to be complimented on the production of an excellent draft. The comments we offer are suggestions for your consideration in the development of the final report.

On page 2-5 the last line refers to Stone Container meeting "its goals." Are these goals synonymous with conditions of the discharge permit and the water quality standards for the river? If everything is consistent that should be stated and if it is not, that too should be stated.

Page 2-6 discusses Stauffer Chemical Company and their pollution abatement program. The implication is that they may not be in compliance with either air or water quality standards. If that is the case I think the report should state that fact.

On page 2-17 the report makes a major topic switch from the economics of hydropower into the biology of streams. It does this by opening a discussion on macroinvertebrates. I think the report needs a small transition here to notice the reader that the subject is now the biota or something of that nature.

The discussion on page 2-19 under the heading "Milltown Dam to ..." begins by stating "Pollution in the Clark Fork has had a less dramatic effect....downstream from Missoula..." but it does not tell us why until the second paragraph on 2-20. It might be useful to move the paragraph from 2-20 forward. Throughout this section comparisons are made with other Montana rivers regarding macroinvertebrates, fish etc. Missing from the comparisons and the references was a report by Knudson, 1984 "A preliminary Assessment of Impacts To The Trout Fishery of The Upper Clark Fork River Montana". This report may be of some interest.

AGENDA

Clark Fork Project - Interagency Task Force
September 13, 1988
Cogswell Building, Room C-209
Helena, Montana

I. Discuss Meeting Purpose and Goals --

- brief review of the Clark Fork Status Report and Action Plan
- procedures used to obtain agency review
- time schedule for distribution of report to the public

II. Discussion of Agency Comments --

- comments from individual agencies
- review any agency conflicts

III. Discuss Future Actions by the Task Force

A Discussion of waste water disposal begins on page 2-35. Somewhere in this report a discussion about the relationship between diluting flows and discharge permits should be included. The idea of issuing dilution dependent discharge permits without instream reservations needs to be challenged. This kind of discussion could occur here or in the vicinity of 3-17.

Instream flows are discussed beginning on page 3-14. It might be interesting to suggest that perhaps stream depletion beyond a certain point could be halted by application of the public trust principles. It of course would have to be recognized that they have never been applied. It also might be mentioned that as a matter of policy DNRC simply grants every application for water rights submitted leaving it up to the existing water users to protect their senior rights.

The discussion of superfund begins on page 3-19. The role of the state and the state's "Mini Superfund" Act are not described. The state is presently investing considerable energy in asserting itself in the superfund program and that should be recognized in this report.

On page 3-29 the report makes a transition from discussing sites to discussing types of contamination. A transition statement letting the reader know what is happening would be helpful. In this section of the report the work "redox" appears. I suggest you look at the report with the idea of developing a glossary of terms because we can't assume all readers will be familiar with some of the language we use.

The first paragraph on page 3-42 and the last paragraph on page 3-43 discuss deposition of tailings. I believe a discussion of stream gradient is relevant and should be included. In regard to the comment on 3-42 perhaps gradient is more important than distance when analyzing the distribution of contaminants.

Page 3-48 contains a couple of candidates for the glossary, "amended" and "non amended" soil, along with "bioaccumulation" and "lysimeters" from 3-49. The last paragraph of 3-61 likewise has a load of jargon and a high fog index that a glossary might help.

The last paragraph on page 3-117 is a good one, it should be followed through on or repeated in the "Future Needs" section and the "Action Plan" section.

On page 5-3 I would like to see the "special interest groups" terminology changed to public interest groups, it appears twice on this page.

Abandoning the Warm Springs pond as a treatment pond is suggested under item (2) on page 5.5. I would like to suggest if a new tailing pond is built we consider retaining the existing ponds as a wetland.

On page 5-23 item (7) suggests seeking legislation for a moratorium on new water use permits. Section 85-2-319 of the Montana Codes also provides, "...or the department may by rule reject permit applications or modify or condition permits issued in a highly appropriated basin or sub-basin." The code book I used was an old one (1983) and you might check on whether or not the language is still valid.

I have a suggestion for your consideration under the action plan section of the report. Basically it is to ask the legislature to adopt the Action Plan by legislative resolution and to direct that budget requests and allocations reflect the various strategies identified in the report.

Finally, I have several other reviews that were conducted by our Department. They are attached for your information. Once again we commend you and Carole on an excellent draft and we look forward to your final report.

Sincerely,

Jim Posewitz
Resource Assessment

Attachment

cc: Pat Graham
Jerry Wells
Liter Spence
Glenn Phillips

Montana Department
of
Fish, Wildlife & Parks

MEMORANDUM

DATE: August 17, 1988

TO: Jim Posewitz

FROM: Glenn Phillips

RE: Clark Fork Basin Project, Draft Status Report and Action Plan

In my opinion, this is far and away the best document describing Clark Fork River problems that has been produced to date. I think it is particularly important to have recommendations for future action present in a report that is endorsed by the Governor's Office. For example, I've been pushing for decentralization of the Water Quality Bureau and establishment of a network of regional water quality managers. Having that recommendation show up in this report should increase the chances of that happening.

The few comments that I have are listed below:

The quality of reproduction of Figure 1-1 could be improved.

p 1-7 There appear to be several unnecessary hyphens in the middle paragraph.

p 2-19 The word <u>had</u> should be substituted for <u>has</u> (near the bottom of the page).

2-18 There appears to be an error in the text. How can dilution from the Little Blackfoot River increase macroinvertebrate density from Deer Lodge to Garrison?

Fig. 2-1 It would be useful to indicate the locations of the confluences with Warm Springs Creek and the Little Blackfoot River.

p 3-33a, Fig. 3-4. The quality of the left half of the figure could be improved upon.

p 3-34 Fish, Wildlife and Parks data - (see proceedings of Clark Fork River Symposium) also documents the considerable increase in mainstem Clark Fork River metals concentrations that occurs during bypass events.

p 3-43a-c, Figs 3-8 through 3-10. These data may give us a basis for prioritizing streamside tailings reclamation efforts. For example, river miles 17-37 appear to be among the most severely contaminated.

p 3-57, last paragraph. Fish, Wildlife and Parks data document peaks that occurred during a bypass event in May, 1984. The data included weekly sampling for over 2 months (see Clark Fork River Symposium for details). We have also conducted sampling at a frequency of 3 times/week to support or bioassays in each of the last three years.

p 3-64 It may be true that the pond - 2 discharge was the greatest source of contamination to the Clark Fork River during the Phase - I RI. However, the RI was conducted during an unusually low flow year. This should probably be qualified so that readers are not mislead into believing that this is the case every year.

p 3-61a The use of HD to indicate hardness dependent is probably not necessary -- the footnote should suffice.

p 3-66 The text indicates that water quality improves between Warm Springs and Dempsey but the graph that is referred to shows stations only at Warm Springs and Deer Lodge.

p 3-66 The statement that water quality does not improve below clean water tributaries should be qualified. Sampling stations were many miles apart. In all likelihood water quality improved below these tributaries but then deteriorated again as the river eroded into additional streamside tailings. Even small plumes of clean water may provide important refuges for fish when metals concentrations are elevated.

p 3-73 Second paragraph, sixth sentence. The word <u>be</u> should be changed to <u>been</u>.

p 3-81a This figure and the accompanying text indicate that a reduction in phosphorus loading from Butte and Deer Lodge could have a significant impact on the Clark Fork River from Warm Springs to Rock Creek.

p 3-105 Third paragraph, last word. Brown <u>trout's</u> should be changed to brown <u>trout</u>.

p 3-107, first paragraph. The sentence "Fingerlings were less sensitive than fry." should be deleted. This is repetitive of a statement made earlier in the same paragraph "Fry were less tolerant than fingerlings ..."

p 5-9 The section dealing with identification of priority streamside tailings areas should include a recommendation to review existing water quality data-- particularly metals loading data -- to help identify and prioritize which streamside tailings areas are the best candidates for reclamation.

p 5-9 I would like to see us support some type of a "learn as we go process" whereby we attempt some demonstration reclamation projects (e.g. streamside tailings) even before the CERCLA process has reached the remedial action stage.

p 5-26 Nelson Thomas of EPA - Duluth indicated that phosphorus present in naturally occurring Phosphoria Formations is in a form that is not available to plants. Before we undertake a study of the Phophoria Formation we should contact Nelson Thomas and evaluate his reasoning.

p 5-28 The mining companies should pay for baseline water quality monitoring of tributaries that may be affected by mining.

p 5-28 I continue to believe that continuous automated sampling is necessary in the upper Clark Fork. I would like to see continuous recorders used to monitor pH and conductivity and perhaps twice daily sampling for metals. All of the samples collected would not need to be analyzed. However, at least we would have samples when important events occur such as thunderstorms or spring snowmelt.

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1-2	Last paragraph line 7. Change "dams" to "reservoirs".
1-3	Last paragraph line 3. Some confusion on what other uses are being served besides for "Missoula Valley residents".
1-7	Paragraph 2 line 7. "ag-riculture" should read "agriculture"
	Paragraph 2 line 8. same for "con-sisted" Paragraph 2 line 12. same for "Nat-ural" Paragraph 2 line 15. same for "re-flects"
1-10	Paragraph 5 line 3 & 4. "The current process" is somewhat out of context. Needs rephrasing.
1-11	Paragraph 6 line 1. Check acreage figures for Georgetown Lake (2,768 acres or 2,850 acres)
2-5	Paragraph 4 line 2. Pulp mill known in 1957 as <u>Hoerner</u> - Waldorf?
2-7a	Middle paragraph. 3rd sentence is not correctly written.
2-10	Paragraph 1 line 3. Is "depleted" the same as crop "consumption" or is it the diverted amount? Not clear!
2-11a	Table 2-8. Under column "current and future activities" there is an extra "with" in paragraph 1.
2-16	Paragraph 2 line 16. Clarify. Does hydropower "deplete" water or does this relate to depletion by other uses and is, therefore, not available for hydropower purposes?
2-19	Paragraph 3 line 15. The second "has" should read "had".
2-21	Paragraph 4 line 3. What kind of "trout"?
2-22	Paragraph 4 line 15. Population size between Beavertail Hill and Rock Creek not specifically stated as it is for the other river sections.

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2-37	Paragraph 2. Add "average" between "the" and "annual"
2-37	Paragraph 2 lines 1-6. This wording would apply only to irrigation and domestic uses, not instream flow uses.
2-37	Paragraph 5 line 3. 45 to 60-day comment period.
2-37	Paragraph 5 line 7-10. Board probably can't make decision that soon - more like winter 1988 or early 1989.
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3-7	Paragraph 2 line 4. Should 20,488 be 20,475? Compare with Table 3-3 totals (31,337 - 10,862 = 20,475)
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3-15	Paragraph 4. Still need to clarify the numbers discrepancies. Need to discuss with DNRC.
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3-53	Paragraph 2 last line. Should read "... has none-the-less undergone a rather dramatic recovery." or "... has none the less staged a rather dramatic comeback."
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3-73 to 3-76 — 1978	No mention of Ken Knudson's 1976-1977 diurnal DO & algal study on Clark Fork. Knudson, K. and Kurt Hill. 1987. An investigation to define minimum stream flows necessary to sustain the fish and wildlife resources of the Upper Clark Fork River. Montana Department Fish & Game Ecological Services Division. 42 pp.
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3-77	Paragraph 1. What caused the foaming in the Bitterroot River? Are there any natural sources of foam?

Non-point source chapter: Is this the place to discuss the pilot program Dennis Workman and the Clark Fork Coalition have implemented using portable iron diversions in place of stream gravel irrigation diversions?

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3-114	Paragraph 2 last sentence. Should read "some of the Warm Springs Creek water ..."
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5-22	6. Need some examples here to make clear what differences in water rights law interpretation there are between agencies.
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5-31	5. What's the difference between an "interstate basin commission" and a "Clark Fork Basin Commission" proposed in No. 2?
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