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MANUSCRIPT THESIS

WATER QUALITY OF THE COEUR D'ALENE RIVER BASIN

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TABLE OF CONTENTS

Page

ABSTRACT i
ACKNOWLEDGEMENTS ii
INTRODUCTION 1
Purpose and Scope of Study 1
Description of Study Area 1
Location 1
Population and Economy 2
BASIN ANALYSIS 5
Climate 5
Vegetation 5
Geology 6
Hydrology 6
Previous Work in Area 7
SAMPLING PROGRAM 9
Data Collection Scheme 9
Data Analysis 10
Acidification of Samples Containing Iron, Lead, and Zinc 10
WATER QUALITY 13
South Fork Coeur d'Alene River 13
Quality as a Consequence of Mining Industry 13
Effect of Flow Rate on Rate of Mass Transport of Zinc 15
Quality as a Consequence of Domestic Influence 16
North Fork Coeur d'Alene River 17
Main Stem Coeur d'Alene River 17
Quality as a Consequence of Mining Industry 17
Quality as a Consequence of Domestic Influence 18
Prediction Equations 19
Hourly Variations in Water Quality 19
Ground Water Analyses 20
Effect of Water Quality on Biota 21
DISCUSSION AND RECOMMENDATIONS 23
SUMMARY AND CONCLUSIONS 27
REFERENCES CITED 29

APPENDIX I - MAPS AND GRAPHS

Page

Figure 1. A Map of Western United States Showing the Coeur d'Alene River Basin Study Area.......... I-1
Figure 2. Map of the Coeur d'Alene River Basin.......... I-2
Figure 3. Hydrograph of Discharge vs. Time, Coeur d'Alene River, December, 1968-March, 1970.......... I-3
Figure 4. Sampling Stations on Main Stem, Coeur d'Alene River.......... I-4
Figure 5. Sampling Stations on South Fork, Coeur d'Alene River.......... I-5
Figure 6. Sampling Stations on North Fork, Coeur d'Alene River.......... I-6
Figure 7. Zinc Concentration vs. Distance for Stations 1-34, Coeur d'Alene River, September 14, 1969 (Low Flow).......... I-7
Figure 8. Zinc Mass Transport, Zinc Concentration and Flow vs. Time for Station 13, Coeur d'Alene River 1969-1970.......... I-8
Figure 9. Zinc Mass Transport, Zinc Concentration and Flow vs. Time for Station 22, Coeur d'Alene River 1969-1970.......... I-9
Figure 10. Biochemical Oxygen Demand vs. Distance for Stations 1-34, Coeur d'Alene River, September 14, 1969 (Low Flow).......... I-10
Figure 11. Nitrate Concentration vs. Distance for Stations 1-34, Coeur d'Alene River, September 14, 1969 (Low Flow).......... I-11
Figure 12. Phosphate Concentration vs. Distance for Stations 1-34, Coeur d'Alene River, September 14, 1969 (Low Flow).......... I-12
Figure 13. Coliform Count (MPN) vs. Distance for South Fork, Coeur d'Alene River, Idaho, September 14, 1969 (Low Flow). Idaho Department of Health.......... I-13
Figure 14. pH vs. Distance for Stations 1-34, Coeur d'Alene River, September 14, 1969 (Low Flow).......... I-14
Figure 15. Dissolved Oxygen and Temperature vs. Time for Stations 9, 13, 34, September 5-9, 1968.......... I-15
Figure 16. Electrical Conductivity and pH vs. Time for Stations 9, 13, 34, September 5-9, 1968.......... I-16
Figure 17. Fluoride Concentration vs. Distance, Coeur d'Alene River, August 6, 1970 (Low Flow).......... I-17

APPENDIX II - TABLES

Table 1. Population Along the South Fork of the Coeur d'Alene River.......... II-1
Table 2. National Rating in Mineral Production for Mines of Coeur d'Alene District, Idaho (1968).......... II-2
Table 3. Analysis of Coeur d'Alene River Below Cataldo and South Fork, Coeur d'Alene River (1932).......... II-3
Table 4. Lead and Zinc Analysis of Water from Coeur d'Alene River Drainage (1955).......... II-4
Table 5. Analysis of South Fork Coeur d'Alene River (March 12, 1964).......... II-5
Table 6. Chemical Analysis of Belt Rocks in Percent of Unaltered Rock in Coeur d'Alene District.......... II-6
Table 7. Coeur d'Alene Basin Stream Maximum, Minimum, and Mean Flow.......... II-7
Table 8. Mass Flow of Ions in Main Stem, Coeur d'Alene River, Station 9.......... II-8

Page

Table 9. Mass Flow of Ions in South Fork, Coeur d'Alene River, Station 13 .... II-9
Table 10. Mass Flow of Ions in South Fork, Coeur d'Alene River, Station 22 .... II-10
Table 11. Mass Flow of Ions in North Fork, Coeur d'Alene River, Station 34 .... II-11
Table 12. Comparison of St. Joe and Coeur d'Alene Rivers II-12

APPENDIX III - WATER QUALITY DATA FOR THE COEUR D'ALENE RIVER BASIN

River Water Data (December 1968-March 1970)
- December 17, 1968 .... III-1
- January 20, 1969 .... III-3
- February 26, 1969 .... III-5
- March 24, 1969 .... III-7
- April 23, 1969 .... III-9
- May 21, 1969 .... III-11
- June 12, 1969 .... III-13
- July 15, 1969 .... III-15
- August 19, 1969 .... III-17
- September 13, 1969 .... III-19
- October 30, 1969 .... III-21
- November 24, 1969 .... III-23
- December 19, 1969 .... III-25
- January 26, 1970 .... III-27
- February 21, 1970 .... III-29
- March 20, 1970 .... III-31

Ground Water Quality III-33
Abandoned Mine Drainage Quality III-35

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ABSTRACT

The Coeur d'Alene River system of northern Idaho is divided into three components: the North Fork which supports a healthy aquatic community, the South Fork which has received mining and domestic wastes for over 80 years and during which time has been devoid of aquatic life, and the Main Stem which has been affected by the condition of the South Fork.

Water samples collected from 34 stations on the Coeur d'Alene River system over a sixteen-month period indicate zinc and cadmium concentrations above toxic limits for fish survival over much of the South Fork and Main Stem; with the exception of fluoride which is high at two stations during low flow, concentrations of most other elements are comparable to or slightly greater than concentrations observed in the North Fork. The water quality data indicate one major source for zinc, cadmium, and fluoride and one less easily identifiable source. High river stage also increases total mass of zinc transported in solution, which suggests a source during high flow in addition to present day mine waste disposal operations. Elimination of the high zinc and cadmium concentrations is considered to be essential to the complete recovery of the river.

Basin-wide installation of settling ponds for mill wastes (not for all industrial wastes) by December 1968 has greatly improved the quality of water, particularly with respect to suspended solids. As a result, macrobenthic fauna recently have been discovered in the South Fork and a greater number of species found in the Main Stem, which indicate that the river is beginning to recover.

Raw sewage, discharged into the South Fork throughout its reach, is the source of a complex pollution problem. Although the river system has adequate assimilative capacity to handle the present organic load, the effect of the raw sewage on the bacteriological quality of the water is evident.

INTRODUCTION

PURPOSE AND SCOPE OF STUDY

Increased interest in the environment during recent years has focused much attention on the quality of the nation's rivers and streams. This situation has been particularly true in several areas of Idaho because of pollution by one of Idaho's oldest and most important industries (mining) and by certain communities. Due to the complex pollution problem in the Coeur d'Alene River basin in particular, a program was established to collect, analyze, and interpret water quality information from that basin so that corrective recommendations could rest on a sound foundation.

The Coeur d'Alene constitutes one of Idaho's major rivers and it has received mining and domestic wastes for over 80 years. The basin is located in the panhandle region of northern Idaho within the Bitterroot Range of the Northern Rocky Mountains. The river is composed of three main sections referred to as the South Fork, North Fork, and Main Stem. (See Fig. 2, App. I.) This paper discusses data collected from December 1968 through March 1970 from 34 carefully selected sampling stations along this river system.

The Coeur d'Alene basin is ideally suited for a comparative water quality study. With the exception of a greater concentration of economically significant deposits of metallic sulfide minerals located along the South Fork, the two main tributaries of the Coeur d'Alene River are similar in hydrogeologic environment. The North Fork is essentially undeveloped while the South Fork has been receiving discharges of mine tailings and domestic waste since before Idaho became a state. The Main Stem combines the flows from the developed and the undeveloped tributary basins.

Because of the complex nature of the Coeur d'Alene River, this study was designed to: 1) Report on the water quality of the South Fork of the Coeur d'Alene River as affected by both mining and domestic wastes; 2) use the North Fork of the Coeur d'Alene River as a basis of comparison because of its natural, unaltered state; 3) report on the quality of the Main Stem of the Coeur d'Alene River and analyze the effect of mixing of the waters from the two forks; and 4) give constructive comments and suggestions relating to improvement of critical water quality problems within the Coeur d'Alene River basin so that rational decisions concerning pollution control and abatement can be made.

DESCRIPTION OF STUDY AREA

Location

The Coeur d'Alene River basin is near the base of the panhandle region of northern Idaho in Shoshone and Kootenai Counties. (See Fig. 1, App. I.) The Bitterroot Range forms the eastern boundary of the Coeur d'Alene River basin; the Coeur d'Alene Mountains form the northern boundary; and the St. Joe Mountains form the southern boundary. Most of the main ridge systems in the basin trend westward from the Bitterroot Range.

The Coeur d'Alene River basin has a maximum elevation of 6838 feet and a minimum elevation of 2125 feet, giving a maximum relief of 4713 feet. Many of the slopes of the area are inclined at an angle of 30° or more with the terrain being very rugged. The Main Stem of the Coeur d'Alene River flows through a valley which averages three-quarters of a mile to one mile wide; while both the North Fork and South Fork are within steep, narrow valleys with very few areas over half a mile wide. The entire basin occupies an area of 1380 square miles.

Population and Economy

The Main Stem of the Coeur d'Alene River meanders through a wide river valley with a drainage area of about 160 square miles. The Main Stem extends from Coeur d'Alene Lake, upstream approximately 31.5 miles where it divides into the North Fork and South Fork. Agriculture is the main industry along this reach of the river; much of the bottom land is cultivated to produce hay and pasture for cattle.

Many small lakes in the area provide a large recreation attraction with Coeur d'Alene Lake, at the mouth of the Coeur d'Alene River, cited as one of the five most beautiful lakes in the world (Ida. Dept. Com. Dev., 1963, p. 23). The population of the Main Stem basin is approximately 2000 people and includes the three small towns of Rose Lake, Cataldo, and Kingston, with respective populations of 200, 215, and 500 (Bowen, 1970, written communication and Callihan, 1970, written communication).

The North Fork of the Coeur d'Alene River has a drainage area of 895 square miles and lies within the Bitterroot Mountains. The North Fork is relatively undeveloped with only a minor amount of agriculture and a few summer vacation homes within its basin. Throughout the year the main industry within the North Fork basin is lumbering plus some small scale mineral exploration around the town of Murray. During the summer there is considerable tourist trade. The permanent population of the area is 870 people and only three small towns exist: Prichard and Murray, in the upper region of the basin, combined population 175 (Callihan, 1970, written communication); and Enaville, at the mouth of the North Fork, population 70 (Brandon, 1970, written communication).

The South Fork of the Coeur d'Alene River lies entirely within Shoshone County, Idaho, and has a drainage area of 270 square miles. The South Fork flows in a relatively narrow canyon for approximately 30 miles within the Coeur d'Alene Mountains; its headwaters are in the Bitterroot Mountains at the Idaho-Montana border; and its mouth is at the confluence of the North Fork. The population of the South Fork drainage basin is approximately 17,850 (Callihan, 1970, written communication). This figure includes three main cities and several smaller communities and housing developments along this reach of the river. (See Table 1, App. II.)

The main industry along the South Fork portion of the basin is mining and processing of extracted ores. At the present time there are nine large operating mines and several smaller working mines in the basin. In addition to the regular mining operations in the basin there is an antimony plant, a lead-silver smelter, an electrolytic-zinc plant, a phosphoric acid plant, a sulphuric acid plant, and a fertilizer plant. The area is noted as one of the major silver-lead and zinc producing areas in the world. In addition, the area has yielded a considerable quantity of cadmium, copper, antimony, and gold, and has an overall mineral production of more than 2.5 billion dollars. (See Table 2, App. II.)

The Coeur d'Alene Mining District produces all of the antimony taken from Idaho and a major portion of the state's gold, lead, silver, copper, iron, and zinc. In 1968, 57 percent of the total mineral production for the state of Idaho was from the Coeur d'Alene area. On a national basis in mineral production, the state of Idaho ranked first in silver and antimony, second in lead, and third in zinc. The Sunshine Mine, located on Big Creek in the Coeur d'Alene District, produced nearly all of the antomony in 1968 for the nation (U. S. Bur. Mines, 1969, p. 172, 235, 644, 1013, and 1164). In addition, the district contains the first, second, third, and fifth ranked silver mines in the United States. The importance of the South Fork of the Coeur d'Alene River to the economy of Idaho and the U. S. should not be underestimated.

BASIN ANALYSIS

CLIMATE

The climate of the Coeur d'Alene River basin is strongly seasonal with mild temperatures prevalent during the summer months and below-zero temperatures common during the winter months. The mean annual temperature for 1969 was 44°F with a mean high of 64°F recorded in August and a mean low of 20°F recorded in January. Temperature extremes for 1969 were 106°F on August 23 at Wallace and -18°F on January 31 at Kellogg.

Most of the precipitation is in the form of snow which falls during the winter months. Precipitation averages 30.31 inches with averages ranging from 9.42 inches in January to 0.06 inches in August. Thunder showers persist from late June through part of August. In the latter part of September and early spring a short rainy season can usually be expected. Snowfall in the basin reached a depth of 68 inches in February 1969 at the U. S. Weather Bureau Station at Mullan. In 1969 the last trace of snow pack at Mullan was recorded in mid-April and the first measurable snowfall occurred in mid-November (U. S. Dept. Com., 1969). Snow in the lower, western portion of the valley often melts between storms but at higher elevations large drifts accumulate and, where protected from the sun, may remain until late August. Some deep snows in cirque basins may persist until covered by the winter's snowfall. The seasonal climate in the area has an appreciable effect on the utilization of nutrients and on the variability of concentrations of dissolved constituents in the waters of the Coeur d'Alene River system.

VEGETATION

A variety of vegetation occurs in the area. Some changes in the natural vegetation have occurred as a result of man's influence on the environment. Much of the original coniferous forests have been harvested for use in the mines as timbers and fuel. Most of the tree population near Kellogg has been eliminated, primarily because of smelter fumes but in part because of a large fire in 1910. Most of the burned area has been re-timbered by second growth of lodgepole pine. Stands of Douglas fir, the most common tree in the basin; western larch; and stumps of western red cedar are found throughout the area. The lower, dryer areas of the valley contain, for the most part, western yellow pine and some deciduous trees such as willow and alder. Brushy plants and grasses cover the area in uneven distribution depending on availability of ground water. The brushy plants include deer brush and whortleberry. Bear grass, the most common grass, is evident throughout the basin.

Within the high elevations there exists a much higher density of vegetation including western white pine, which grows extensively along the North Fork of the Coeur d'Alene drainage; grand fir or white fir; and some western hemlock. Along high ridges there are groves of alpine fir, mountain hemlock, and Engelmann spruce. Aspen groves are scattered throughout the basin on the high open slopes. The brushy plants of the high elevations include huckleberry or whortleberry, twinberry, syringa, mountain ash, and chokecherry. Other varieties are scattered in minor amounts throughout the high elevations (Hobbs and others, 1965, p. 6 and Ida. Dept. Com. Dev., 1963, p. 47-73).

GEOLOGY

The rocks of the area consist mainly of the Precambrian Belt Series which is composed of fine-grained argillites and quartzites associated with smaller amounts of carbonate-bearing, dolomitic rocks. Quartz and sericite are the principal minerals within the Belt Series; accessory minerals include feldspar, muscovite, magnetite, illmenite, zircon, tourmaline, rutile, and titanite. The average chemical analysis of the Belt Rocks is presented in Table 6, Appendix II.

Tertiary Columbia River Basalt extends from Coeur d'Alene Lake ten miles up the Main Stem of the Coeur d'Alene with the main basalt outcrops around the mouth of the river. The river valleys are partially filled with alluvial deposits which vary in thickness from less than one foot to several hundred feet. The deepest and most extensive alluvial deposits occur along the Main Stem. The alluvium consists mostly of unconsolidated sand and gravel. Tailings from previous mine milling operations have formed a veneer of silt over large valley areas. One of the most extensive of these areas is located on and downstream from Missions Flats (Ellis, 1940, p. 10).

At the head of the Coeur d'Alene basin there is evidence of glaciation which occurred during Pleistocene time. Glacial material can be found in scattered patches on the upper reaches of both forks of the Coeur d'Alene River (Hobbs and others, 1965, p. 68-69).

Mountain soils of the area consist of a thin layer of forest litter and decomposed rocks, and are found at elevations ranging from 2000 to over 6000 feet. In scattered areas at lower elevations the soils contain small amounts of volcanic ash or loess (Ida. Dept. Com. Dev., 1963, p. 78). Inherent in the approach used herein is the assumption that the Belt Rocks of the North Fork and South Fork produced similar, original, natural, aquatic environments in the two rivers.

HYDROLOGY

The flows of the streams of the Coeur d'Alene basin are extremely variable so that flow rate must be considered when evaluating water quality data. Winter floods caused by rain and melting snow are common. A monthly hydrograph for the period of December 1968 through March 1970 for each reach of the river is presented in Figure 3, Appendix I. The hydrograph shows a high flow rate during the spring months at the time of snow melt and a rather low flow during the fall when ground-water discharge is the major source of water. The maximum, minimum, and mean flow for the period of record are shown in Table 7, Appendix II.

Along the Main Stem of the Coeur d'Alene River the water table is above the surface of the adjacent valley floor during the spring months. Consequently, much of the land used for farming is flooded and must be pumped during the spring months to permit cultivation. The flooding also exposes large areas of old tailings to river flow during these months. The valley areas of the Coeur d'Alene River basin produce an adequate ground-water supply for domestic use because of the high permeability of the sand and gravel alluvium; but much of the domestic water supply comes from convenient springs and creeks in the area. There is no record of ground water being used for irrigation prior to 1965. Several of the small lakes along the lower reach of the Coeur d'Alene River have no perennial outlet stream but remain fresh because of the inflow of fresh ground and surface water (Nybroten, 1966, p. 19 and Ida. Bur. Mines Geol., 1964, p. 276).

PREVIOUS WORK IN AREA

Much work of the past has reflected the gross pollution of the Coeur d'Alene River prior to the establishment of settling ponds. During the period 1911-1913 Kemmerer and others conducted a biological and chemical study of Coeur d'Alene Lake (Kemmerer, et al., 1923). The investigators noted, ". . . at Harrison it (Coeur d'Alene Lake) receives the muddy waters of the Coeur d'Alene River, which drains an immense area, including the famous Coeur d'Alene Mining District. These waters are so laden with silt that they may be traced far out into the clear waters of the lake, . . ." (Kemmerer, et al. 1923, p. 80).

Ellis (1940) conducted limited analyses of the Coeur d'Alene basin water and found that in 1932, 1) the Coeur d'Alene mine wastes had not disturbed the balance of dissolved gases (including oxygen), carbonates, and acids to any critical degree except in the immediate vicinity of flumes emptying wastes into the river, 2) the specific electrical conductance of the river rose 100 percent or more downstream from the introduction of mine wastes; however, specific electrical conductance remained low everywhere, and 3) suspended solids had made the river uninhabitable to most aquatic life. Ellis also conducted experiments which showed that some dissolved constituent in the Coeur d'Alene River water was lethal to fish in 72 hours. The fish used were native to the rivers in the vicinity of the Coeur d'Alene basin. Ellis' description of the mucous of the gills of the dead fish suggest that death was caused by zinc. Ellis found that dissolved constituents also killed all plankton within 36 hours. The effects of suspended solids were eliminated by allowing the water to settle before testing. Ellis concluded the only solution for the pollution problem was the exclusion of all mine wastes from the Coeur d'Alene River. Table 3, Appendix II gives the results of chemical analyses of the Coeur d'Alene River conducted in 1932 by Ellis.

A survey was conducted by Chupp in 1955 to find the extent and cause of waterfowl mortality along the Main Stem of the Coeur d'Alene River (Chupp, 1955). The study revealed appreciable amounts of lead and zinc in the soil, plants, and at times in the water of the lower Coeur d'Alene valley. Tissue analysis from a number of waterfowl collected in the area also showed abnormally high amounts of lead (Chupp, 1956, p. 94). Table 4, Appendix II gives amounts of lead and zinc found by Chupp in waters of the Coeur d'Alene River.

In 1964 a waste disposal study was conducted for the county of Shoshone and the cities along the South Fork by the consulting firm of Cornell, Howland, Hayes, and Merryfield. It was estimated that an average of 2217 tons per day of mine slimes were being discharged into the South Fork at that time. The sewage from Kellogg, Wallace, Osburn, Mullan, Smelterville, Silverton, Elizabeth Park, and Wardner (an approximate accumulated population of 14,130) was being discharged raw into the South Fork (Cornell, et al., 1964, p. 12A and 34). During this study a few chemical analyses of the South Fork waters were conducted. They are presented in Table 5, Appendix II. The values are for March and are low because of high river stage.

A 1970 study showed that residents recognize water pollution as being widespread and severe in the South Fork region (Ellsworth, 1970, p. 30). Other studies of the area, which will be discussed in more detail later, include a bioassay study on native cutthroat trout using Coeur d'Alene River water (Sappington, 1969) and a species diversity study of macrobenthic life on the Coeur d'Alene River (Savage, 1970). Since 1968 the Idaho Department of Health has been active in gathering coliform data at 21 stations along the Coeur d'Alene River system (Idaho Dept. of Health, 1968) and in 1962 the Idaho Department of Health conducted a biological survey of the Coeur d'Alene River (Ida. Dept. of Health, 1962).

SAMPLING PROGRAM

DATA COLLECTION SCHEME

The data upon which this report is based were collected monthly from December 1968 through March 1970 which includes only the period after settling ponds were put into operation by mining companies located in the river basin. Thirty-four sampling points were carefully selected to bracket known, probable, and suspected sources of pollution on the Coeur d'Alene River system.

Stations 1 through 10 were established on the Main Stem of the Coeur d'Alene River primarily to measure changes in the water quality caused by mixing of the North and South Fork water; dilution by lesser tributaries and ground-water inflow; and precipitation of ions from solution along the Main Stem. (See Fig. 4, App. I.) Station 1 is 1.42 miles above the mouth of the Coeur d'Alene River and can be used to determine the quality of water entering Coeur d'Alene Lake. Stations 2, 3, and 4 are located approximately equidistant apart to detect natural changes along this reach of the river. Stations 5 and 6 are designed to detect pollution from the community of Rose Lake. Stations 8 and 9 were established to detect pollution from Cataldo. Station 10 is the first station below the confluence of the North and South Forks and gives the first indication of the effects of dilution and mixing of the South Fork waters.

The South Fork contains Stations 11 through 28. (See Fig. 5, App. I.) Station 11, 0.2 miles above the confluence of the South Fork and the North Fork, is used to determine quality before dilution by North Fork waters. By comparing Station 11 with Station 12 the effect of Pine Creek on the water quality of the South Fork can be determined. Station 13 is located below the outfall of an electrolytic zinc plant. Mine water and effluent from a phosphoric acid plant, a fertilizer plant, and a concentrater are also produced immediately upstream from Station 13 but during this study these effluents were directed into a large pond which was in the process of being filled so they probably did not have an appreciable effect on the data for Station 13. Station 14 is above the mine at Kellogg but below the city of Kellogg. Station 15 is above Kellogg but below Elizabeth Park and Montgomery Gulch where a number of people reside and where raw sewage is being discharged into the South Fork. Station 16 is below housing areas near Elk Creek and Moon Creek. Stations 17 and 18 are designed to determine effects of mining operations located on Big Creek. Stations 19 and 20 can be used to distinguish effects of effluent discharged by Osburn and Stations 21 and 22 can be used to identify effects of effluent discharged by Silverton. Station 23 is located below Wallace, which is discharging raw sewage into the South Fork. This station also reflects the effect of mining operations located on Nine Mile Creek. Station 24 provides information on the effect of mining effluents and addition of domestic wastes along Canyon Creek. Station 25, above Wallace, is used to determine water quality prior to the effect of wastes from Wallace and Nine Mile and Canyon Creeks. Station 26 is located below Mullan and Station 27 is located above Mullan, however, the latter station was discontinued in August 1969 because results were identical to results of analyses on Station 28 which is also above Mullan. Tailings from one major mining operation are piped below Station 27 and hence the water quality at Stations 27 or 28 is not affected by this mine. Station 28 is the South Fork sampling point most distant from the mouth of the river (54.52 miles above Coeur d'Alene Lake). It is above any major known source of pollution.

Stations 29 through 34 are located on the North Fork of the Coeur d'Alene River. (See Fig. 6, App. I.) Station 30 which is 57.42 miles above the mouth, is the North Fork station most distant from the Coeur d'Alene River mouth. Station 29 was established to evaluate pollution from Prichard Creek where two small communities are located. Stations 31 through 34 were approximately evenly spaced to detect any change in water quality prior to mixing with the South Fork and to gain information on water quality of an unpolluted stream with a healthy aquatic environment for this particular climate and rock types.

DATA ANALYSIS

The samples were collected in one-liter polyethylene bottles which were washed in a dilute HCl solution and then well rinsed with distilled water prior to sample collection. Samples were obtained from currents near the bank of the stream; stagnant areas were avoided. A previous study near Rose Lake revealed that the location of the point of extraction in the cross section of the stream did not affect concentration (Burns, 1970, p. 8). The sample bottles were rinsed thoroughly with stream water at the time of sampling. Immediately after collectio the samples were analyzed for temperature, pH, and electrical conductivity. Care was taken to keep the samples cool during transportation to a laboratory whenever dissolved oxygen, biochemical oxygen demand, nitrates, and total phosphates were to be determined. These constituents plus chlorides were determined using procedures outlined in "Standard Methods for Examination of Water and Waste Water", 12th Ed., 1965.

The samples were then analyzed for arsenic (As), calcium (Ca), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), nickel (Ni), lead (Pb), and zinc (Zn) using a Perkin-Elmer model 303 atomic absorption spectrophotometer. The elements arsenic, chromium, and nickel were analyzed from December 1968 to July 1969, an eight-month period, and then discontinued because of no detection. In July 1969 analyses for potassiu and sodium were initiated and in November 1969 analysis for cadmium was initiated. Problems of a technical nature with the atomic absorption spectrophotometer resulted in no data for lead from January 1969 through July 1969; copper for January February, April, May, and June 1969; and zinc for December 1968.

Acidification of Samples containing Iron, Lead, and Zinc

Experimentation with acidified and unacidified samples prior to analysis for lead and zinc revealed that acidification increased the concentrations of both ions. Two explanations are possible: acidification is known to minimize adsorption of these ions onto the walls of the container; however, experimentatio revealed that acidification also strips off ions adsorbed to the solids suspended in the sample, especially when those suspended solids are mine tailings. All samples analyzed during this project were collected in polyethelene bottles; consequently, adsorption of ions onto container walls would be expected to be minimal. Therefore, the high concentrations of lead and zinc observed in acidified samples are interpreted as being caused by removal of ions from suspended matter in the sample. Filtering of samples was avoided because of the fear of the adsorption of heavy metals onto the filter paper. Additional complications occurred when samples collected near the antimony plant were acidified. These samples are naturally basic and acidification causes a precipitate to form, which obviously changes concentrations of some dissolved constituents.

If the suspended solids settle out in the natural environment (as in the river delta or flood plain deposits) the ions adsorbed thereon may never become available to aquatic life. On this basis, and because of the above complications, the decision was made to utilize unacidified samples for analysis. The suspended solids were allowed to settle and the supernatant was analyzed. Inherent in this approach is the assumption that the partition of ionic species between water and solid was at equilibrium. The data represented herein are believed to be as representative as possible of ion concentrations actually in the water, rather than a combination of ions in the water and ions added to, or removed from, the water by a change in the physical-chemical environment within the sample after collection.

Finally, extraction techniques were not utilized in this study. Such techniques are frequently used to increase the detectibility of dissolved ions by the atomic absorption spectrophotometer. However, it was observed that results were difficult to reproduce when this technique was employed so the decision was made to settle for slightly higher limits of detectibility.

A few data for this area during the period of this study are available from another source which can be used as a check on the data presented in Appendix III. The Federal Water Quality Administration collected a series of samples during the 24 hour period of September 23 to September 24, 1969 (Burns, 1970). Their results are very similar to results obtained from samples collected at approximately the same time during this study.

WATER QUALITY

SOUTH FORK COEUR D'ALENE RIVER

Quality as a Consequence of Mining Industry

The South Fork of the Coeur d'Alene River is the portion of the basin which receives essentially all of the pollutants from industry, mining, and domestic sources. (See Fig. 5, App. I.) As a result, a major emphasis has been placed on this portion of the river system. Industrial pollution caused by mining and related operations is of major interest because of the significant effect these industries have on water quality. During the period of study, analyses were made for the elements arsenic, cadmium, copper, chromium, lead, nickel, iron, and zinc to determine the concentration of these elements and to determine where they are entering the river system. Several of these elements are known to be toxic to aquatic life at various concentrations. The elements sodium, potassium, and manganese are also common in industrial wastes. Samples were analyzed for calcium and magnesium because of their capability of reducing the toxicity of several other elements to fish (McKee and Wolf, 1963, p. 296).

During the course of study no arsenic or chromium was detected. Nickel was detected from Station 13 and downstream during December 1968. Concentrations of 0.2 parts per million (ppm) Ni (399.94 lbs/day) in December occurred at Station 13 with a decrease downstream. Nickel analyses during the first five months of 1969 showed no detectable amounts. As a result, analyses of nickel, arsenic, and chromium were discontinued in July 1969. It should be noted, however, that the limit of detectability of arsenic using College of Mines equipment is rather high (10 ppm). The detectability limits on nickel and chromium are 0.1 ppm and 0.5 ppm respectively.

Sodium and potassium have shown consistently high readings at Stations 13 and 18. Station 13 is below the discharge of the electrolytic zinc plant, and Station 18 is adjacent to a settling pond which receives waste from the electrolytic plant. (See Fig. 5, App. I.) Several seepages discharging discolored water into the South Fork were noted around Station 18. These seepages have discolored the rocks near the south bank of the South Fork. A distinct odor also exists at these seepages and therefore it is concluded that the seepages are a result of ground-water flow from the settling pond approximately 400 feet south of Station 18. Although higher concentrations of sodium were noted at Station 18, they are well below toxic limits for aquatic life and at the concentration level present can be expected to reduce toxicity of excessive potassium (McKee and Wolf, 1963, p. 259).

Because of the influence of the settling pond along the south bank of the river at Station 18, samples gathered in this area are not necessarily representative of river water quality above Big Creek. Two completely different analyses could be obtained depending on whether the sample was taken from the north bank or south bank. Consequently, Station 19 was used as the upstream station to determine the effect of the mining operation on the South Fork.

Concentrations of potassium and manganese are nowhere found to be above the toxic limits for aquatic life. Cadmium has been detected at several points along the South Fork but only at Station 13 and below does the concentration exceed the toxic limit for aquatic life as given by McKee and Wolf (1963, p. 149)

Maximum concentration found for cadmium was 0.45 ppm (240.12 lbs/day) for November 1969 at Station 13. A possible synergistic effect with zinc could cause the concentrations of cadmium below Station 24 to be toxic to some types of fish. The concentration in this vicinity has reached a maximum value of 0.04 ppm cadmium and 4.4 ppm zinc. Salmon fry have been reported killed with 0.03 ppm cadmium plus 0.15 ppm zinc (McKee and Wolf, 1963, p. 150).

Concentrations of copper observed in the South Fork during the study were never above the detectable limit of 0.1 ppm. The lead concentrations observed were also at or below 0.1 ppm (See Tables 9 and 10, App. II and App. III.) except for two occasions, one in December, 1968 at Station 13 and the other in February, 1970 at Station 17. No obvious explanation for the latter anomaly is available. The main effect expected of copper and lead at concentrations of less than 0.1 ppm on the South Fork is their undesirable synergistic effect when combined with zinc.

One set of fluoride analyses was conducted in August, 1970 (period of low flow). These analyses are significant and are included in Figure 17, Appendix I, even though the samples were collected after the official termination date of this project. Figure 17 in Appendix I indicates an increase in fluoride concentration at Stations 24 and 13. The concentration below both stations is well above the 2.3 ppm reported to be detrimental to trout (McKee and Wolf, 1963, p. 191). More data are needed for a thorough understanding of fluoride distribution.

Dissolved zinc and fluoride appear to be the major problems along the South Fork of the Coeur d'Alene River with respect to industry. A maximum concentration of 21.0 ppm (11545.37 lbs/day) zinc has been noted on the South Fork at Station 13. (See Table 9, App. II.)

Values of zinc, biochemical oxygen demand (BOD), and pH for the South Fork were subjected to Student's "t" test in order to compare values of these constituents upstream and downstream from sources of effluents. Calculation was made by the formula:

$$t = \frac{(\overline{X}_1 - \overline{X}_2) - (u_1 - u_2)}{S_{\overline{X}_1 - \overline{X}_2}}$$

t = deviation of the estimated means from that of the populations

$\overline{X}_1$ = mean of sample 1

$\overline{X}_2$ = mean of sample 2

u_1 = mean of population 1

u_2 = mean of population 2

$S_{\overline{X}_1 - \overline{X}_2}$ = sample estimate of the standard error of $(\overline{X}_1 - \overline{X}_2)$

Hypothesis: $H_0: u_1 = u_2$

$H_A: u_1 \neq u_2$

The value of "t" has been evaluated at the 0.05 level to establish confidence limits for the test. At the 0.05 level of significance one may be confident that the "t" test is valid 95 percent of the time. Computer analysis of the above "t" distribution was used to establish whether there existed a statistically significant difference between upstream and downstream portions of known or suspected sources of pollution. To reduce the effect of skewness in the data a log (x + 1) transformation was found to be most effective in producing normality.

The results of the test showed a significant difference (increase) at the 0.05 level of significance in the mean values of zinc concentration between Stations 13 and 14 (below and above zinc plant), Stations 24 and 25 (below and above Canyon Creek), and Stations 26 and 28 (below and above settling pond) on the South Fork. The mean zinc concentrations for Stations 13, 24, and 26 (all downstream from a source of effluent) are 9.18 ppm, 3.07 ppm, and 0.18 ppm respectively. However, even though the zinc concentration at Station 26 is significantly higher than at Station 28, it is still below toxic limits during most of the year. However, when the additional source of effluent just above Station 24 is added, the concentration of zinc becomes well above the toxic limit for trout, as specified by Sappington (1969, p. 23). During the summer of 1970 several young boys were observed catching cutthroat trout from the South Fork between Stations 25 and 26.

A significant decrease at the 0.05 level of significance was found in zinc concentration between Stations 17 and 19. This may be attributable to dilution by Big Creek which enters the South Fork between these points. One would expect very low concentrations of zinc in Big Creek because of the high pH of the pond effluent which it receives.

Values of zinc concentrations for the river reach are presented in Figure 7, Appendix I for the low flow period of 1969 and values in pounds per day for two stations on the South Fork are shown in Tables 9 and 10, Appendix II. Noteworthy is the fact that Lake Creek and Nine Mile Creek produce no significant change in zinc concentration in the South Fork where they enter the river. To establish whether settling pond discharge has an effect on water temperature a "t" test was performed on Stations 26 and 28, points above and below the discharge of a settling pond. No significant change was found in water temperature below the settling pond indicating that the pond is effective in stabilizing the warmer tailings water before it enters the South Fork.

Effect of Flow Rate on Rate of Mass Transport of Zinc

To visualize the effect of dilution on zinc concentration during periods of high flow, a graph was prepared showing flow rate and zinc concentration plotted against time. (See Figs. 8 and 9, App. I.). From the graphs one can readily see a relationship of lower concentration during high flow and higher concentration during low flow. It is important to note, however, that the tremendous increase in flow during flood stage overrides the importance of the decrease in zinc concentration due to dilution. Consequently, greater values of pounds per day of zinc going down the river occur during periods of lowest concentrations of zinc. This relationship suggests that flood waters introduce a source of zinc in addition to present day waste disposal operations. It was observed that during the high flow stage the suspended load in the river first increased noticeably upon flowing through a flat area below Station 21 where old tailings have been deposited by the river.

Conductivity values of less than 600 micromhos found in the South Fork are within the range of most of the streams and rivers supporting a good mixed fish fauna including trout (McKee and Wolf, 1963, p. 234-237 and 273). Tests also indicate that dissolved oxygen (DO) was always at or near saturation levels. (See App. III.)

Quality as a Consequence of Domestic Influence

Domestic waste entering the South Fork constitutes a complex pollution problem in itself. Untreated wastes from all but two of the cities and towns along the South Fork are being discharged into the South Fork or its tributaries. In order to determine the effect of the domestic waste on the river system, several analyses of chlorides, nitrates, phosphates, biochemical oxygen demand, and dissolved oxygen were conducted during the sampling period.

Biochemical oxygen demand for the South Fork has an overall mean value of 2.12 ppm and ranges from 0.24 ppm to 6.5 ppm. Figure 10, Appendix I shows the fairly constant BOD values along the South Fork for the low flow period in 1969. Stations 26 below Mullan, 23 below Wallace, 16 below Elk Creek, and 15 below Elizabeth Park have shown a slightly higher BOD than stations just upstream from these points. In order to test the statistical significance of these slight differences, a Student's "t" test was conducted to compare BOD values upstream and downstream from these and other critical points along the South Fork. The results of this test indicate no difference in BOD at the 0.05 level of significance for any of the stations on the South Fork. The organic load, contributed by the population centers along the South Fork, does not appear to be sufficient to produce a significant BOD in the river.

Nitrate concentrations were found to increase at two locations: Station 26 below Mullan and Station 15 below Elizabeth Park. The nitrate concentrations are everywhere consistently low with a mean value of 0.33 ppm and range of 0.0 to 1.52 ppm. A graph of nitrate concentration during low flow period, September 1969 (when conditions might be expected to be worst), is shown in Figure 11, Appendix I.

Phosphate concentrations analyzed on two occasions show an increase in concentration at Stations 26, 15, 14, 13, and 11. Phosphate has a mean concentration of 0.24 ppm with values ranging from 0.0 to 1.14 ppm. The higher values correspond to sample stations below major communities as shown by Figure 12, Appendix I.

Chloride concentrations of up to 12.0 ppm were observed in May 1969 but decreased to concentrations of 0.2 ppm or less and were discontinued in September 1969 because they were sufficiently low to be inconsequential. Chloride concentrations increased slightly at Stations 21, 15, 13, and 11 during the sampling period, perhaps due to additional domestic effluent being discharged into the stream above these points.

Nitrate, phosphate, and chloride concentrations found during the study are well below the standards recommended by the United States Public Health Service and for maintaining healthy aquatic life (McKee and Wolf, 1963, p. 159, 224 and 240). Although low, the presence of nitrates and phosphates are now causing an increase in aquatic plant growth above Station 13. This increase has occurred since the installation of settling ponds.

The pH of samples taken from the South Fork show a definite decrease downstream with major fluctuations during periods of low flow. (See Fig. 14, App. I.) Although there is a decrease in pH with distance downstream along the reach of the South Fork, it is not considered particularly low. A Student's "t" test conducted on the pH values at stations upstream and downstream from suspected sources of pollution revealed a significant decrease at the 0.05 level between Stations 13 and 14. No other stations were significantly different at the 0.05 level.

The best picture of domestic pollution can be visualized through coliform counts made by the Idaho Department of Health. Figure 13, Appendix I gives most probable (M.P.N.) values for stations along the South Fork during a low flow month. Values of over 160,000/100 ml. show that a definite problem exists on the South Fork below the towns of Mullan, Wallace, Silverton, and Osburn.

NORTH FORK COEUR D'ALENE RIVER

The North Fork of the Coeur d'Alene River does not have the domestic or industrial development which has occurred along the South Fork. During the period of study the North Fork has not had any detectable concentrations of arsenic, chromium, nickel, or cadmium. Copper, lead, and zinc were found in trace amounts of less than 0.1 ppm. Manganese and potassium mean concentrations were 0.5 ppm while calcium, magnesium, and sodium have mean concentrations of 4.0 ppm, 1.8 ppm, and 1.3 ppm respectively. (See Fig. 7, App. I and Table 11, App. II.) There is no significant difference between stations on the North Fork with respect to concentrations of the above elements.

Nitrates and phosphates have been negligible with only Station 30 showing a low positive value of <0.26 ppm nitrate on two occasions. (See Figs. 11 and 12, App. I.) Chlorides decreased to 0.0 after high flow stage ended on the North Fork in July 1969. A mean five-day BOD value of 1.7 was observed with no differenc between stations at the 0.05 level of significance. (See Fig. 10, App. I.) Electrical conductivity values are below 62 micromhos at 20°C and pH values from 6.00 to 8.80 pH units are well within values of natural, unpolluted waters. (See Fig. 14, App. I.) No difference at the 0.05 level of significance was found for pH values between stations on the North Fork. Dissolved oxygen values are always at or near saturation values for the North Fork. Coliform counts showing M.P.N. values of from 8 to 79 have been recorded by the Idaho Department of Health for the North Fork near Station 34 during the period of this study. (See App. III and Fig. 13, App. I.)

MAIN STEM COEUR D'ALENE RIVER

Quality as a Consequence of Mining Industry

Water quality within the Main Stem of the Coeur d'Alene River is primarily a result of the mixing of the North Fork and South Fork waters. During the course of this investigation, arsenic, chromium, and nickel were not detected in the Main Stem. Copper and lead were found in concentrations of equal to or less than

0.1 ppm during the sampling period. Zinc concentrations were found to have a mean concentration of 1.4 ppm during the winter months, a mean of 0.4 ppm during high flow in the spring, and a mean concentration of 3.4 ppm during the summer and fall months of low flow. (See Fig. 7, App. I.)

During periods of low flow several seepages were noted entering the river between Stations 7 and 8. This area, known as Mission Flats, is covered by extensive deposits of old mine tailings. A Student's "t" test was performed on zinc concentrations above and below Mission Flats to determine if leaching of these tailings had a statistically significant effect on the water quality of the Main Stem; no significant difference at the 0.05 level was found in zinc concentration.

Cadmium concentration of 0.7 ppm was noted at the beginning of the testing period while concentrations of less than 0.02 ppm were recorded toward the end of the sampling period. This decrease in cadmium concentration is possibly due to the implementation of settling ponds by the mining industry at the beginning of the study period. Magnesium, manganese, calcium, sodium, and potassium showed low concentrations during the spring and high concentrations during the fall. Except for cadmium the concentration of these elements is similar to the concentration mentioned for the South Fork and the North Fork with no significant difference at the 0.05 level between stations on the Main Stem of the Coeur d'Alene River. Mass flow of all ions in pounds per day for Station 9 are given in Table 8, Appendix II.

Mean specific electrical conductance values of 94 micromhos at 20°C occurred along the Main Stem. High values occurred during the months of low flow and lower values during spring months of high flow.

Quality as a Consequence of Domestic Influence

With respect to domestic pollution, Stations 10, 5, 3, 2, and 1 showed a slight increase in concentrations of chlorides, nitrates, and phosphates relative to the concentrations observed at stations just upstream. Biochemical oxygen demand reached a high of 3.9 ppm during the winter of 1969 but lower mean values of 1.2 ppm were observed during the summer months. The pH values ranged between 5.75 and 8.3 for the Main Stem. No significant difference at the 0.05 level of significance was found for either pH or BOD when data from Stations 1 and 10 were subjected to Student's "t" test. Station 1 is near the mouth of the Coeur d'Alene River and Station 10 is at Kingston just below the confluence of the North Fork and South Fork, consequently, sources of effluent along the Main Stem have little effect on these two parameters.

Two coliform tests conducted by the Idaho Department of Health during the study period resulted in a M.P.N. of 240 in June 1969 and a M.P.N. of 1609 in August 1969. (See Figs. 10-14, App. I.)

PREDICTION EQUATIONS

A regression analysis was conducted on zinc, pH, and flow for Stations 9, 13, 22, and 34 to find a prediction equation for pH or zinc given the flow of the river. The regression was accomplished using a standard linear regression program. The program computes a prediction equation to fit the mathematical model $Y = \alpha + \beta X$

where Y = dependent variable
X = independent variable
α = mean of the sample corresponding to $X = 0$
β = the slope of the regression line

Two regression analyses were run with Y equal to the flow rate and X equal to zinc and pH respectively. A third regression was run with Y equal to zinc and X equal to pH.

The prediction equation with flow as the dependent variable (Y) and zinc as the independent variable (X) for Station 9 was $Y = 3.18 - 0.00031X$. The coefficient of determination was only 0.319 which leaves much to be desired since the nearer this value approaches 1.0 the more accurate is the prediction equation. At this level this equation is not particularly useful. The standard deviation of Y given X equals 1.66.

For Station 13 the regression equation is $Y = 12.08 - 0.0054X$ with a coefficient of determination of 0.370 and a standard deviation of Y given X of 4.95. For Station 22 a regression equation of $Y = 2.85 - 0.0019X$ was found and a coefficient of determination of 0.28 with a standard deviation of Y given X of 1.17. Again these coefficients of determination are too low to make these equations useful.

The regression analysis for flow as the dependent variable (Y) and pH as the independent variable (X) had coefficients of determination of 0.00683 for Station 9; 0.00000129 for Station 13; 0.0729 for Station 22; and 0.000608 for Station 34. This indicated the regression equations computed for these stations would be practically useless because of the extremely low coefficient of determination values. The regression analysis using zinc as the dependent value (Y) and pH as the independent value (X) also had coefficients of determination in a range similar to those mentioned above and the resulting equations are not considered usable.

HOURLY VARIATIONS IN WATER QUALITY

To account for some of the variability within the monthly samples a 24 hour survey was conducted to help determine whether the discharges by the industries concerned were constant or variable in quantity and chemical composition. Analyses were made for pH, electrical conductivity, alkalinity, temperature, and dissolved oxygen. Tests were conducted in September 1968, one month before two settling ponds were put into effect, for Stations 9, 13, and 34. Samples were taken at two-hour intervals and analyses showed for Stations 9, 13, and 34 respectively: mean pH values of 7.02, 5.13, and 7.67; mean conductivity values of 165, 405, and <60; and mean dissolved oxygen values of 7.1, 6.4, and 7.95. Deviations were found on Station 13 for pH, conductivity, and dissolved oxygen when compared to data on the North Fork.

The deviations found in the South Fork with respect to temperature follow closely with those found on the North Fork and are day to day variations. The deviations found for dissolved oxygen, electrical conductivity, and pH do not follow any pattern set by the North Fork or any expected natural day to day variations. (See Figs. 15 and 16, App. I.)

From these data one can conclude that the discharge of pollutants in the South Fork is not constant in rate or concentration. The data for Station 13 vary much more widely than do the data for Station 34, especially with respect to pH, conductivity, and dissolved oxygen. Projecting this into the data collected later in 1968-1970, explains some of the variability obtained in data on the South Fork.

GROUND WATER ANALYSES

Four wells within the South Fork basin were sampled to determine the quality of the ground water in the area. It was hypothesized that old tailings within the basin may have a definite effect on the water quality of the South Fork. The wells located near Wallace, Osburn, Smelterville, and Pinehurst were sampled from July through November of 1969. All of the wells are shallow, penetrating alluvium to depths of 35 feet or less. The well at Wallace, in the Wallace Elks Club, is approximately 700 feet from the river. Water quality of this well is within acceptable limits with respect to the same parameters used on the river water.

An industrial well located near Osburn between Stations 20 and 21 is at the Zanetti Ready Mix Plant and is approximately 700 feet south of the river. Mean zinc concentrations of 12.9 ppm and mean lead concentrations of <0.1 ppm were observed with higher zinc concentrations observed during periods of heavy pumping.

The well located near Smelterville, between Stations 12 and 13, is approximately 3500 feet from the river and is located in a swampy area up gradient from a settling pond. This well was used to obtain water for the Page Mine operation. Water quality of this well was found to be within the acceptable limits discussed for the Coeur d'Alene River.

A domestic well near Pinehurst, called the Lion's Well, is located near Station 12 approxinately 1000 feet from the South Fork. A zinc concentration of 1.1 ppm and no detectable lead were observed upon one sampling of this well. Concentrations of the other elements analyzed were within acceptable limits for domestic use or for fish and aquatic life. (See App. III.)

To determine if drainage from old mining operations affects water quality, water samples were taken from three abandoned mines. These also give limited data on the nature of ground water from the surrounding rock formations before it enters the alluvium of the valley, although the samples may represent ground water that has been somewhat altered by exposure to air. Samples from the Morning Mine, located one mile below Mullan along the South Fork, had mean magnesium concentrations of 22.1 ppm but zinc and lead concentrations were low and would result in no problems except for possible synergistic effects.

Another mine (Moe) is located approximately two miles below Mullan on the south side of the South Fork near Station 26. In all samples lead concentration was below 0.1 ppm. Other elements analyzed from this mine were within the acceptable limits discussed earlier.

The third mine sampled (Silver Buckle) is located below Wallace approximately 0.7 miles up Lake Creek. All elements analyzed were within acceptable limits for fish or aquatic survival. Values of pH for the three mines sampled ranged between 7.55 and 8.30. This range is very similar to pH found in unpolluted portions of the Coeur d'Alene River but is slightly higher than ground-water samples taken from wells in the valley. (See App. III.) These data do not indicate that drainage from abandoned mines in the area constitutes a water quality hazard as has been the case in many other mining areas.

EFFECT OF WATER QUALITY ON BIOTA

Species diversity surveys made by Ellis in 1932, the Idaho Department of Health in 1962, and Savage in 1970 give evidence of the gross pollution problem which existed prior to 1968. Ellis (1940) found no fish fauna, bottom fauna, or plankton organisms living in the Main Stem or the South Fork from a point above Wallace downstream in 1932. Normal fish fauna, plankton, and aquatic vegetation were found in the upper portion of the South Fork and along the tributaries of the South Fork above points of pollution by mine wastes. Neither were fish nor plankton found in Coeur d'Alene Lake at the mouth of the Coeur d'Alene River. Dace and minnows taken from Coeur d'Alene Lake and transferred in live cages to the mouth of the Coeur d'Alene River die in 72 hours while controls showed no ill effects after 120 hours. Plankton placed in waters from the polluted portion of the Coeur d'Alene River died in 18 hours or less (Ellis, 1940, p. 15-16, 51-52).

In December 1962 the Idaho State Department of Health conducted a biological survey of the Coeur d'Alene River with respect to macroscopic benthic organisms (Olson, 1963). Above Mullan (Station 28) there were many benthic organisms of the pollution intolerant variety. The stream was clear with no evidence of mine waste. Along the South Fork (Stations 25, 18, and 11) no benthic organisms were found. At these points the water was turbid with evidence of mine waste apparent.

On the North Fork (Station 34) above the confluence with the South Fork many benthic organisms were found and the stream contained no evidence of pollution by mine wastes. On the Main Stem (Stations 8 and 6) no benthic organisms were found and there was evidence of fine silt on the bottom, typical of mine wastes. It was concluded that: 1) the absence of benthic organisms on the South Fork and Main Stem appeared to be related to the presence of mine wastes; 2) the problem of sewage was masked by the presence of mine waste; and 3) the South Fork above Mullan and the North Fork are capable of supporting and do indeed support a variety of benthic organisms of the pollution intolerant type (Olson, 1963, p. 1-4).

Savage conducted macrobenthic surveys on all three branches of the river in September 1968 and September 1969, both before and after establishment of settling ponds by all the mining companies in the area. Savage's sample points corresponded to Station 34 on the North Fork, Station 13 on the South Fork, and Station 9 on the Main Stem for this study. In 1968 the North Fork was found to contain an average of 20 species per square foot. Thirty species were observed with 15 species present in more than 80 percent of the samples. A mean of 405 ± 137 organisms per square foot was found on the North Fork and an average diversity value[1] of 2.970 was observed, which is not indicative of serious pollution.

In 1969 the composition of the riffle was essentially unchanged although only 6 of 31 species per square foot occured in 80 percent of the samples. A mean number of 268 ± 192 organisms per square foot and average diversity value of 3.035 was found, indicating increased equitability in distribution of individuals among the species, again with no indication of appreciable pollution.

In the Main Stem only one species, chironomids, was found in 1968 giving a diversity value of 0.0. In 1969 there were three species found per square foot with 97.5 percent of these being chironomids giving a diversity value of 0.214. The South Fork contained no macrobenthic life in 1968 and one species, chironomids, appeared in 1969. Significant differences at the 5 percent level were found between polluted and unpolluted stations on the Coeur d'Alene River with no significant difference between years.

Savage concluded that siltation was a serious limiting factor in preventing colonization of the riffles in the South Fork and Main Stem of the Coeur d'Alene River by macrobenthic fauna. Following reduction of turbidity as a result of the establishment of settling ponds by the mining industry, macrobenthic life was found in the South Fork and increased in the Main Stem indicating a trend toward recovery of these streams. It was noted that zinc ion concentrations were high enough during the times of low flow below Station 13 to be acutely toxic to most macroinvertebrates (Savage, 1970).

In a series of bioassay tests to determine zinc toxicity, Sappington (1970) used water from the North Fork of the Coeur d'Alene River and cutthroat trout native to the area. In a static bioassay, 24, 48, and 96 hour median tolerance limit (TLM) values of 0.62, 0.27, and 0.09 ppm zinc were found for the trout and in a recirculating flowing water bioassay system a 24 hour TLM value of 0.42 ppm zinc was found (Sappington, 1970). In summary, the study by Sappington showed that North Fork cutthroat cannot survive indefinitely in North Fork water to which about 0.1 ppm zinc has been added.

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[1]Margalef = Species Diversity Formula: $\overline{H} = -\Sigma P_i \ln P_i$

$P_i = \frac{n_i}{N}$ = probability of selecting in sampling an individual of i^{th} type

n_i = number of individuals of the i^{th} type

N = total number of individuals found in sample

(Savage, 1970, p. 22)

DISCUSSION AND RECOMMENDATIONS

The quality of water in the South Fork and Main Stem of the Coeur d'Alene River basin is a direct result of domestic and industrial activities. This fact has been demonstrated through comparison of North Fork, South Fork, and Main Stem waters. The main toxic elements analyzed were nickel, chromium, arsenic, lead, copper, zinc, and cadmium. No detectable concentrations of chromium or arsenic were found in the three reaches of the river analyzed. (See App. III for water quality data.) Nickel and lead were found on the South Fork below Station 13 (See Figs. 4, 5, and 6, App. I for station locations.) during the first month after initiation of the use of settling ponds, but concentrations from 0.0 to only trace amounts of less than 0.1 ppm of nickel and lead were found at later dates. Copper was found in trace amounts of less than 0.1 ppm throughout the river system during the sampling period.

The establishment of settling ponds in November 1968 could have been instrumental in causing the concentrations of the above mentioned elements, especially nickel, lead, and copper to drop from that reported by previous studies on the river system. This argument is strengthened by the fact that lead and nickel were detected the month after establishment of ponds but not detected in following months. Additional studies are being conducted at the University of Idaho as to the effectiveness of settling ponds in removing dissolved solids.

Because at the levels indicated in Appendix III there is no significant difference between the North Fork and the South Fork with respect to the elements nickel, lead, copper, arsenic, and chromium, these elements are not considered detrimental to aquatic life in the streams except for possible synergistic effects with zinc.

The cadmium and zinc concentrations in the South Fork of the Coeur d'Alene River are cause for concern, especially in light of synergistic effects. Cadmium concentrations on the South Fork are above recommended limits for fish at Stations 13 and 24 when one considers the synergistic effect of cadmium and zinc. McKee and Wolf (1963) report that 0.03 ppm cadmium and 0.15 ppm zinc is synergistically toxic to small salmon fry. Lethal concentrations of cadmium vary from 0.01 to 10 ppm depending on test animal (McKee and Wolf, 1963, p. 150), however, pollution tolerant animals are not usually native to northern Idaho's mountain streams and so are of little interest here. Cadmium concentrations of the North Fork and at Station 28 on the South Fork have been found only in trace amounts of less than 0.01 ppm while concentrations of up to 0.45 ppm have been found on the downstream portions of the South Fork. Cadmium concentrations from the South Fork have affected the Main Stem of the Coeur d'Alene causing concentrations of up to 0.05 ppm to occur. As mentioned above, this concentration in combination with zinc has been reported lethal to fish (McKee and Wolf, 1963, p. 150). Cadmium appears to decrease in the river system with distance downstream, especially from Station 13. This can be explained by precipitation of cadmium salts and settling out of the precipitate, by adsorption of cadmium on the bottom sediments of the river, and by dilution.

Zinc concentrations in the South Fork are significantly above those reported on the North Fork or at Station 28 (upstream from industrial and domestic effluents) on the South Fork. The zinc concentrations on the South Fork below Station 24 are well above toxic limits of from 0.1 ppm to 1.0 ppm for native cutthroat trout. In view of the data reported by Sappington (1970) and the concentrations reported in the text of this report there exists a definite problem with respect to zinc concentrations on the South Fork from Station 24 downstream. These high concentrations for zinc on the South Fork have a definite effect on the Main Stem by causing toxic concentrations to exist throughout the entire length of the Main Stem of the Coeur d'Alene River, in spite of the dilution provided by the North Fork water. This concentration of zinc could also be affecting Coeur d'Alene Lake at the mouth of the Coeur d'Alene River. A study is being conducted at this time to determine what effect, if any, there is.

High zinc concentrations at Station 24 are the result of Canyon Creek discharging into the South Fork immediately upstream from this point. Data were collected from Canyon Creek and from a settling pond located near Canyon Creek during the summer of 1969. During this period ground-water seepage and evaporation were the only forms of discharge for the settling pond. Mean zinc concentrations of 1.4 ppm were found in the pond and 4.8 ppm zinc were found in Canyon Creek. Seepages analyzed down gradient from the settling pond show an increase in zinc concentration with distance. The increase in zinc concentration with distance and the higher concentration in Canyon Creek compared to that found in the settling pond indicates the settling pond effluent is not the major source of zinc ions. High concentrations of zinc in Canyon Creek are possibly the result of ground water leaching old sediments and tailings which have been deposited in the valley above Woodland Park.

Fluoride concentrations at both Stations 24 and 13 are above detrimental limits for trout as reported by McKee and Wolf (1963, p. 191). The South Fork concentrations were two to three times those of the North Fork during the single sample run reported herein.

The concentrations of calcium and magnesium on the South Fork above Station 13 are two to three times the concentrations found in the North Fork, and at Station 12 are four to five times the North Fork concentrations. These dissolved constituents should have a definite beneficial effect in reducing the toxicity of zinc and cadmium, however, these concentrations are not high enough to render the observed zinc and cadmium non-toxic to aquatic life.

Iron concentrations during the period of study were low with maximum concentrations of 2.0 ppm observed in June 1969. Because the higher concentrations of iron were observed during maximum flow and found in both the South Fork and the North Fork it is concluded that iron concentrations are predominantly from natural sources. Iron would not be expected to remain in solution under the oxidizing conditions indicated by the observed, near saturation, dissolved oxygen values.

Electrical conductivity values for the North Fork have consistently been below 60 micromhos at 20°C but have ranged up to 600 micromhos at 20°C for the South Fork. Even with this significantly higher reading for the South Fork it is within limits of waters with good fish production (McKee and Wolf, 1963, p. 273).

Observed pH values on the North Fork and on most of the South Fork are within acceptable limits for support of fish. An exception occurs at Station 13 where a consistantly low pH places the water below this point in a category of marginal fish production. The main problem would be with migrating fish because of a sharp difference between pH at Stations 13 and 14. A gradual decrease in pH on the Main Stem (Stations 1-10) occurs during the summer months. (See Fig. 14, App. I.) However, the pH values for Stations 1 and 10 are not significantly different at the 0.05 level. The reason for this pH drop in the Main Stem during the summer months is not known at this time. A possible explanation is proposed by Schmidt and Conn (1969) for a similar problem in New Brunswick. T. Ferroxidans may be oxidizing thio sulphate and thionates to sulphate with a concomitant decrease in pH. A Student's "t" test comparing pH at Stations 34 (on the North Fork) and 28 (on the South Fork) gave no significant difference at the 0.05 level; however, comparison of Station 34 with Station 11 (on the South Fork) was significantly different at the 0.05 level, thus indicating that the upstream portion of the South Fork (above Mullan) is comparable to the North Fork with respect to pH but is significantly lower by the time it reaches a point immediately upstream from the confluence of the South Fork with the North Fork.

Data from the St. Joe River, which lies to the south of the South Fork drainage, indicate that the St. Joe is similar in quality to the North Fork of the Coeur d'Alene River and the South Fork above Mullan. Mean values of dissolved solids obtained during two months of low flow in 1969 at the mouth of the St. Joe and at Stations 1, 28, and 34 are given in Table 12, Appendix II (Wissmar, written communication, 1970).

Ground-water samples from several wells within the valley are generally within acceptable limits as discussed for river water quality. One exception is high zinc concentrations observed in an industrial well during periods of heavy pumping.

Data from three non-working mines suggest that abandoned mine drainage in the area does not constitute a water quality hazard, as is the case in many other mining districts.

Domestic sewage introduced into the river system has been reported to cause measurable phosphate anomalies at the mouth of the river in Coeur d'Alene Lake (Williams, 1969). The majority of the domestic nutrients may be utilized by algal growth on the bottom of the South Fork between Stations 14 and 24 during the summer months. Industrial effluent (not from settling pond) entering the South Fork between Stations 13 and 14 essentially precludes algae growth in the South Fork downstream from Station 13; the phosphate remains in solution through this reach of the river.

BOD values are low throughout the river system and do not pose a problem. During the period of this study, dissolved oxygen values were always at or near saturation levels because of the high aeration capability of the stream. Temperatures of the stream are variable depending on the season of the year, but are within limits of good fish propagation.

Settling ponds put into operation in November of 1968 have had a definite beneficial effect on the water quality of the South Fork. Macro-benthic life is making a comeback since the establishment of settling ponds and the concomitant reduction of suspended solids after an absence of more than 50 years from the South Fork. The decrease in concentration of some dissolved elements may be attributed to settling ponds although final conclusions cannot be drawn until the completion of a detailed study of the effectiveness of the settling ponds now being conducted by the staff and students at the University of Idaho is completed. It is hoped that this study will provide the mining industry with suggestions and recommendations regarding the existing settling ponds. A second study is dealing with the existing sediments both in old settling ponds and in the flats of the Coeur d'Alene River, to determine their effect on water quality.

The main emphasis of further pollution control must be placed on the reduction of zinc concentration entering the South Fork above Stations 13 and 24. This fact was presented to the industries concerned, and with respect to Station 13 the industry is completing a study on removal of zinc, as well as cadmium, through a process of treatment and recycling, which shows promise of being effective. Above Station 24 the industry concerned is in the process of building two new settling ponds and is studying other methods of improvement. It is worthy of note, however, that it is yet to be established that the settling ponds on Canyon Creek are responsible for the increase in zinc at Station 24, just downstream from where Canyon Creek enters the South Fork. Preliminary studies on the settling pond and on Canyon Creek indicate the major source of zinc is from leaching of old sediments and tailings. Other streams on which mining operations are located enter the South Fork and do not cause a statistically significant increase in the zinc concentration as does Canyon Creek. These include Lake Creek, Nine-Mile Creek, and Big Creek. The first two are much smaller than Canyon Creek while Big Creek is comparable in size to Canyon Creek. In addition, these streams do not flow through the extensive gravel and tailings deposits as does Canyon Creek.

The figures on mass flow in Appendix II indicate there is a source of zinc and other elements being introduced during high flow in the spring. This source could well be the old tailings which have been deposited in the valley during the more than 80 years of mining operations prior to the establishment of settling ponds. During high water in the spring these tailings are picked up and carried along by the turbid waters. As a result, analyses of the water will include elements which have been stripped from these old tailings plus elements derived from present operations.

Seepages from a settling pond discharging into the South Fork at Station 18 and into Big Creek before entering the South Fork are causing adverse conditions to exist in both streams. These seepages are of a high pH and where the seepage water comes in contact with the stream water a precipitate forms which is high in antimony and sulfur and which coats the bottom of the stream. Means of sealing the settling pond and neutralizing the pond water should be considered by the mining company concerned. Kealy and Soderberg (1969) and Kealy and Busch (1970) contain suggestions that should prove helpful in solving these problems.

Much of the problem relating to domestic sewage can be eliminated by introduction of sewage treatment facilities by the major towns of Mullan, Wallace, Silverton, and Osburn. Another method of disposing of raw sewage used by the city of Kellogg is the utilization of settling ponds of the mining industry. Raw sewage from the city of Kellogg is piped into a settling pond along with industrial and mine waste. The method appears to be beneficial to both the mining industry and the city concerned. If other proposals fail, this method of disposal may be adaptable to many of the major towns and communities along the South Fork with a minimum of expense.

SUMMARY AND CONCLUSIONS

1) The Coeur d'Alene River basin has been the location of very intensive mining activities for more than 80 years. Prior to 1968, most of the waste generated by concentrating plants associated with these operations was discharged into the South Fork of the Coeur d'Alene River. This study includes the period of time immediately after the mining industry of the Coeur d'Alene District installed settling ponds to improve water quality.

2) Monthly samples were collected from 34 stations within the Coeur d'Alene basin during a period from December 1968 through March 1970 and analyzed for 13 metals along with nitrates, phosphates, chlorides, dissolved oxygen, biochemical oxygen demand, electrical conductivity, pH, and temperature.

3) The North Fork of the Coeur d'Alene River was used as a basis of comparison because of its excellent water quality. Data from the South Fork above Mullan and the St. Joe River also show excellent water quality, comparable to that on the North Fork.

4) The South Fork of the Coeur d'Alene River is receiving much domestic and industrial waste and as a result the concentrations of certain dissolved constituents are above acceptable limits. The major problem is the high concentrations of zinc and cadmium, especially downstream from Stations 24 and 13. Lead and copper are below our detectable limits but may be toxic because of synergistic effects when combined with concentrations of zinc found in the South Fork. Calcium and magnesium are present in concentrations sufficient to decrease slightly the toxicity of lead, cadmium, and zinc to fish. Nickel and chromium concentrations are negligible. Arsenic is consistently below the University of Idaho's equipment limit of detectability (10 ppm). Values of pH are significantly low from Station 13 downstream. High coliform counts indicate that a domestic pollution problem exists, although nitrates, phosphates, BOD, and chloride concentrations are not considered harmful with the exception of providing nutrients for accelerated aquatic plant growth.

5) The quality of the Main Stem of the Coeur d'Alene River is controlled by the mixing of the North Fork and South Fork. The effect of the South Fork causes the Main Stem to be of substandard quality throughout its length, primarily because of high zinc concentrations.

6) Effort must be exerted to investigate the nature of contaminants entering the South Fork above Stations 13 and 24 to reduce toxic concentrations of zinc, cadmium, and fluoride.

7) The mining industries of the area have shown concern for the problem through the establishment and improvement of settling ponds or other processes to reduce toxic elements. As a result of this, some biological growth is becoming re-established in part of the South Fork and increasing in the Main Stem.

8) Domestic sewage from all of the towns along the South Fork with the exception of Smelterville and Kellogg should be treated in order to reduce bacterial contamination. Utilization of the settling ponds of the mining industry to dispose of domestic waste should also be considered if other alternatives prove to be infeasible.

9) The ground water in certain areas is high in zinc and to a lesser extent lead concentrations. This is especially evident in samples from one industrial well when it has been pumped heavily.

10) During high flow stage of the South Fork and Main Stem, high mass transport values are partially due to the leaching and transport of old mine tailings which were deposited in the valley prior to the establishment of settling ponds.

11) Drainage from three abandoned mines samples in the area contains low concentrations of zinc and other elements; pH is above 7.0. No problems with drainage from abandoned mines are expected, if these data can be considered representative of all mines in the area.

12) Seepage from a settling pond near Station 18 is causing adverse conditions to exist along Big Creek and the South Fork.

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APPENDIX I - MAPS AND GRAPHS

A Map of Western United States Showing the Coeur d'Alene River Basin Study Area.

FIGURE 1

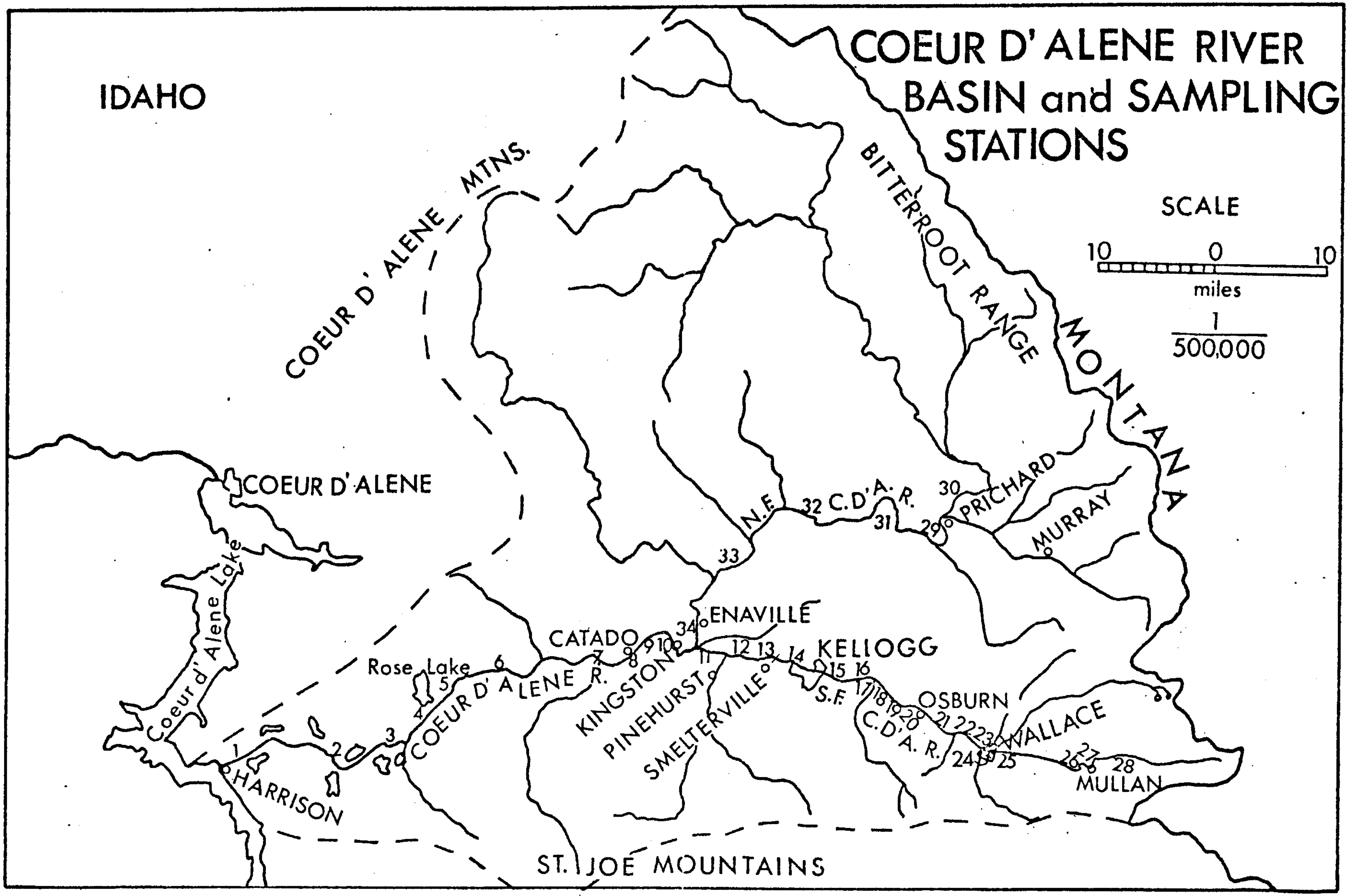


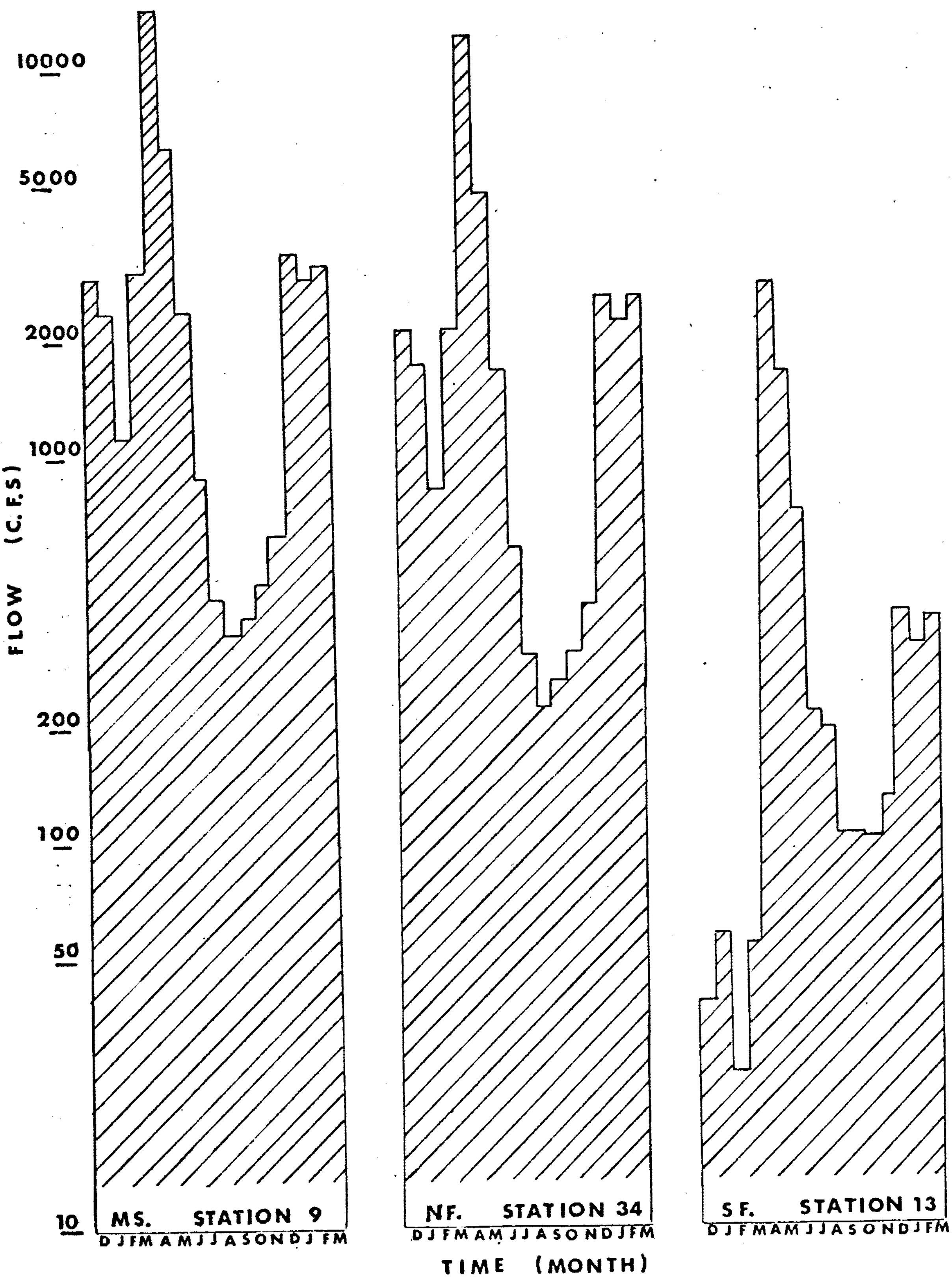
FIGURE 2. MAP OF THE COEUR D'ALENE RIVER BASIN

FIGURE 3

HYDROGRAPH OF DISCHARGE VS. TIME

COEUR d'ALENE RIVER

DEC. 1968 - MARCH 1970



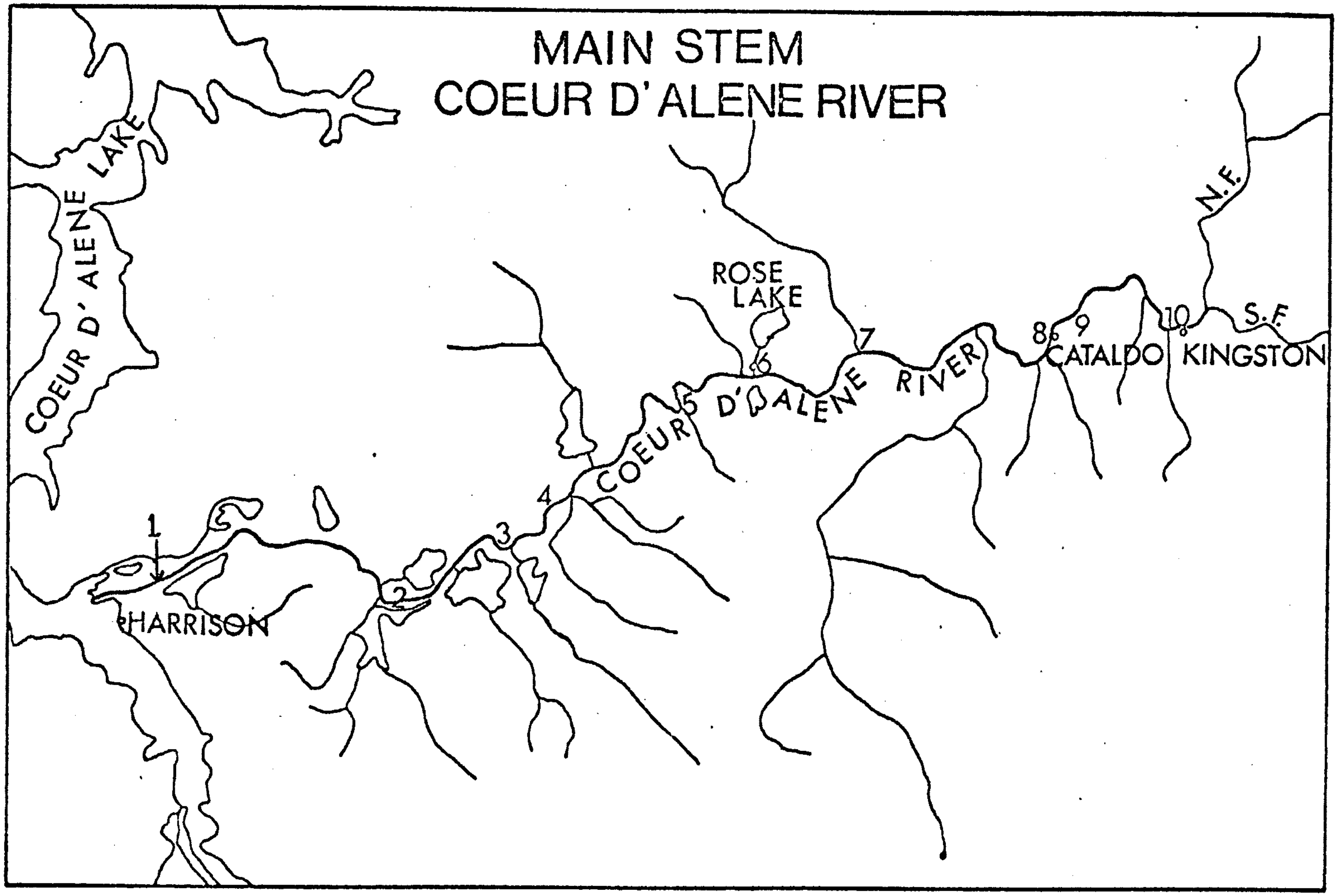


FIGURE 4. SAMPLING STATIONS ON MAIN STREM COEUR d' ALENE RIVER

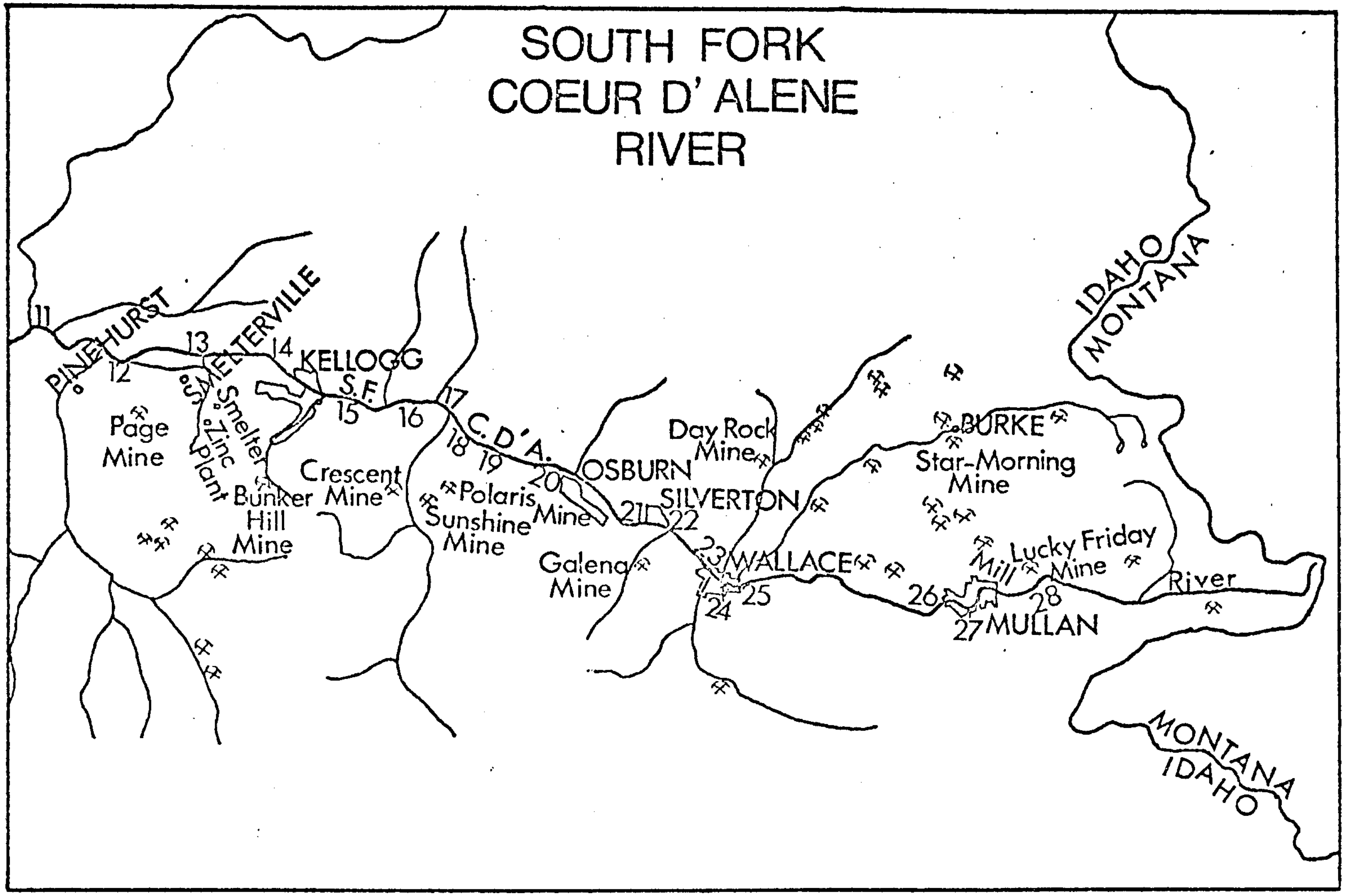


FIGURE 5. SAMPLING STATIONS ON SOUTH FORK COEUR d' ALENE RIVER

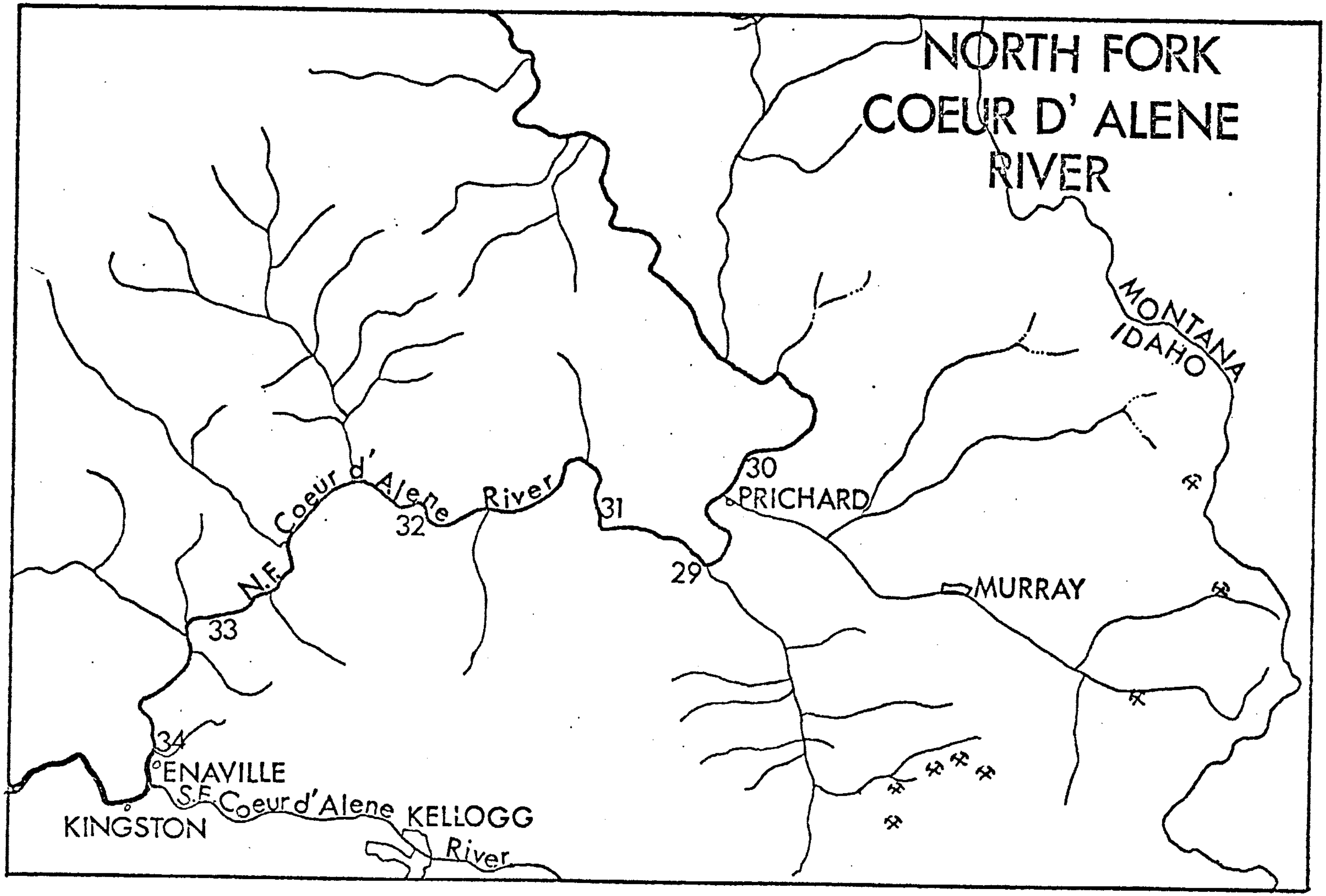


FIGURE 6. SAMPLING STATIONS ON NORTH FORK COEUR d' ALENE RIVER

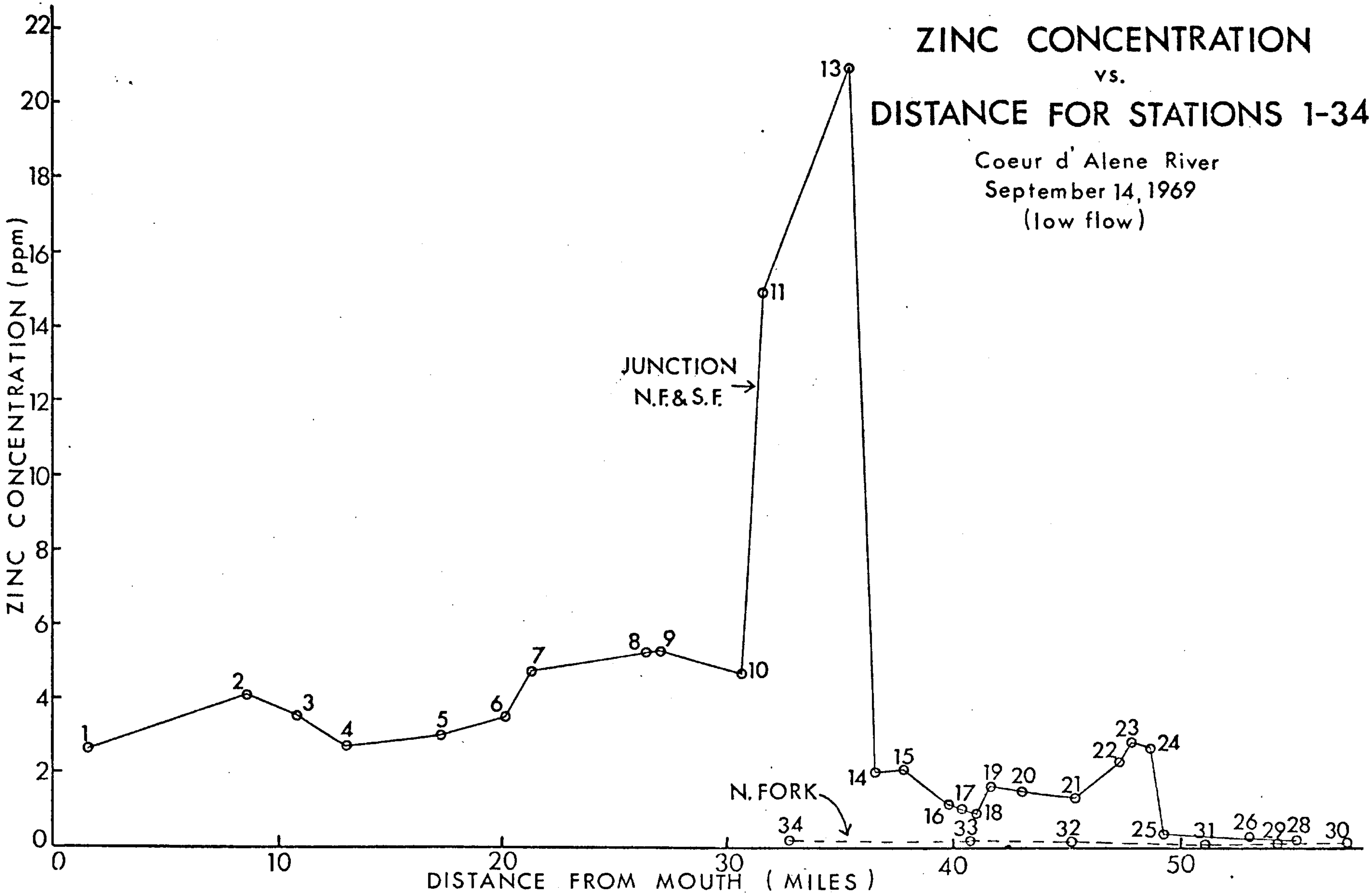

ZINC CONCENTRATION
vs.
DISTANCE FOR STATIONS 1-34
Coeur d' Alene River
September 14, 1969
(low flow)
ZINC CONCENTRATION (ppm)
DISTANCE FROM MOUTH (MILES)
JUNCTION
N.F.& S.F.
N. FORK
0
2
4
6
8
10
12
14
16
18
20
22
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
10
11
13
14
15
16
17
18
19
20
21
22
23
24
25
26
28
29
30
31
32
33
34

FIGURE 7

FIGURE 8

ZINC MASS TRANSPORT

ZINC CONCENTRATION AND FLOW VS. TIME FOR STATION 13 COEUR d'ALENE RIVER

1969 – 1970

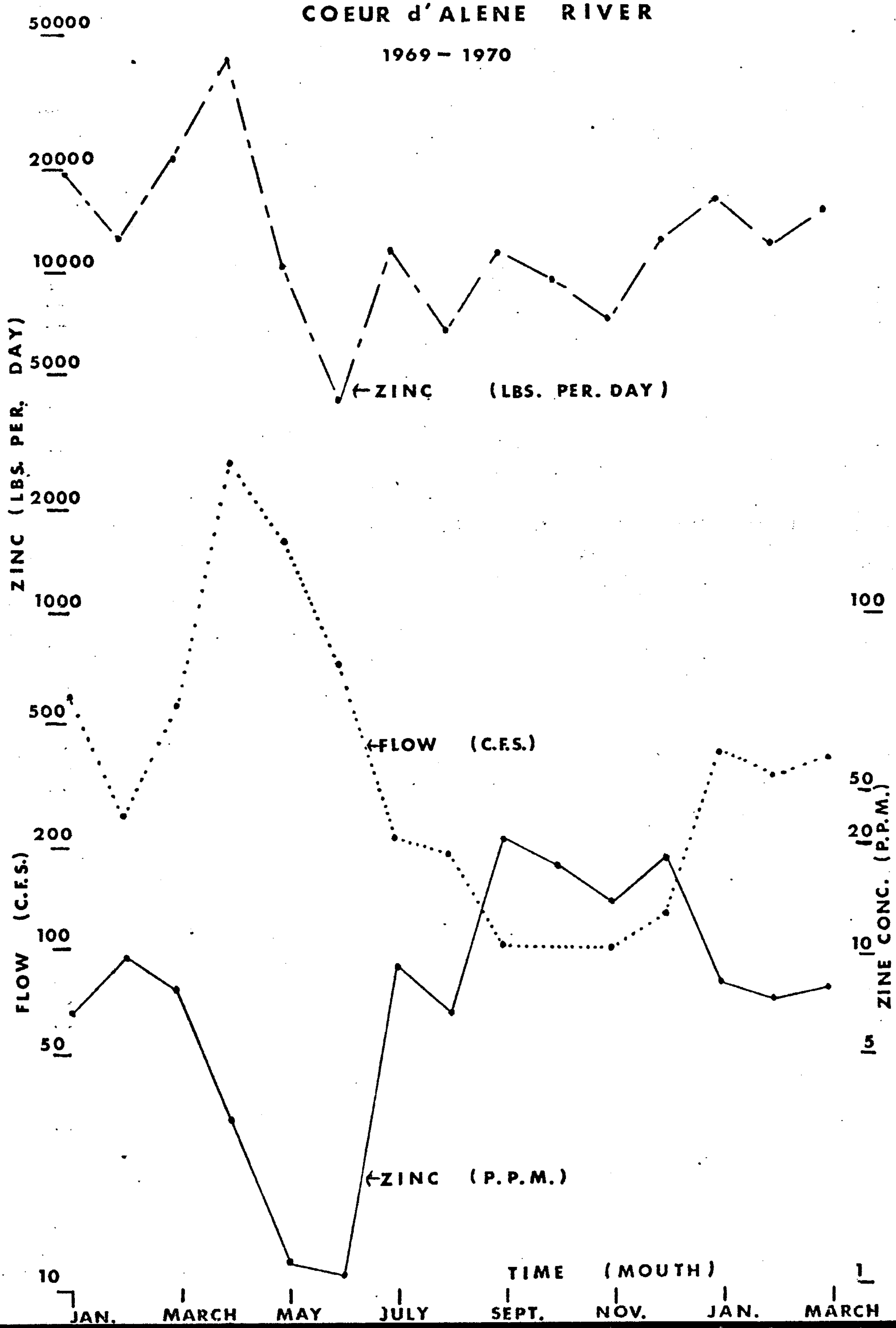
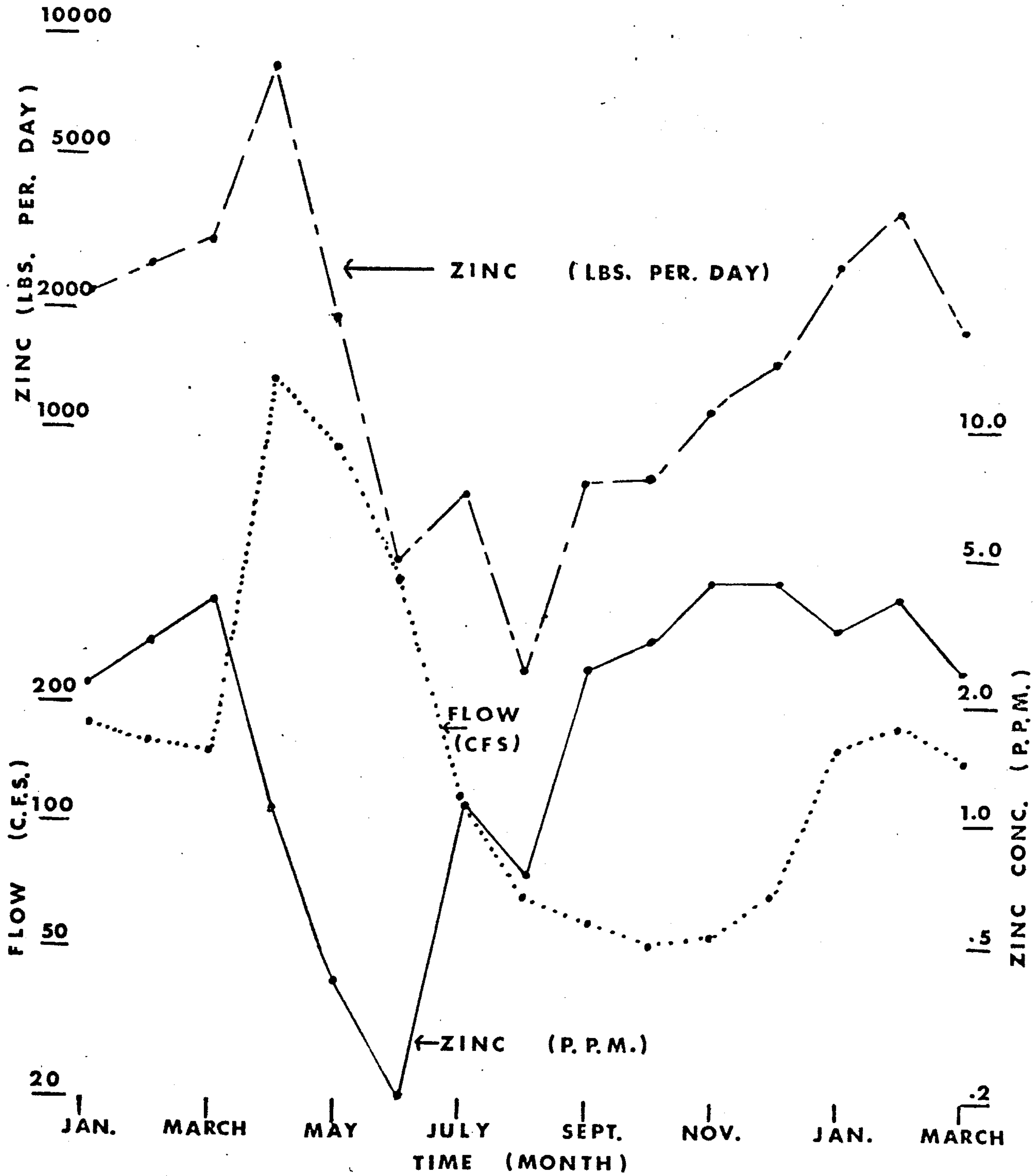


FIGURE 9
ZINC MASS TRANSPORT
ZINC CONCENTRATION AND FLOW VS. TIME FOR STATION 22
COEUR d'ALENE RIVER

1969 - 1970



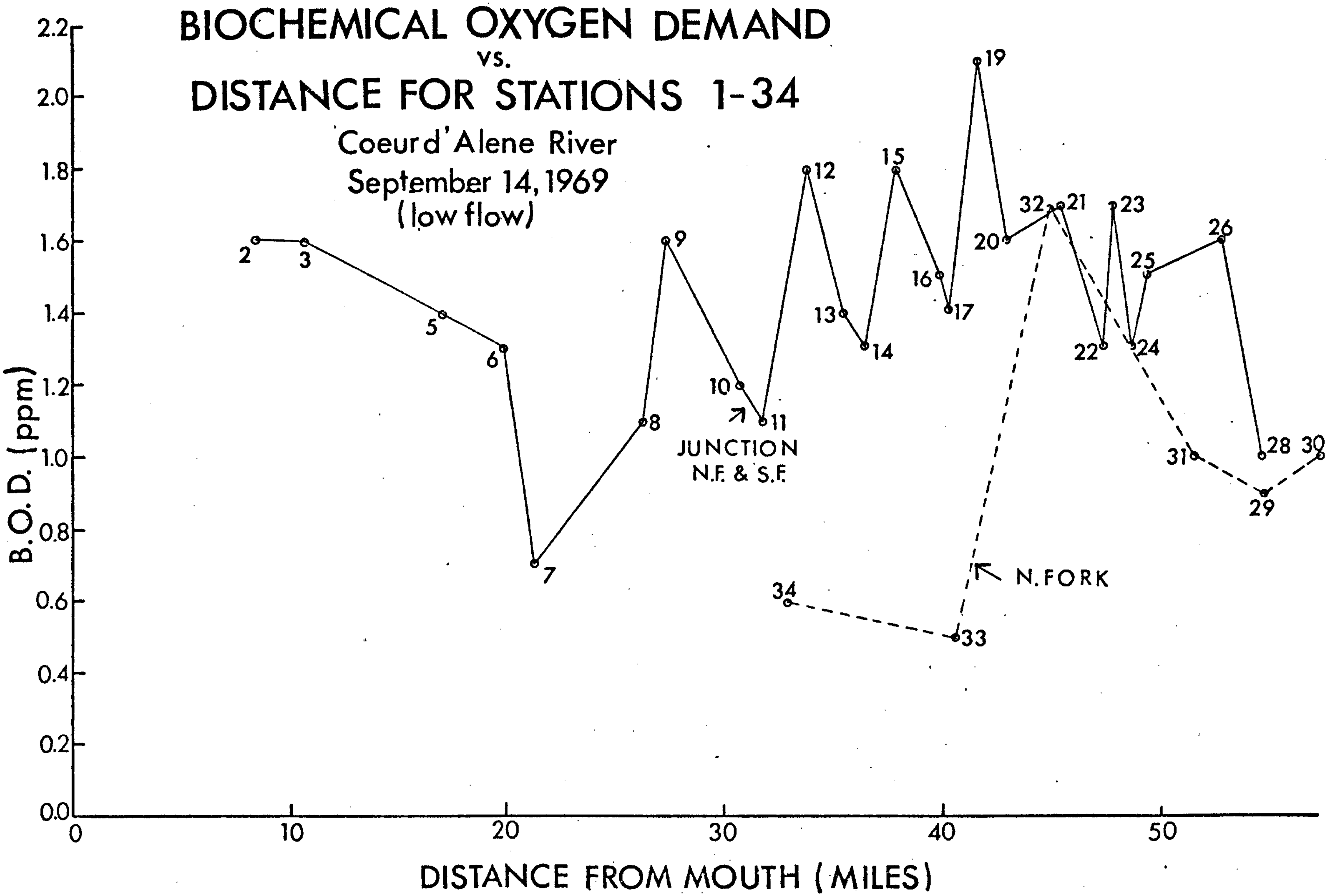

BIOCHEMICAL OXYGEN DEMAND
vs.
DISTANCE FOR STATIONS 1-34
Coeur d'Alene River
September 14, 1969
(low flow)
B.O.D. (ppm)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
0
10
20
30
40
50
DISTANCE FROM MOUTH (MILES)
JUNCTION
N.F. & S.F.
N. FORK
2
3
5
6
7
8
9
10
11
12
13
14
15
16
17
19
20
21
22
23
24
25
26
28
29
30
31
32
33
34

FIGURE 10

NITRATE CONCENTRATION
vs.
DISTANCE FOR STATIONS 1-34

Coeur d'Alene River
September 14, 1969
(low flow)

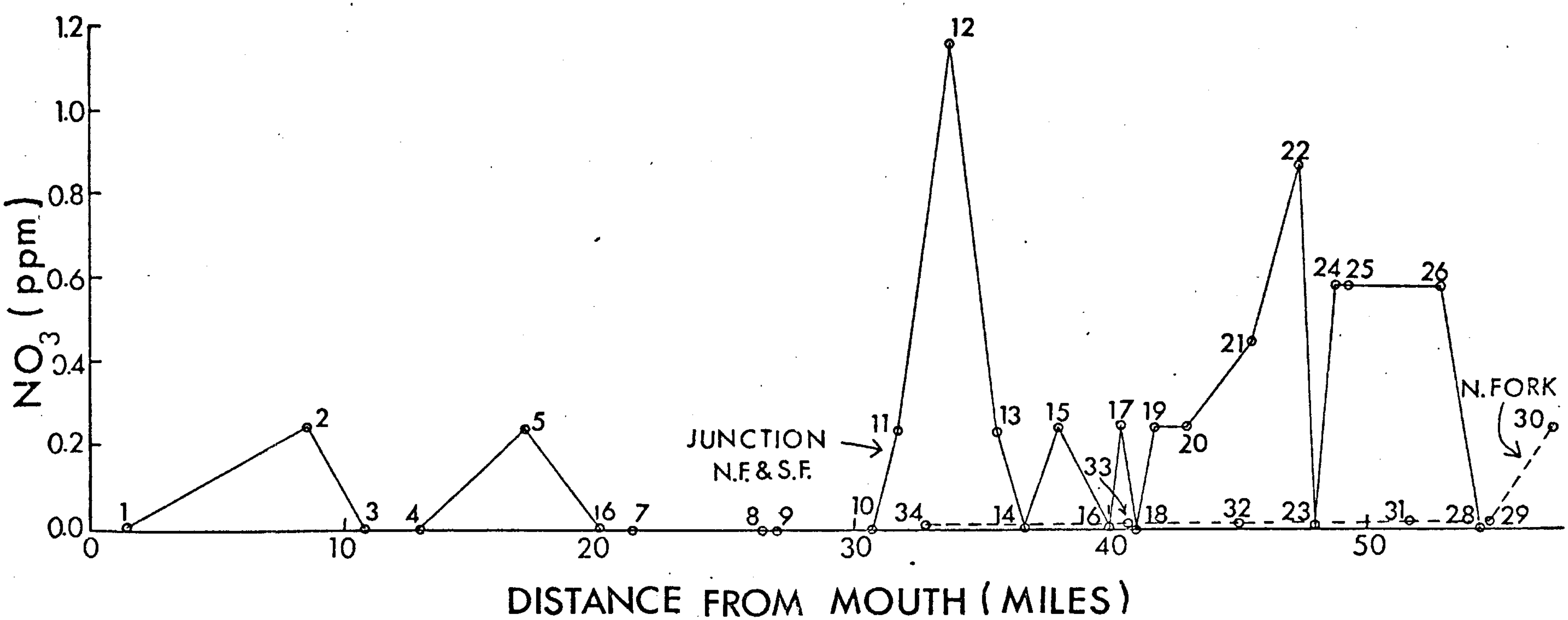


FIGURE 11

PHOSPHATE CONCENTRATION
vs.
DISTANCE FOR STATIONS 1-34

Coeur d'Alene River
September 14, 1969
(low flow)

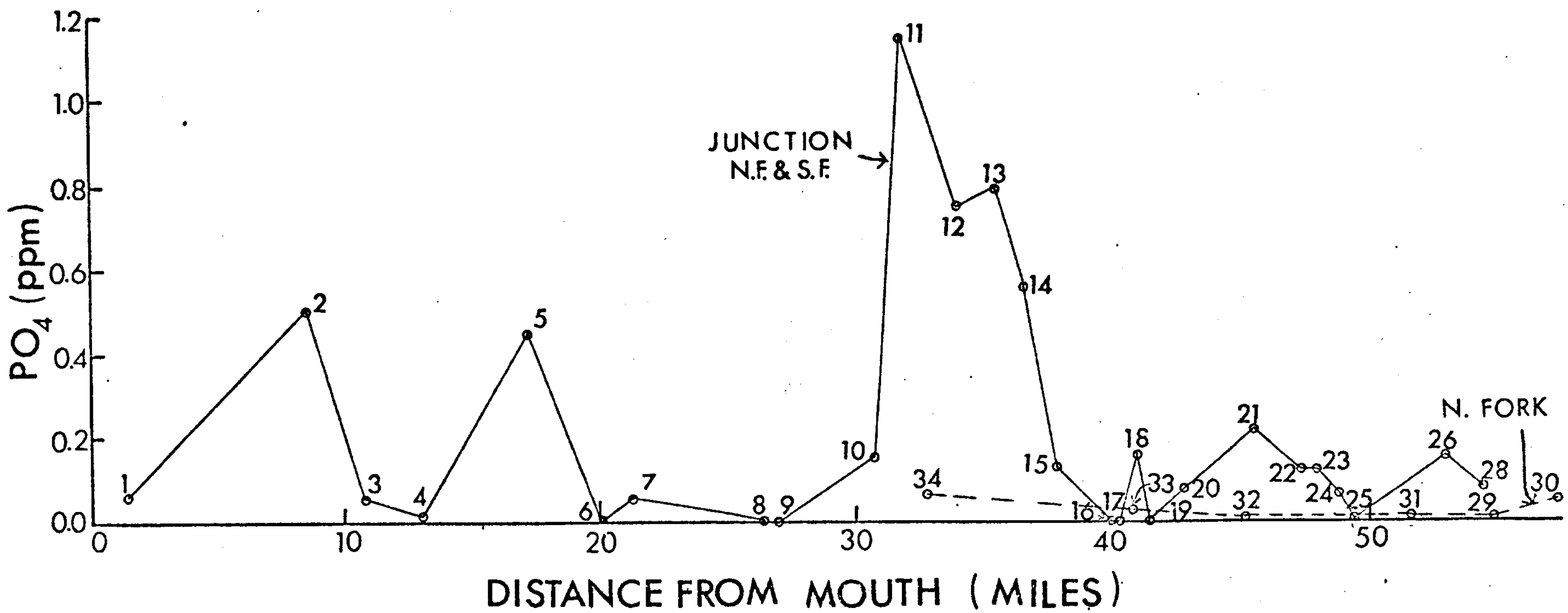
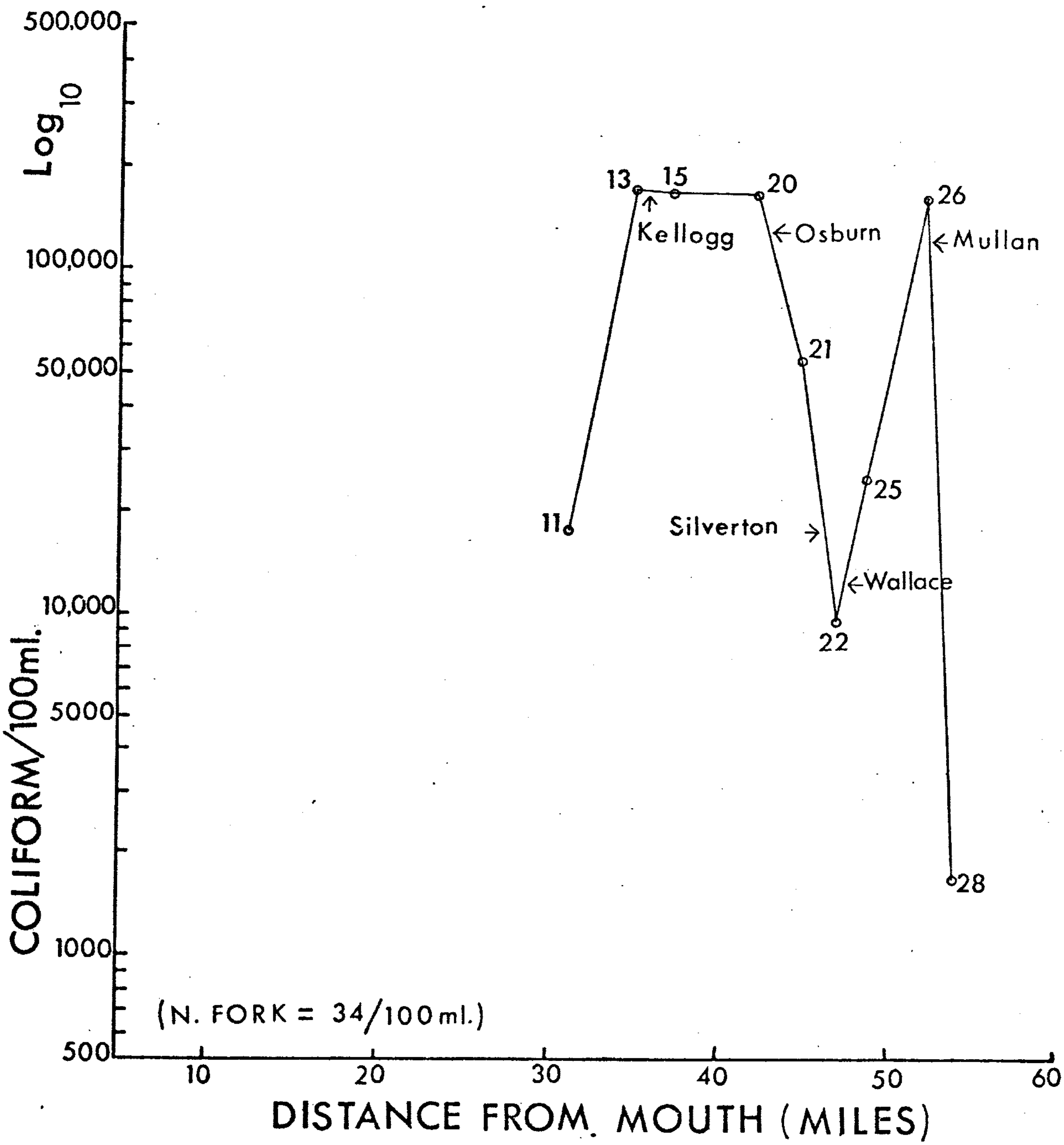


FIGURE 12

FIGURE 13

COLIFORM COUNT (MPN) vs. DISTANCE FOR SOUTH FORK

Coeur d'Alene River, Idaho
September 4, 1969
(low flow)
Idaho Department of Health



pH
vs.
DISTANCE FOR STATIONS 1-34

Coeur d'Alene River
September 14, 1969
(low flow)

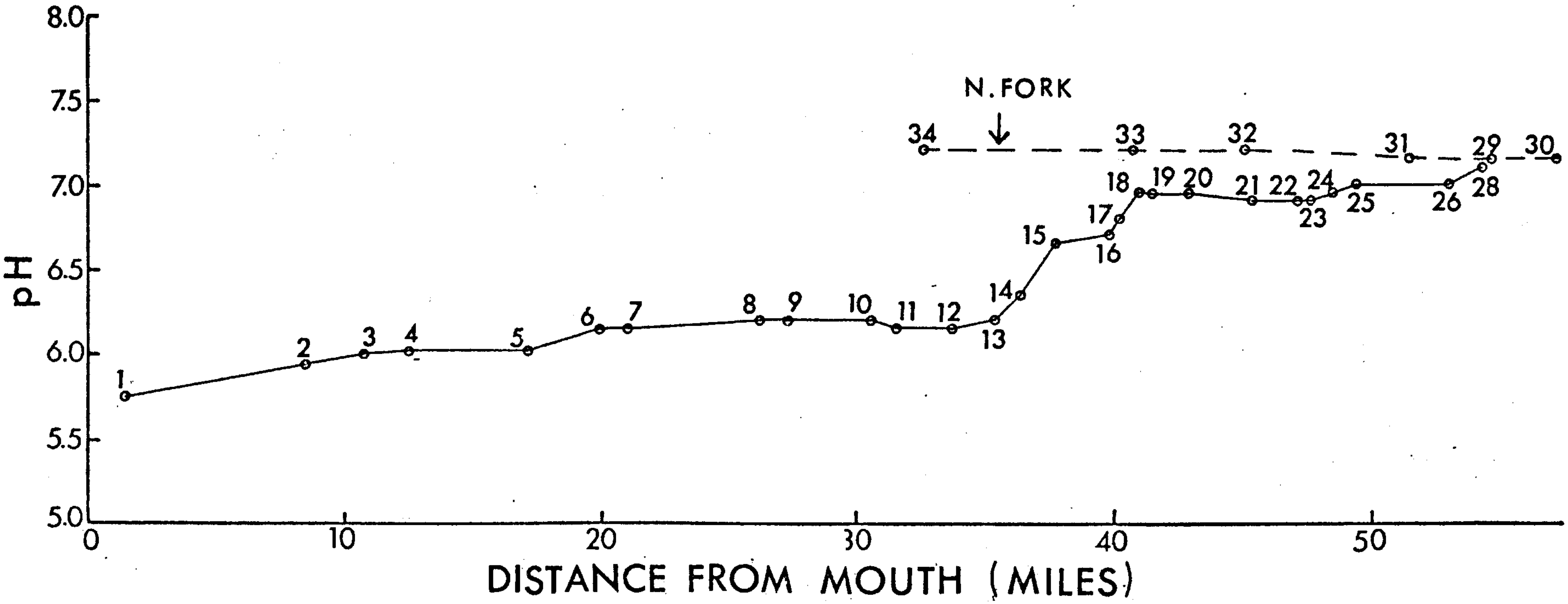


FIGURE 14

FIGURE 15

DISSOLVED OXYGEN AND TEMPERATURE VS. TIME FOR STATIONS 9, 13, 34

SEPT. 5 - 9, 1968

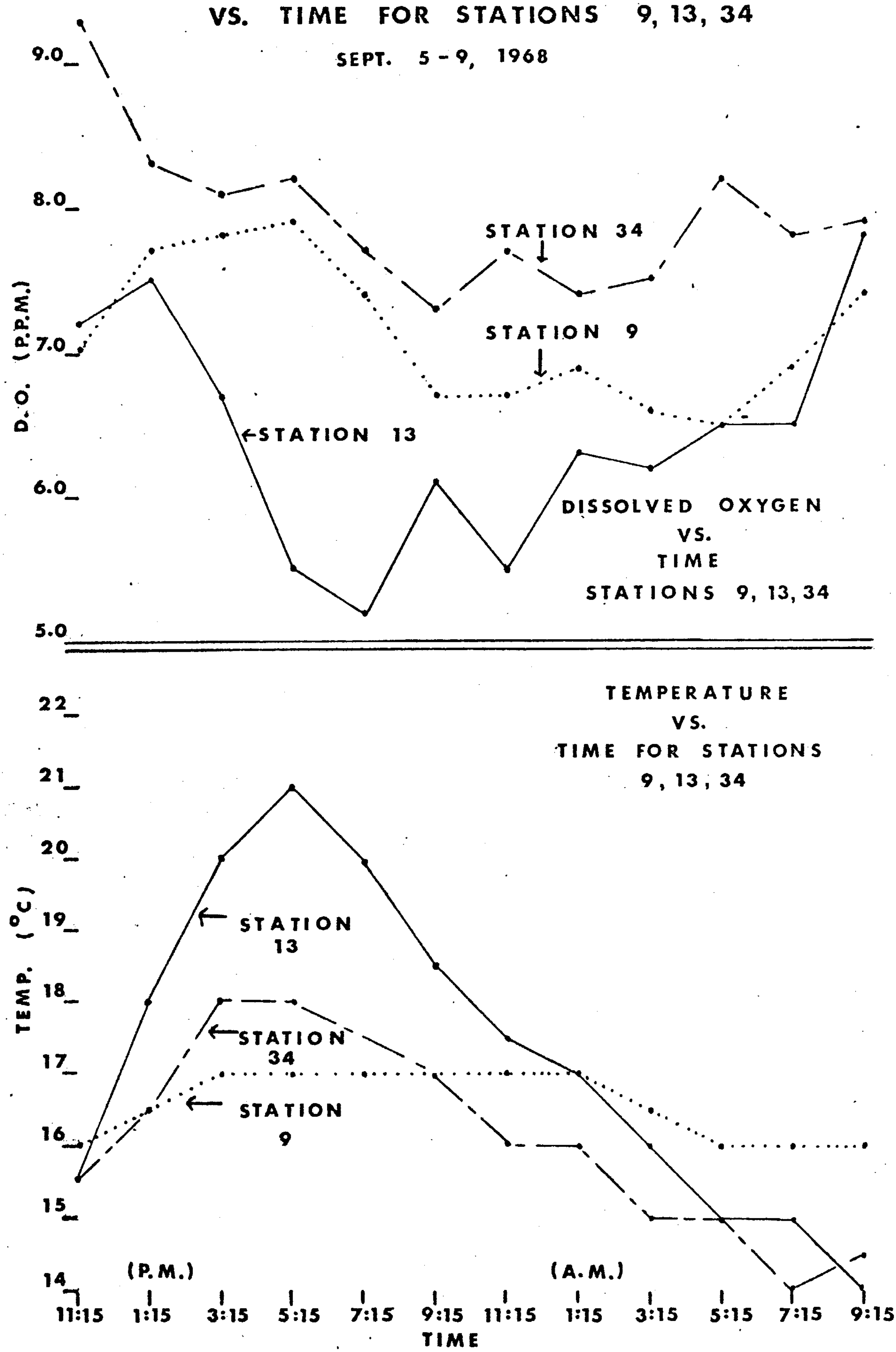


FIGURE 16

ELECTRICAL CONDUCTIVITY AND pH VS. TIME FOR STATIONS 9,13,34
SEPT. 5 – 9 1968

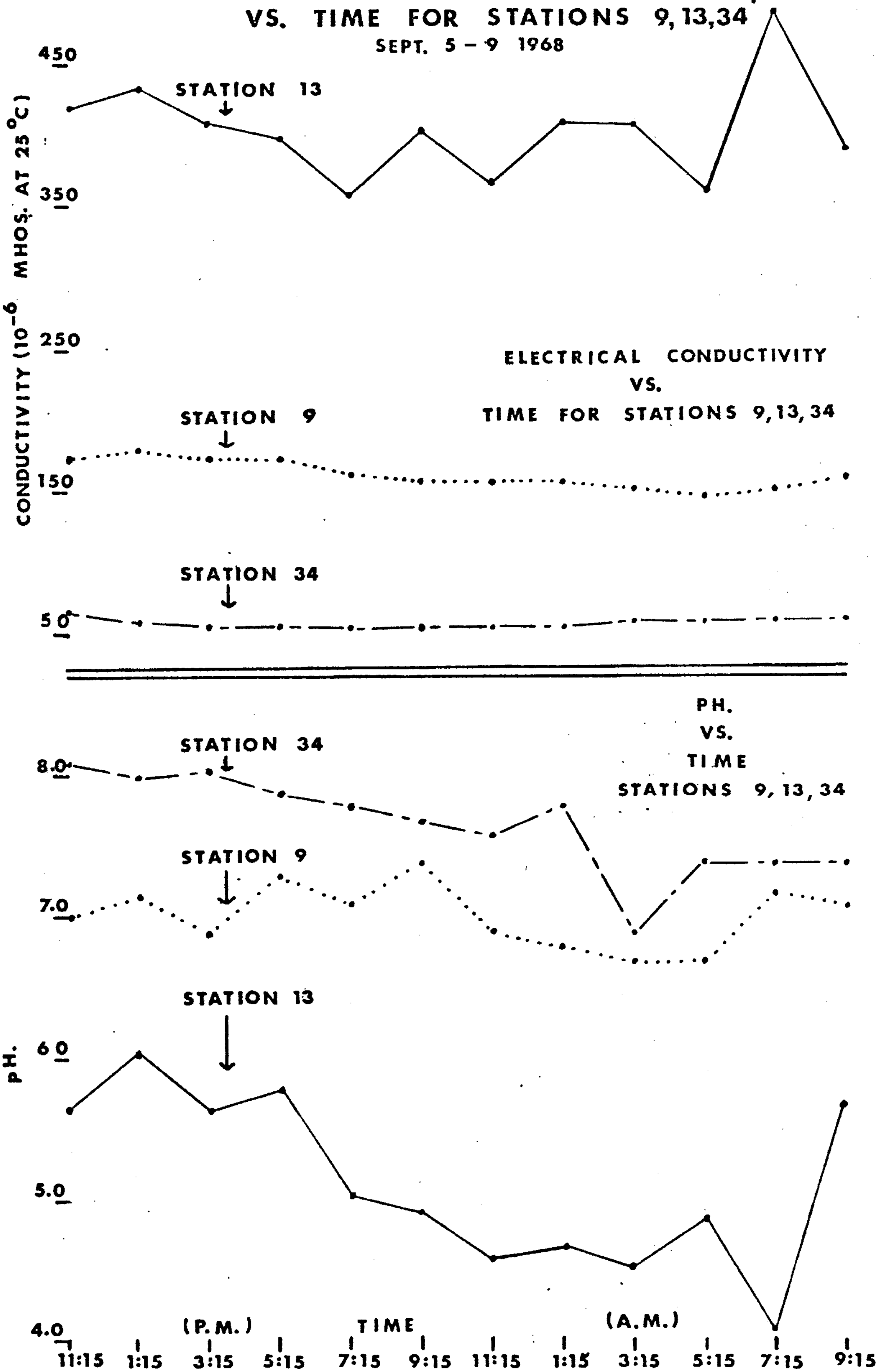
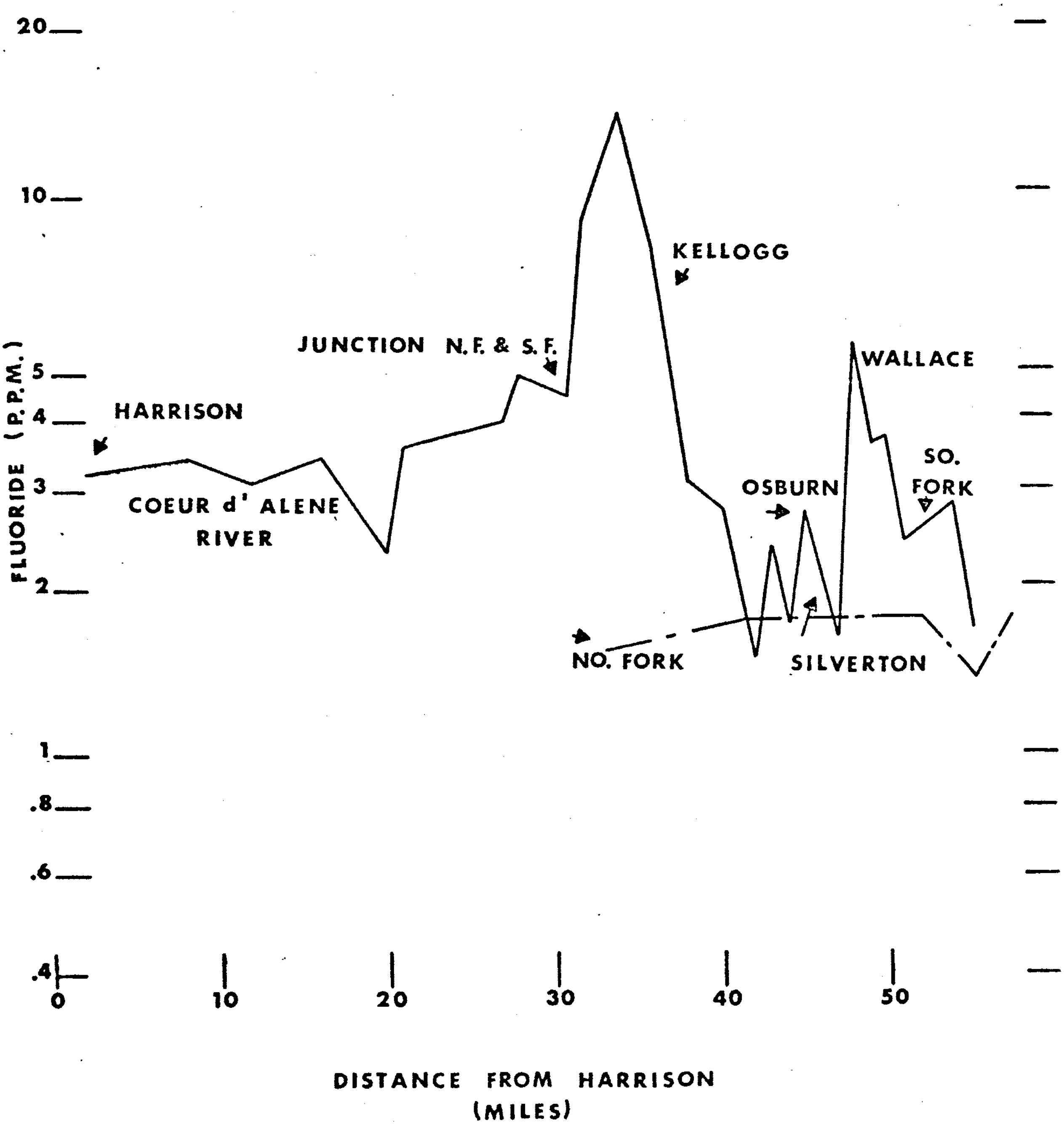


FIGURE 17

FLUORIDE CONCENTRATION VS. DISTANCE

COEUR d'ALENE RIVER
AUGUST 6, 1970
(LOW FLOW)



APPENDIX II - TABLES

Table 1

Population along the South Fork of the Coeur d'Alene River[1]

Cities	Population
Mullan	1750
Wallace	2400
Burke Canyon and Nine Mile Creek	1925
Silverton	750
Osburn	1200
Kellogg	3700
Wardner, Big Creek, Elizabeth Park, Elk Creek, and Montgomery Gulch	3300
Smelterville	1300
Pinehurst	1400
Total	17725

[1]From: City of Mullan, Marie Driscall, Mae Callihan, Nettie T. McClain, written communication, 1970.

Table 2

National rating in mineral production for mines of Coeur d'Alene District, Idaho (1968)[1]

Mine	Silver	Lead	Zinc	Antimony
Sunshine	1	-	-	1
Galena	3	-	-	-
Bunker Hill	4	4	6	-
Lucky Friday	5	10	-	-
Crescent	6	-	-	-
Silver Summit	19	-	-	-
Star-Morning	21	12	12	-
Page	-	16	22	-
Day Rock	-	20	-	-

[1]From: U. S. Bur. Mines, 1969, p. 172, 644, 1013 & 1164.

Table 3

Analysis of Coeur d'Alene River below Cataldo and South Fork Coeur d'Alene River (1932)[1]

Current Station No.	Ellis No.	Date	Depth (M)	Temp. (C°)	pH	CO_2 (cc/l) Free	CO_2 (cc/l) Fixed	D.O. (ppm)	% Saturation	Spec. Cond. x10^6 @25°C.
1	C5	7-11-32	s*	-	6.8	-	-	-	-	-
2	C24	7-14-32	s	18.5	7.1	1.1	5.9	7.5	86.77	-
2	C24	7-14-32	B-17**	18.76	7.0	1.0	5.7	5.5	53.84	-
3	C16	7-12-32	B-12	18.0	6.9	-	-	6.1	69.72	-
7	C52	7-20-32	s	-	-	1.8	6.7	-	-	100.5
17	C43	7-19-32	s	16.5	6.9	1.1	11.5	4.7	53.03	-
18	C42	7-19-32	s	17.0	7.3	1.8	10.4	6.1	69.18	-
22	C41	7-19-32	s	14.5	7.5	1.2	12.5	5.0	54.43	-
25	C39	7-19-32	0.6	12.5	7.0	0.5	7.5	7.4	77.04	-
28	C51	7-19-32	s	-	7.3	0.6	11.0	-	-	-
***	C21	7-14-32	s	18.4	7.1	0.9	4.9	8.4	96.62	-

[1]From: Ellis, 1940 (Table 2 Part II and III).
*s - Surface
**B - Bottom
***Mouth of St. Joseph River

Table 4

Lead and zinc analysis of water from Coeur d'Alene River drainage (1955)[1]

Present Station No.	Chupp No.	Pb (ppm)	Zn (ppm)
28	1	<1	<5
Between 25 & 26	2	5	<5
25	3	5	5
34	4	<1	<5
11	5	<1	5
3	7	<1	<5

[1] From: Chupp (1955, p. 85).

Table 5

Analysis of South Fork Coeur d'Alene River (March 12, 1964)[1]

(All concentrations in parts per million.)

Current Station No.	C.H.H.M. Station No.	pH	Susp. Solids	Dissolved Solids	PO_4	Fe	Cu	Pb	Zn	F
28	1	7.0	0	-	0	0.1	-	-	-	-
26	2	7.7	-	-	0	-	-	-	-	-
14	5	6.8	719	40	-	0.02	0.04	0.1	0.24	1.00
13	6	6.6	640	68	-	0.02	0.04	0.1	2.50	1.83
8	8	6.0	-	-	0	-	-	-	-	-

[1]From: Cornell, Howland, Hayes and Merryfield, 1964, Liquid Waste Products Source, Quantities and Analysis, p. 12, Table II-4.

Table 6

Chemical analysis of Belt rocks in percent of unaltered rock in Coeur d'Alene District[1]

Oxides	Percent
SiO_2	67.4
Al_2O_3	13.8
Fe_2O_3	2.4
FeO	1.28
MgO	2.78
CaO	2.11
Na_2O	1.76
K_2O	3.6
TiO_2	0.49
P_2O_5	0.12
MnO	0.05
CO_2	2.51
H_2O	1.85
	100.15

[1]From: Hobbs and others, 1965, p. 28.

Table 7

Coeur d'Alene basin stream maximum, minimum, and mean flow[1]

Stream	Station	Years of Record	Max. Dischr. (cfs)	Min. Dischr. (cfs)	Av. Dischr. (cfs)
N.F.	Near Prichard	17	11,900	34	738
N.F.	Enaville	29	34,800	104	1937
S.F.	Silverton	2	982	58	-
S.F.	Smelterville	3	2,940	94	377
M.S.	Cataldo	49	67,000	122	2516

[1]From: U. S. Geol. Survey, 1969, p. 56-62.

Table 8

Mass flow of ions in Main Stem, Coeur d'Alene River - Station 9 (pounds per day)

Date	Flow (cfs)	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
12/17/68	2850	110602.8	-	0.0	0.0	-	50692.9	3072.3	-	-	0.0	-
01/20/69	2310	79685.7	-	-	0.0	-	44823.2	6225.5	-	-	-	16186.2
02/26/69	1100	106721.9	-	-	5929.0	-	29645.0	2964.5	-	-	-	13636.7
03/24/69	2940	118849.4	-	1584.7*	12677.3	-	68140.3	4754.0	-	-	-	23769.9
04/23/69	14100	319195.7	-	-	83598.8	-	144398.0	6839.9	-	-	-	37999.5
05/21/69	6210	16736.0	-	-	33471.9	-	13388.8	10041.6	-	-	-	10041.6
06/12/69	2290	8640.2	-	-	6171.6	-	6171.6	2468.6	-	-	-	2468.6
07/15/69	859	31484.1	-	463.0*	926.0	4630.0	13890.0	1852.0	13890.0	-	-	12501.0
08/19/69	414	28339.5	-	0.0	223.2	2008.3	7587.0	1115.7	9372.1	-	-	4462.9
09/14/69	338	19493.5	-	182.2*	364.4	2368.4	9473.5	3825.8	9655.6	-	182.2*	9655.6
10/17/69	372	22256.4	-	200.5*	200.5	2406.1	10827.4	3809.7	9624.4	-	200.5	11228.4
11/24/69	462	25897.9	124.5	-	249.0*	2739.2	13198.0	3237.2	10458.8	-	249.0	13945.0
12/19/69	606	29397.1	163.3	-	326.6	3593.0	15352.0	5226.1	12085.5	-	326.6*	14045.3
01/26/70	3260	101914.1	351.4	-	1757.1*	14057.1	47442.8	12300.0	36899.9	-	1757.1*	19328.5
02/21/70	2870	97397.3	299.7	-	2996.8	10488.9	41955.7	7492.1	32965.2	-	1498.4	19479.5
03/20/70	3030	97990.2	163.3*	-	1633.2	11432.2	40829.2	6532.7	32663.4	-	1633.2*	16331.7

*Trace values of <0.1 ppm were treated as 0.1 and represent maximum possible mass flow values. Cadmium values of <0.01 ppm were treated as 0.01 and represent maximum possible mass flow values.

Table 9

Mass flow of ions in South Fork, Coeur d'Alene River - Station 13 (pounds per day)

Date	Flow (cfs)	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
12/17/68	371	35994.4	-	0.0	599.9	-	17597.3	3399.5	-	-	1599.8	-
01/20/69	560	69423.2	-	-	2716.6	-	23845.3	5132.3	-	-	-	19619.7
02/26/69	243	-	-	-	1571.7	-	12442.8	3405.4	-	-	-	12442.8
03/24/69	522	48674.9	-	281.4*	3094.9	-	-	5064.4	-	-	-	21383.2
04/23/69	2570	156530.9	-	-	1385.2	-	60950.1	9004.0	-	-	-	44327.3
05/21/69	1600	9486.4	-	-	6899.2	-	6036.8	4312.0	-	-	-	10348.8
06/12/69	700	6036.8	-	-	3773.0	-	3018.4	1509.2	-	-	-	4150.3
07/15/69	212	18854.2	-	114.3*	342.8	2285.4	6856.1	114.3*	8455.9	-	-	10169.9
08/19/69	191	30472.9	-	0.0	103.0	2470.8	4632.7	2059.0	14207.0	-	-	6691.7
09/14/69	102	15393.8	-	55.0*	110.0	1594.4	5607.8	3408.6	6707.3	-	55.0*	11545.4
10/17/69	101	14916.3	-	54.4*	54.4*	1742.1	6587.1	3485.1	5988.3	-	54.4*	9526.8
11/24/69	99	14567.5	240.1	-	53.4*	1334.0	6563.4	2668.1	5442.8	-	53.4	7203.7
12/19/69	126	18608.4	258.1	-	67.9*	2173.3	8421.3	4754.0	8013.9	-	67.9*	12564.1
01/26/70	385	39427.8	394.3	-	207.5	4357.8	15771.1	5602.9	13903.5	-	207.5*	16601.2
02/21/70	320	34151.0	103.5	-	517.4	3622.1	12936.0	4312.0	10693.8	-	172.5*	12073.6
03/20/70	367	37188.8	79.1	-	593.4	3758.5	13846.9	4351.9	13846.9	-	197.8*	15231.6

*Trace values of <0.1 ppm treated as 0.1 and represent maximum possible mass flow values.
Cadmium values of <0.01 ppm treated as 0.01 and represent maximum possible mass flow values.

Table 10

Mass flow of ions in South Fork, Coeur d'Alene River - Station 22 (pounds per day)

Date	Flow (cfs)	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
12/17/68	165	11205.8	-	0.0	0.0	-	5247.2	88.9	-	-	0.0	-
01/20/69	182	9809.8	-	-	1471.5	-	4218.2	588.6	-	-	-	2256.3
02/26/69	161	13884.6	-	-	1041.4	-	5206.7	86.8	-	-	-	2603.4
03/24/69	153	12617.5	-	82.5*	824.7	-	5690.2	164.9	-	-	-	3051.3
04/23/69	1370	66458.7	-	-	8861.2	-	25845.1	738.4	-	-	-	8122.7
05/21/69	908	3425.9	-	-	3425.9	-	2447.1	1468.2	-	-	-	1957.7
06/12/69	440	1897.3	-	-	4743.2	-	1185.8	237.2	-	-	-	474.3
07/15/69	117	5108.1	-	63.1*	126.1	504.5	1955.0	63.1*	1198.2	-	-	693.7
08/19/69	65	5010.0	-	35.0*	35.0	315.3	1296.3	35.0*	1261.3	-	-	245.2
09/14/69	57	1781.9	-	30.7*	30.7*	184.3	860.2	30.7	491.6	-	30.7*	737.4
10/17/69	50	3907.8	-	26.9*	26.9*	404.3	1590.1	26.9*	1078.0	-	26.9*	754.6
11/24/69	52	3783.8	5.6	-	28.0*	308.3	1569.6	56.1	1009.0	-	28.0*	1121.1
12/19/69	67	4694.7	10.8	-	36.1*	541.7	2094.6	144.5	1552.9	-	36.1*	1480.6
01/26/70	156	10258.3	8.4	-	84.1*	924.9	3615.6	168.2	2438.4	-	84.1*	2606.6
02/21/70	175	12262.3	18.9	-	94.3	1131.9	4244.6	188.7	2735.4	-	94.3*	3490.0
03/20/70	142	9873.4	15.3	-	76.5	841.9	3291.1	76.5	1990.0	-	76.5*	1836.9

*Trace values of <0.1 ppm were treated as 0.1 and represent maximum possible mass flow values.
Cadmium values of <0.01 ppm were treated as 0.01 and represent maximum mass flow values.

Table 11

Mass flow of ions in North Fork, Coeur d'Alene River - Station 34 (pounds per day)

Date	Flow (cfs)	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
12/17/68	2090	49566.4	-	0.0	0.0	-	20277.2	0.0	-	-	0.0	-
01/20/69	1700	32986.8	-	-	8246.7	-	20158.6	4581.5	-	-	-	-
02/26/69	698	18434.9	-	-	4514.7	-	10158.0	376.2*	-	-	-	376.2*
03/24/69	2110	54589.9	-	1137.3*	11372.9	-	29569.5	1137.3*	-	-	-	1137.3*
04/23/69	11900	205251.1	-	-	76969.1	-	102625.5	5131.3	-	-	-	0.0
05/21/69	4640	12504.8	-	-	17506.7	-	10003.8	7502.9	-	-	-	2501.0*
06/12/69	1630	34264.2	-	-	21964.3	-	3514.3	0.0	-	-	-	878.6*
07/15/69	570	8295.2	-	307.2*	307.2	1843.4	4301.2	307.2*	4301.2	-	-	307.2*
08/19/69	299	8541.5	-	0.0	322.3	805.8	2578.6	161.2*	2417.4	-	-	161.2*
09/14/69	219	4013.4	-	118.0*	118.0*	590.2	2360.8	118.0*	1888.7	-	118.0*	118.0*
10/17/69	254	6160.8	-	136.9*	136.9*	684.5	3011.9	136.9*	1916.7	-	136.9	136.9*
11/24/69	305	8548.5	16.4*	-	164.4*	822.0	3945.5	164.4*	2301.5	-	164.4*	164.4*
12/19/69	397	7917.4	21.4*	-	214.0*	855.9	4707.6	214.0*	2781.8	-	214.0*	214.0*
01/26/70	2530	42273.7	136.4*	-	1363.7*	6818.4	23182.4	1363.7*	16364.0	-	1363.7*	1363.7*
02/21/70	2170	39767.4	117.0*	-	1169.6*	5848.2	19883.7	1169.6*	14035.6	-	1169.6*	1169.6*
03/20/70	2460	51711.6	132.6*	-	1325.9*	5303.8	22541.0	1325.9*	14585.3	-	1325.9*	1325.9*

*Trace values of <0.1 ppm were treated as 0.1 and represent maximum possible mass flow values. Cadmium values of <0.01 ppm were treated as 0.01 and represent maximum possible mass flow values.

Table 12

Comparison of St. Joe and Coeur d'Alene Rivers (ppm)
(August-September, 1969)

River	Ca	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
Mouth of St. Joe*	8.9	0.0	0.15	0.7	1.4	<0.1	1.6	0.0	<0.1
Mouth of North Fork #34	4.6	0.0	0.10	0.5	2.0	<0.1	1.5	<0.1	<0.1
Mouth of Coeur d'Alene #1	6.8	0.1	0.10	0.7	2.5	0.7	2.5	<0.1	2.6
South Fork Above Mullan #28	8.0	<0.1	<0.1	0.4	3.1	<0.1	1.4	<0.1	<0.1

*Wissmar, written communication, 1969.

APPENDIX III - WATER QUALITY DATA FOR THE COEUR D'ALENE RIVER BASIN

December 17, 1968

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	2.0	7.50	50	-	<0.1	-	-	-
2	2.0	7.70	68	-	<0.1	-	-	-
3	2.0	7.80	62	-	<0.1	-	-	-
4	2.0	7.90	55	-	<0.1	-	-	-
5	2.0	8.00	68	-	<0.1	-	-	-
6	2.5	8.00	78	-	<0.1	-	-	-
7	2.5	8.00	72	-	<0.1	-	-	-
8	2.5	8.05	52	-	<0.1	-	-	-
9	2.5	7.85	72	-	<0.1	-	-	-
10	3.5	7.80	65	-	<0.1	-	-	-
11	3.5	7.65	160	-	<0.1	-	-	-
12	3.5	7.25	235	-	<0.1	-	-	-
13	4.0	7.60	240	-	<0.1	-	-	-
14	2.5	7.90	130	-	<0.1	-	-	-
15	2.5	8.05	130	-	<0.1	-	-	-
16	2.5	7.90	180	-	<0.1	-	-	-
17	2.5	8.05	100	-	<0.1	-	-	-
18	2.0	7.90	105	-	<0.1	-	-	-
19	2.0	7.70	120	-	<0.1	-	-	-
20	2.0	7.80	105	-	<0.1	-	-	-
21	2.0	7.80	105	-	<0.1	-	-	-
22	2.3	7.80	120	-	<0.1	-	-	-
23	2.0	7.80	120	-	<0.1	-	-	-
24	2.0	7.80	120	-	<0.1	-	-	-
25	2.0	8.20	105	-	<0.1	-	-	-
26	2.0	8.10	90	-	<0.1	-	-	-
27	2.5	8.15	90	-	<0.1	-	-	-
28	2.0	8.20	<50	-	<0.1	-	-	-
29	2.0	8.25	<50	-	<0.1	-	-	-
30	2.0	8.25	<50	-	<0.1	-	-	-
31	2.0	8.20	<50	-	<0.1	-	-	-
32	2.0	8.15	<50	-	<0.1	-	-	-
33	2.5	8.15	<50	-	<0.1	-	-	-
34	2.7	8.10	<50	-	<0.1	-	-	-

December 17, 1968 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	<10.0	7.2	-	<0.5	0.0	0.0	-	3.2	0.0	-	<0.1	0.0	-
2	<10.0	7.0	-	<0.5	0.0	0.0	-	3.0	0.0	-	<0.1	0.0	-
3	<10.0	7.0	-	<0.5	0.0	0.0	-	3.0	0.0	-	<0.1	0.0	-
4	<10.0	7.2	-	<0.5	0.0	0.0	-	3.3	0.1	-	<0.1	0.0	-
5	<10.0	7.2	-	<0.5	0.0	0.0	-	3.0	0.2	-	<0.1	0.0	-
6	<10.0	7.6	-	<0.5	0.0	0.0	-	3.4	0.3	-	<0.1	0.0	-
7	<10.0	7.2	-	<0.5	0.0	0.0	-	3.4	0.3	-	<0.1	0.0	-
8	<10.0	7.2	-	<0.5	0.0	0.0	-	3.3	0.3	-	<0.1	0.0	-
9	<10.0	7.2	-	<0.5	0.0	0.0	-	3.3	0.2	-	<0.1	0.0	-
10	<10.0	8.3	-	<0.5	0.0	0.1	-	3.5	0.3	-	<0.1	0.0	-
11	<10.0	14.4	-	<0.5	0.0	0.2	-	7.3	0.9	-	0.1	0.0	-
12	<10.0	19.8	-	<0.5	0.0	0.3	-	9.2	1.7	-	0.2	0.3	-
13	<10.0	18.0	-	<0.5	0.0	0.3	-	8.8	1.7	-	0.2	0.8	-
14	<10.0	12.2	-	<0.5	0.0	0.0	-	6.1	0.1	-	<0.1	0.0	-
15	<10.0	12.6	-	<0.5	0.0	0.0	-	6.5	0.1	-	<0.1	0.0	-
16	<10.0	12.8	-	<0.5	0.0	0.0	-	6.2	0.1	-	<0.1	0.0	-
17	<10.0	10.1	-	<0.5	0.0	0.1	-	4.7	0.1	-	<0.1	0.0	-
18	<10.0	13.8	-	<0.5	0.0	0.0	-	6.2	0.3	-	<0.1	0.0	-
19	<10.0	14.0	-	<0.5	0.0	0.0	-	6.1	0.1	-	<0.1	0.0	-
20	<10.0	13.1	-	<0.5	0.0	0.0	-	5.9	0.1	-	<0.1	0.0	-
21	<10.0	13.1	-	<0.5	0.0	0.0	-	5.9	0.1	-	<0.1	0.0	-
22	<10.0	12.6	-	<0.5	0.0	0.0	-	5.9	0.1	-	<0.1	0.0	-
23	<10.0	12.6	-	<0.5	0.0	0.0	-	6.2	0.1	-	<0.1	0.0	-
24	<10.0	11.9	-	<0.5	0.0	0.1	-	5.9	0.2	-	<0.1	0.0	-
25	<10.0	11.1	-	<0.5	0.0	0.0	-	5.1	0.0	-	<0.1	0.0	-
26	<10.0	10.1	-	<0.5	0.0	0.0	-	4.6	0.0	-	<0.1	0.0	-
27	<10.0	10.6	-	<0.5	0.0	0.1	-	5.1	0.0	-	<0.1	0.0	-
28	<10.0	7.9	-	<0.5	0.0	0.0	-	3.8	0.0	-	<0.1	0.0	-
29	<10.0	4.5	-	<0.5	0.0	0.0	-	2.0	0.0	-	<0.1	0.0	-
30	<10.0	4.7	-	<0.5	0.0	0.0	-	2.2	0.0	-	<0.1	0.0	-
31	<10.0	4.6	-	<0.5	0.0	0.0	-	2.0	0.0	-	<0.1	0.0	-
32	<10.0	4.7	-	<0.5	0.0	0.0	-	2.0	0.0	-	<0.1	0.0	-
33	<10.0	4.6	-	<0.5	0.0	0.0	-	2.0	0.0	-	<0.1	0.0	-
34	<10.0	4.4	-	<0.5	0.0	0.0	-	1.8	0.0	-	<0.1	0.0	-

(1) D.O. was determined by measuring D.O. at 20° C in sample which had been sealed and returned to lab. Value in table should be viewed as minimum possible D.O. in river water.

(2) All concentrations except temp., pH and E.C. are in parts per million. E.C. is in micromhos @20° C. Temperature is in degrees centigrade.

January 20, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	0.0	6.60	84	-	-	-	-	-
2	0.0	6.50	84	-	-	-	-	-
3	0.0	6.50	78	-	-	-	-	-
4	0.0	6.50	79	-	-	-	-	-
5	0.0	6.45	76	-	-	-	-	-
6	0.0	6.45	86	-	-	-	-	-
7	0.0	6.45	77	-	-	-	-	-
8	0.0	6.55	86	-	-	-	-	-
9	0.0	6.55	77	-	-	-	-	-
10	0.0	6.45	94	-	-	-	-	-
11	0.5	6.20	190	-	-	-	-	-
12	1.0	6.20	260	-	-	-	-	-
13	1.0	6.20	233	-	-	-	-	-
14	1.0	6.30	119	-	-	-	-	-
15	0.5	6.40	118	-	-	-	-	-
16	0.5	6.50	113	-	-	-	-	-
17	0.5	6.65	87	-	-	-	-	-
18	0.5	6.70	150	-	-	-	-	-
19	0.5	6.65	121	-	-	-	-	-
20	0.5	6.65	108	-	-	-	-	-
21	0.5	6.70	106	-	-	-	-	-
22	0.5	6.70	102	-	-	-	-	-
23	0.5	6.70	97	-	-	-	-	-
24	1.0	6.65	131	-	-	-	-	-
25	0.5	6.80	92	-	-	-	-	-
26	0.5	6.95	80	-	-	-	-	-
27	0.5	6.80	81	-	-	-	-	-
28	0.5	6.95	64	-	-	-	-	-
29	0.0	6.95	40	-	-	-	-	-
30	0.0	6.95	43	-	-	-	-	-
31	0.0	7.00	44	-	-	-	-	-
32	0.0	7.00	42	-	-	-	-	-
33	0.0	7.10	42	-	-	-	-	-
34	0.0	7.10	40	-	-	-	-	-

January 20, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	<10.0	6.7	-	<0.5	-	1.0	-	3.6	0.4	-	<0.1	-	0.8
2	<10.0	6.5	-	<0.5	-	1.5	-	3.8	0.3	-	<0.1	-	0.8
3	<10.0	6.7	-	<0.5	-	0.9	-	3.7	0.5	-	<0.1	-	1.1
4	<10.0	7.2	-	<0.5	-	0.9	-	3.9	0.6	-	<0.1	-	1.5
5	<10.0	6.5	-	<0.5	-	0.5	-	3.8	0.7	-	<0.1	-	1.6
6	<10.0	6.4	-	<0.5	-	1.5	-	3.8	1.6	-	<0.1	-	2.0
7	<10.0	6.4	-	<0.5	-	1.6	-	3.9	0.6	-	<0.1	-	1.3
8	<10.0	7.9	-	<0.5	-	0.9	-	3.7	0.4	-	<0.1	-	1.4
9	<10.0	6.4	-	<0.5	-	0.0	-	3.6	0.5	-	<0.1	-	1.3
10	<10.0	8.7	-	<0.5	-	1.5	-	4.0	0.4	-	<0.1	-	1.9
11	<10.0	20.0	-	<0.5	-	0.9	-	6.6	1.1	-	<0.1	-	5.6
12	<10.0	20.5	-	<0.5	-	0.9	-	9.4	1.8	-	<0.1	-	8.7
13	<10.0	23.0	-	<0.5	-	0.9	-	7.9	1.7	-	<0.1	-	6.5
14	<10.0	10.2	-	<0.5	-	1.0	-	5.5	0.6	-	<0.1	-	1.8
15	<10.0	9.6	-	<0.5	-	0.0	-	5.3	0.4	-	<0.1	-	2.1
16	<10.0	11.2	-	<0.5	-	1.0	-	5.1	0.5	-	<0.1	-	2.3
17	<10.0	8.0	-	<0.5	-	0.5	-	4.0	0.4	-	<0.1	-	0.3
18	<10.0	12.0	-	<0.5	-	0.9	-	5.3	0.6	-	<0.1	-	0.1
19	<10.0	12.6	-	<0.5	-	0.9	-	5.5	0.6	-	<0.1	-	3.6
20	<10.0	11.2	-	<0.5	-	1.0	-	5.1	0.5	-	<0.1	-	2.6
21	<10.0	12.1	-	<0.5	-	1.0	-	5.2	0.4	-	<0.1	-	2.5
22	<10.0	10.0	-	<0.5	-	1.5	-	4.3	0.6	-	<0.1	-	2.3
23	<10.0	10.6	-	<0.5	-	0.5	-	4.3	0.7	-	<0.1	-	2.7
24	<10.0	11.6	-	<0.5	-	1.0	-	5.5	0.7	-	<0.1	-	8.1
25	<10.0	9.5	-	<0.5	-	0.5	-	4.3	0.6	-	<0.1	-	0.1
26	<10.0	7.7	-	<0.5	-	0.9	-	4.4	0.5	-	<0.1	-	0.4
27	<10.0	7.3	-	<0.5	-	0.5	-	4.3	0.4	-	<0.1	-	0.3
28	<10.0	7.0	-	<0.5	-	0.9	-	4.0	0.5	-	<0.1	-	<0.1
29	<10.0	3.4	-	<0.5	-	0.9	-	2.5	0.5	-	<0.1	-	-
30	<10.0	4.2	-	<0.5	-	0.9	-	2.6	0.4	-	<0.1	-	-
31	<10.0	4.0	-	<0.5	-	0.5	-	2.5	0.4	-	<0.1	-	-
32	<10.0	3.6	-	<0.5	-	1.0	-	2.3	0.5	-	<0.1	-	-
33	<10.0	3.7	-	<0.5	-	0.9	-	2.2	0.4	-	<0.1	-	-
34	<10.0	3.6	-	<0.5	-	0.9	-	2.2	0.5	-	<0.1	-	-

February 26, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	2.2	6.40	120	-	-	-	-	-
2	3.0	6.80	100	-	-	-	-	-
3	3.0	6.50	100	-	-	-	-	-
4	3.4	6.80	95	-	-	-	-	-
5	3.4	6.60	132	-	-	-	-	-
6	3.4	6.60	140	-	-	-	-	-
7	3.4	7.00	130	-	-	-	-	-
8	3.4	6.70	170	-	-	-	-	-
9	3.4	6.80	160	-	-	-	-	-
10	3.4	6.10	205	-	-	-	-	-
11	5.0	5.70	445	-	-	-	-	-
12	5.0	4.80	600	-	-	-	-	-
13	5.0	4.40	420	-	-	-	-	-
14	5.0	7.00	145	-	-	-	-	-
15	5.0	7.00	145	-	-	-	-	-
16	5.0	6.90	140	-	-	-	-	-
17	5.0	7.70	118	-	-	-	-	-
18	5.0	7.90	310	-	-	-	-	-
19	5.0	6.80	140	-	-	-	-	-
20	5.0	6.50	130	-	-	-	-	-
21	5.0	6.30	130	-	-	-	-	-
22	5.0	6.70	130	-	-	-	-	-
23	5.0	7.10	140	-	-	-	-	-
24	5.0	6.70	150	-	-	-	-	-
25	5.0	7.40	110	-	-	-	-	-
26	5.0	7.20	90	-	-	-	-	-
27	5.0	7.40	75	-	-	-	-	-
28	5.0	7.30	65	-	-	-	-	-
29	1.7	7.10	<50	-	-	-	-	-
30	1.7	7.10	<50	-	-	-	-	-
31	3.4	6.30	<50	-	-	-	-	-
32	2.3	7.10	<50	-	-	-	-	-
33	2.2	6.90	<50	-	-	-	-	-
34	2.2	6.70	<50	-	-	-	-	-

February 26, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	10.0	12.5	-	<0.5	-	1.2	-	4.7	1.0	-	<0.1	-	2.4
2	10.0	9.0	-	<0.5	-	1.2	-	5.0	0.7	-	<0.1	-	2.0
3	10.0	9.0	-	<0.5	-	1.0	-	4.5	0.7	-	<0.1	-	2.3
4	10.0	10.0	-	<0.5	-	1.0	-	4.6	0.8	-	<0.1	-	2.1
5	10.0	15.0	-	<0.5	-	1.5	-	5.0	0.6	-	<0.1	-	2.4
6	10.0	15.0	-	<0.5	-	0.7	-	5.2	0.5	-	<0.1	-	2.3
7	10.0	13.0	-	<0.5	-	0.7	-	4.5	0.5	-	<0.1	-	2.1
8	10.0	17.1	-	<0.5	-	1.2	-	4.6	0.5	-	<0.1	-	2.3
9	10.0	18.0	-	<0.5	-	1.0	-	5.0	0.5	-	<0.1	-	2.3
10	10.0	22.0	-	<0.5	-	1.2	-	5.1	0.6	-	<0.1	-	3.3
11	10.0	-	-	<0.5	-	1.0	-	8.7	1.9	-	<0.1	-	7.5
12	10.0	-	-	<0.5	-	1.0	-	10.2	2.7	-	<0.1	-	11.5
13	10.0	-	-	<0.5	-	1.2	-	9.5	2.6	-	<0.1	-	9.5
14	10.0	28.6	-	<0.5	-	1.0	-	5.7	0.1	-	<0.1	-	1.5
15	10.0	15.0	-	<0.5	-	0.7	-	6.0	0.1	-	<0.1	-	1.7
16	10.0	11.9	-	<0.5	-	0.5	-	6.0	0.1	-	<0.1	-	1.4
17	10.0	9.8	-	<0.5	-	1.0	-	4.6	0.1	-	<0.1	-	0.2
18	10.0	15.5	-	<0.5	-	1.0	-	5.7	0.4	-	<0.1	-	2.0
19	10.0	18.0	-	<0.5	-	1.5	-	6.4	0.1	-	<0.1	-	2.8
20	10.0	14.0	-	<0.5	-	1.5	-	5.6	0.2	-	<0.1	-	2.3
21	10.0	15.0	-	<0.5	-	0.7	-	6.3	0.1	-	<0.1	-	2.7
22	10.0	16.0	-	<0.5	-	1.2	-	6.0	0.1	-	<0.1	-	3.0
23	10.0	17.0	-	<0.5	-	1.2	-	6.1	0.1	-	<0.1	-	3.5
24	10.0	15.0	-	<0.5	-	1.0	-	6.5	0.3	-	<0.1	-	5.3
25	10.0	14.0	-	<0.5	-	0.7	-	5.5	<0.1	-	<0.1	-	0.1
26	10.0	12.0	-	<0.5	-	0.7	-	5.0	<0.1	-	<0.1	-	0.1
27	10.0	11.0	-	<0.5	-	1.0	-	5.0	<0.1	-	<0.1	-	<0.1
28	10.0	8.5	-	<0.5	-	0.6	-	4.3	<0.1	-	<0.1	-	<0.1
29	10.0	5.0	-	<0.5	-	1.5	-	3.0	<0.1	-	<0.1	-	<0.1
30	10.0	5.1	-	<0.5	-	0.7	-	3.2	<0.1	-	<0.1	-	<0.1
31	10.0	5.2	-	<0.5	-	0.7	-	2.9	<0.1	-	<0.1	-	<0.1
32	10.0	5.0	-	<0.5	-	0.6	-	2.6	<0.1	-	<0.1	-	<0.1
33	10.0	5.1	-	<0.5	-	0.7	-	2.5	<0.1	-	<0.1	-	<0.1
34	10.0	4.9	-	<0.5	-	1.2	-	2.7	<0.1	-	<0.1	-	<0.1

March 24, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	2.0	6.90	75	-	-	-	-	-
2	2.0	6.90	75	-	-	-	-	-
3	2.0	6.85	75	-	-	-	-	-
4	3.0	7.00	75	-	-	-	-	-
5	3.0	7.20	75	-	-	-	-	-
6	3.0	7.05	75	-	-	-	-	-
7	2.0	7.15	70	-	-	-	-	-
8	2.0	7.10	75	-	-	-	-	-
9	3.0	7.00	75	-	-	-	-	-
10	3.0	7.00	85	-	-	-	-	-
11	4.0	6.75	170	-	-	-	-	-
12	4.0	6.65	280	-	-	-	-	-
13	3.0	6.70	260	-	-	-	-	-
14	3.0	6.95	250	-	-	-	-	-
15	3.0	7.00	140	-	-	-	-	-
16	4.0	7.10	140	-	-	-	-	-
17	5.0	7.00	120	-	-	-	-	-
18	4.0	7.20	220	-	-	-	-	-
19	4.0	6.90	130	-	-	-	-	-
20	4.0	7.20	130	-	-	-	-	-
21	4.0	7.35	115	-	-	-	-	-
22	4.0	7.35	140	-	-	-	-	-
23	4.0	7.30	150	-	-	-	-	-
24	4.0	7.30	140	-	-	-	-	-
25	4.0	7.50	120	-	-	-	-	-
26	4.0	7.60	105	-	-	-	-	-
27	3.0	7.50	95	-	-	-	-	-
28	2.0	7.50	60	-	-	-	-	-
29	3.0	7.70	<50	-	-	-	-	-
30	3.0	7.50	<50	-	-	-	-	-
31	4.0	7.50	<50	-	-	-	-	-
32	3.0	7.70	<50	-	-	-	-	-
33	3.0	7.60	<50	-	-	-	-	-
34	3.0	7.70	<50	-	-	-	-	-

March 24, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	<10.0	9.0	-	<0.5	<0.1	1.1	-	4.5	0.6	-	<0.1	-	1.7
2	<10.0	8.6	-	<0.5	<0.1	1.0	-	4.4	0.5	-	<0.1	-	1.5
3	<10.0	8.0	-	<0.5	<0.1	1.6	-	4.2	0.5	-	<0.1	-	1.5
4	<10.0	7.6	-	<0.5	<0.1	1.1	-	4.5	0.5	-	<0.1	-	1.5
5	<10.0	7.0	-	<0.5	<0.1	1.6	-	4.5	0.3	-	<0.1	-	1.3
6	<10.0	7.5	-	<0.5	<0.1	1.6	-	4.2	0.4	-	<0.1	-	1.4
7	<10.0	7.3	-	<0.5	<0.1	1.0	-	4.1	0.3	-	<0.1	-	1.1
8	<10.0	7.8	-	<0.5	<0.1	1.1	-	4.3	0.2	-	<0.1	-	1.2
9	<10.0	7.5	-	<0.5	<0.1	0.8	-	4.3	0.3	-	<0.1	-	1.5
10	<10.0	8.3	-	<0.5	<0.1	1.0	-	4.6	0.3	-	<0.1	-	1.6
11	<10.0	12.5	-	<0.5	<0.1	1.6	-	3.1	1.0	-	<0.1	-	1.3
12	<10.0	19.0	-	<0.5	<0.1	1.1	-	-	1.6	-	<0.1	-	1.7
13	<10.0	17.3	-	<0.5	<0.1	1.1	-	-	1.8	-	<0.1	-	7.6
14	<10.0	12.0	-	<0.5	<0.1	1.0	-	7.5	0.3	-	<0.1	-	3.0
15	<10.0	12.2	-	<0.5	<0.1	1.0	-	6.9	0.1	-	<0.1	-	2.5
16	<10.0	12.6	-	<0.5	<0.1	0.2	-	6.8	<0.1	-	<0.1	-	2.7
17	<10.0	14.0	-	<0.5	<0.1	1.0	-	7.8	0.1	-	<0.1	-	3.1
18	<10.0	13.3	-	<0.5	<0.1	1.9	-	6.9	0.3	-	<0.1	-	3.0
19	<10.0	15.0	-	<0.5	<0.1	1.6	-	7.9	0.1	-	<0.1	-	3.3
20	<10.0	13.3	-	<0.5	<0.1	1.1	-	6.7	<0.1	-	<0.1	-	3.0
21	<10.0	14.3	-	<0.5	<0.1	1.0	-	7.2	0.1	-	<0.1	-	3.7
22	<10.0	15.3	-	<0.5	<0.1	1.0	-	6.9	0.2	-	<0.1	-	3.7
23	<10.0	11.5	-	<0.5	<0.1	1.0	-	7.6	0.1	-	<0.1	-	4.4
24	<10.0	15.4	-	<0.5	<0.1	1.6	-	7.4	0.1	-	<0.1	-	4.3
25	<10.0	15.0	-	<0.5	<0.1	1.9	-	6.8	<0.1	-	<0.1	-	0.5
26	<10.0	13.3	-	<0.5	<0.1	1.0	-	6.5	<0.1	-	<0.1	-	0.4
27	<10.0	12.5	-	<0.5	<0.1	1.1	-	6.3	<0.1	-	<0.1	-	0.1
28	<10.0	9.3	-	<0.5	<0.1	0.8	-	5.2	<0.1	-	<0.1	-	0.0
29	<10.0	5.0	-	<0.5	<0.1	0.8	-	2.9	<0.1	-	<0.1	-	<0.1
30	<10.0	5.8	-	<0.5	<0.1	1.0	-	3.4	<0.1	-	<0.1	-	<0.1
31	<10.0	5.5	-	<0.5	<0.1	0.8	-	3.1	0.0	-	<0.1	-	<0.1
32	<10.0	5.3	-	<0.5	<0.1	1.0	-	2.9	0.0	-	<0.1	-	<0.1
33	<10.0	8.5	-	<0.5	<0.1	1.1	-	2.9	<0.1	-	<0.1	-	<0.1
34	<10.0	4.8	-	<0.5	<0.1	1.0	-	2.6	<0.1	-	<0.1	-	<0.1

April 23, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	6.5	7.15	52	5.5	-	-	9.3	1.4
2	5.5	6.95	52	4.9	-	-	9.9	2.4
3	5.5	6.90	52	4.7	-	-	9.3	-
4	5.5	6.90	52	5.0	-	-	9.8	1.7
5	5.0	6.90	52	4.1	-	-	9.4	1.3
6	4.5	6.90	54	4.5	-	-	10.5	2.4
7	4.5	6.90	50	3.9	-	-	9.5	1.2
8	4.0	6.90	50	3.8	-	-	10.1	1.6
9	4.0	6.92	50	4.0	-	-	9.1	0.8
10	4.0	6.91	60	4.0	-	-	9.7	1.4
11	5.5	6.80	100	4.0	-	-	9.5	1.7
12	5.5	6.65	155	5.0	-	-	9.9	1.8
13	5.0	6.55	150	4.7	-	-	9.0	1.4
14	5.0	6.60	95	4.3	-	-	9.3	1.4
15	5.0	6.75	83	4.7	-	-	9.3	1.6
16	5.0	6.92	90	4.6	-	-	10.2	2.5
17	5.0	6.92	100	4.4	-	-	9.9	1.9
18	5.0	7.00	122	6.2	-	-	8.6	2.3
19	5.0	7.05	100	4.8	-	-	10.4	2.6
20	5.0	7.05	88	4.5	-	-	10.4	2.6
21	5.0	7.10	83	4.4	-	-	10.1	2.0
22	5.0	7.11	80	4.2	-	-	9.9	2.8
23	5.0	7.11	83	4.8	-	-	9.9	1.6
24	5.0	7.15	80	4.7	-	-	9.9	1.5
25	4.5	7.21	80	4.6	-	-	10.0	2.2
26	4.0	7.30	70	4.5	-	-	9.9	1.6
27	4.0	7.35	78	4.6	-	-	9.7	1.2
28	4.0	7.45	62	4.4	-	-	9.9	1.4
29	3.5	7.61	<50	4.2	-	-	10.3	2.1
30	3.5	7.65	<50	4.3	-	-	10.2	1.8
31	3.5	7.62	<50	4.6	-	-	10.2	1.7
32	3.5	7.60	<50	5.0	-	-	10.0	1.8
33	4.0	7.60	<50	4.6	-	-	10.4	1.8
34	4.0	7.60	<50	4.7	-	-	10.2	1.9

April 23, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	<10.0	4.5	-	<0.5	-	0.1	-	2.0	0.1	-	<0.1	-	0.5
2	<10.0	4.6	-	<0.5	-	1.1	-	2.0	0.1	-	<0.1	-	0.5
3	<10.0	4.5	-	<0.5	-	1.2	-	2.1	0.1	-	<0.1	-	0.6
4	<10.0	4.5	-	<0.5	-	1.1	-	2.1	0.1	-	<0.1	-	0.5
5	<10.0	4.4	-	<0.5	-	1.2	-	2.0	0.1	-	<0.1	-	0.5
6	<10.0	4.3	-	<0.5	-	0.7	-	2.0	0.1	-	<0.1	-	0.6
7	<10.0	4.2	-	<0.5	-	1.1	-	1.9	0.1	-	<0.1	-	0.4
8	<10.0	4.4	-	<0.5	-	0.7	-	1.9	0.1	-	<0.1	-	0.5
9	<10.0	4.2	-	<0.5	-	1.1	-	1.9	0.1	-	<0.1	-	0.5
10	<10.0	5.2	-	<0.5	-	1.1	-	2.2	0.1	-	<0.1	-	0.7
11	<10.0	7.8	-	<0.5	-	0.1	-	3.4	0.4	-	<0.1	-	2.1
12	<10.0	11.7	-	<0.5	-	1.1	-	4.9	0.7	-	<0.1	-	3.7
13	<10.0	11.3	-	<0.5	-	0.1	-	4.4	0.7	-	<0.1	-	3.2
14	<10.0	8.0	-	<0.5	-	0.7	-	3.5	0.1	-	<0.1	-	1.5
15	<10.0	8.2	-	<0.5	-	1.2	-	3.4	0.1	-	<0.1	-	1.3
16	<10.0	8.6	-	<0.5	-	0.7	-	3.3	0.1	-	<0.1	-	1.3
17	<10.0	9.7	-	<0.5	-	1.1	-	3.8	0.1	-	<0.1	-	1.7
18	<10.0	9.4	-	<0.5	-	0.7	-	3.6	0.1	-	<0.1	-	1.5
19	<10.0	9.7	-	<0.5	-	1.2	-	3.7	0.1	-	<0.1	-	1.7
20	<10.0	9.5	-	<0.5	-	0.7	-	3.3	0.1	-	<0.1	-	1.2
21	<10.0	9.2	-	<0.5	-	1.1	-	3.4	0.1	-	<0.1	-	1.2
22	<10.0	9.0	-	<0.5	-	1.2	-	3.5	0.1	-	<0.1	-	1.1
23	<10.0	9.0	-	<0.5	-	1.1	-	3.4	0.1	-	<0.1	-	1.4
24	<10.0	8.5	-	<0.5	-	1.2	-	3.4	0.1	-	<0.1	-	1.2
25	<10.0	9.2	-	<0.5	-	1.2	-	3.5	0.1	-	<0.1	-	0.2
26	<10.0	8.6	-	<0.5	-	1.1	-	3.4	0.1	-	<0.1	-	0.1
27	<10.0	8.5	-	<0.5	-	1.2	-	3.5	0.1	-	<0.1	-	0.0
28	<10.0	7.5	-	<0.5	-	1.1	-	3.4	0.1	-	<0.1	-	0.0
29	<10.0	3.6	-	<0.5	-	0.7	-	1.6	0.1	-	<0.1	-	<0.1
30	<10.0	3.6	-	<0.5	-	1.2	-	1.8	0.1	-	<0.1	-	0.0
31	<10.0	3.5	-	<0.5	-	1.1	-	1.7	0.1	-	<0.1	-	0.0
32	<10.0	3.6	-	<0.5	-	1.2	-	1.6	0.1	-	<0.1	-	0.0
33	<10.0	3.6	-	<0.5	-	1.1	-	1.6	0.1	-	<0.1	-	0.0
34	<10.0	3.2	-	<0.5	-	1.2	-	1.6	0.1	-	<0.1	-	0.0

May 21, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	11.5	6.70	48	15.0	-	-	9.2	1.2
2	10.5	6.60	48	10.0	-	-	9.6	2.0
3	10.5	6.60	49	8.0	-	-	8.9	1.2
4	10.5	6.60	50	10.0	-	-	8.8	1.4
5	10.0	6.60	52	8.0	-	-	9.6	1.2
6	10.0	6.60	53	10.0	-	-	9.4	2.0
7	9.0	6.70	52	8.0	-	-	9.1	1.3
8	8.5	6.70	51	7.0	-	-	9.5	1.3
9	8.0	6.80	49	10.0	-	-	8.7	1.0
10	8.5	6.30	64	10.0	-	-	9.4	1.2
11	9.0	6.40	98	10.0	-	-	9.3	1.4
12	9.0	6.30	128	8.0	-	-	9.9	1.5
13	9.0	6.20	130	10.0	-	-	8.9	1.3
14	8.5	6.50	65	12.0	-	-	7.4	1.8
15	8.5	6.70	69	10.0	-	-	9.2	1.2
16	8.5	6.80	62	11.0	-	-	9.6	2.0
17	8.0	7.00	54	12.0	-	-	9.2	1.6
18	8.5	6.80	76	12.0	-	-	9.6	1.8
19	9.0	6.80	63	8.0	-	-	10.2	1.6
20	9.0	6.60	63	8.0	-	-	10.1	1.9
21	8.0	6.90	57	9.0	-	-	10.1	1.7
22	8.0	6.80	57	11.0	-	-	9.6	1.4
23	8.0	6.80	58	8.0	-	-	10.0	1.6
24	9.0	6.90	58	10.0	-	-	9.4	1.2
25	8.5	6.90	57	9.0	-	-	9.8	1.9
26	8.5	6.70	49	6.0	-	-	9.2	1.4
27	8.0	6.90	46	8.0	-	-	9.5	1.1
28	8.0	6.90	40	9.0	-	-	8.8	1.2
29	9.0	6.90	32	13.0	-	-	10.1	2.0
30	9.0	7.10	32	9.0	-	-	9.5	1.5
31	9.5	6.80	31	12.0	-	-	9.5	1.4
32	9.5	6.30	32	10.0	-	-	9.8	1.4
33	10.0	6.90	33	6.0	-	-	9.9	1.7
34	10.0	6.50	32	10.0	-	-	9.9	1.6

May 21, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	-	0.6	-	-	-	0.8	-	0.4	0.3	-	-	-	0.4
2	-	0.6	-	-	-	0.8	-	0.4	0.3	-	-	-	0.4
3	-	0.7	-	-	-	0.7	-	0.4	0.3	-	-	-	0.4
4	-	0.6	-	-	-	0.8	-	0.4	0.3	-	-	-	0.4
5	-	0.6	-	-	-	0.8	-	0.4	0.2	-	-	-	0.5
6	-	0.6	-	-	-	0.7	-	0.4	0.4	-	-	-	0.4
7	-	0.6	-	-	-	0.7	-	0.4	0.3	-	-	-	0.3
8	-	0.6	-	-	-	0.9	-	0.4	0.3	-	-	-	0.4
9	-	0.5	-	-	-	1.0	-	0.4	0.3	-	-	-	0.3
10	-	0.6	-	-	-	0.8	-	0.5	0.3	-	-	-	0.5
11	-	0.9	-	-	-	0.8	-	0.6	0.3	-	-	-	0.7
12	-	1.2	-	-	-	0.9	-	0.7	0.5	-	-	-	0.9
13	-	1.1	-	-	-	0.8	-	0.7	0.5	-	-	-	1.2
14	-	0.7	-	-	-	1.1	-	0.5	0.3	-	-	-	0.5
15	-	0.8	-	-	-	0.6	-	0.5	0.3	-	-	-	0.4
16	-	0.7	-	-	-	0.7	-	0.5	0.3	-	-	-	0.5
17	-	0.7	-	-	-	1.0	-	0.4	0.3	-	-	-	0.3
18	-	0.8	-	-	-	1.0	-	0.5	0.3	-	-	-	0.4
19	-	0.7	-	-	-	0.7	-	0.5	0.3	-	-	-	0.6
20	-	0.7	-	-	-	0.8	-	0.5	0.3	-	-	-	0.4
21	-	0.6	-	-	-	0.7	-	0.5	0.2	-	-	-	0.3
22	-	0.7	-	-	-	0.7	-	0.5	0.3	-	-	-	0.4
23	-	0.7	-	-	-	0.7	-	0.5	0.3	-	-	-	0.4
24	-	0.7	-	-	-	0.6	-	0.5	0.3	-	-	-	0.3
25	-	0.8	-	-	-	0.7	-	0.5	0.3	-	-	-	0.3
26	-	0.6	-	-	-	0.8	-	0.4	0.3	-	-	-	0.2
27	-	0.7	-	-	-	0.9	-	0.4	0.3	-	-	-	0.1
28	-	0.6	-	-	-	0.9	-	0.4	0.3	-	-	-	<0.1
29	-	0.5	-	-	-	0.9	-	0.3	0.3	-	-	-	<0.1
30	-	0.5	-	-	-	0.7	-	0.3	0.3	-	-	-	<0.1
31	-	0.5	-	-	-	0.8	-	0.3	0.3	-	-	-	<0.1
32	-	0.6	-	-	-	0.7	-	0.3	0.3	-	-	-	<0.1
33	-	0.5	-	-	-	0.6	-	0.4	0.4	-	-	-	<0.1
34	-	0.5	-	-	-	0.7	-	0.4	0.3	-	-	-	<0.1

June 12, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	17.0	6.30	66	4.5	-	-	7.6	1.1
2	16.0	6.40	68	7.5	-	-	7.0	0.1
3	16.0	6.40	66	3.5	-	-	7.4	2.0
4	16.0	6.45	73	4.5	-	-	8.0	0.4
5	15.5	6.55	73	5.0	-	-	7.9	1.0
6	15.0	6.55	73	5.0	-	-	7.8	1.1
7	15.0	6.55	77	4.0	-	-	7.9	0.9
8	14.0	6.60	74	4.0	-	-	8.2	1.0
9	14.0	6.65	76	5.0	-	-	8.5	0.9
10	14.0	6.60	81	4.0	-	-	7.9	0.7
11	11.5	6.50	133	5.0	-	-	7.9	1.0
12	11.5	6.40	163	4.0	-	-	8.1	1.0
13	11.5	5.85	168	8.0	-	-	7.8	0.6
14	11.5	6.55	81	4.0	-	-	8.3	1.6
15	10.5	6.70	75	4.0	-	-	7.7	0.4
16	10.5	6.75	76	4.0	-	-	8.0	0.9
17	10.0	6.85	70	4.0	-	-	7.9	0.9
18	10.5	6.95	120	6.0	-	-	6.2	0.6
19	10.5	6.85	81	4.0	-	-	8.4	0.6
20	10.5	6.70	73	3.0	-	-	8.6	1.0
21	9.5	6.85	71	4.0	-	-	8.6	1.0
22	9.5	6.80	68	4.0	-	-	8.7	1.3
23	9.5	6.90	67	3.0	-	-	8.6	1.2
24	9.5	6.90	65	5.0	-	-	8.6	1.0
25	9.5	7.00	63	4.0	-	-	8.3	1.1
26	9.0	7.05	56	5.0	-	-	8.7	1.3
27	8.5	7.05	54	5.0	-	-	8.3	0.7
28	8.0	7.05	43	5.0	-	-	8.3	1.1
29	12.5	7.00	39	4.0	-	-	8.4	1.2
30	12.5	7.05	43	5.0	-	-	8.1	0.7
31	12.0	6.85	43	5.0	-	-	7.5	-
32	12.5	6.90	38	4.0	-	-	7.9	0.8
33	13.5	6.00	42	5.0	-	-	7.9	0.9
34	14.0	6.40	40	5.0	-	-	8.0	1.0

June 12, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	<10.0	0.6	-	<0.5	-	0.5	-	0.4	0.1	-	<0.1	-	0.2
2	<10.0	0.7	-	<0.5	-	0.0	-	0.4	0.1	-	<0.1	-	0.1
3	<10.0	0.6	-	<0.5	-	1.0	-	0.4	0.1	-	<0.1	-	0.1
4	<10.0	0.6	-	<0.5	-	0.0	-	0.5	0.1	-	<0.1	-	0.3
5	<10.0	0.6	-	<0.5	-	0.0	-	0.5	0.1	-	<0.1	-	0.3
6	<10.0	0.7	-	<0.5	-	0.5	-	0.5	0.1	-	<0.1	-	0.3
7	<10.0	0.6	-	<0.5	-	1.0	-	0.5	0.2	-	<0.1	-	0.3
8	<10.0	0.8	-	<0.5	-	0.0	-	0.5	0.2	-	<0.1	-	0.2
9	<10.0	0.7	-	<0.5	-	0.5	-	0.5	0.2	-	<0.1	-	0.2
10	<10.0	0.7	-	<0.5	-	1.0	-	0.5	0.1	-	<0.1	-	0.3
11	<10.0	1.4	-	<0.5	-	1.0	-	0.7	0.1	-	<0.1	-	0.8
12	<10.0	0.2	-	<0.5	-	1.0	-	0.9	0.3	-	<0.1	-	0.9
13	<10.0	1.6	-	<0.5	-	1.0	-	0.8	0.4	-	<0.1	-	1.1
14	<10.0	0.8	-	<0.5	-	1.0	-	0.5	0.1	-	<0.1	-	0.4
15	<10.0	0.9	-	<0.5	-	0.0	-	0.5	0.1	-	<0.1	-	0.2
16	<10.0	0.9	-	<0.5	-	0.0	-	0.5	0.1	-	<0.1	-	0.2
17	<10.0	0.7	-	<0.5	-	2.0	-	0.5	0.1	-	<0.1	-	0.2
18	<10.0	0.9	-	<0.5	-	2.0	-	0.5	0.1	-	<0.1	-	0.3
19	<10.0	0.8	-	<0.5	-	2.0	-	0.5	0.0	-	<0.1	-	0.3
20	<10.0	0.8	-	<0.5	-	2.0	-	0.5	0.1	-	<0.1	-	0.3
21	<10.0	0.9	-	<0.5	-	2.0	-	0.5	0.1	-	<0.1	-	0.2
22	<10.0	0.8	-	<0.5	-	2.0	-	0.5	0.1	-	<0.1	-	0.2
23	<10.0	0.7	-	<0.5	-	2.0	-	0.5	0.1	-	<0.1	-	0.2
24	<10.0	0.8	-	<0.5	-	2.0	-	0.5	0.1	-	<0.1	-	0.2
25	<10.0	0.8	-	<0.5	-	2.0	-	0.5	0.1	-	<0.1	-	0.0
26	<10.0	0.6	-	<0.5	-	2.5	-	0.4	0.1	-	<0.1	-	0.0
27	<10.0	0.7	-	<0.5	-	2.5	-	0.4	0.1	-	<0.1	-	0.1
28	<10.0	0.6	-	<0.5	-	2.5	-	0.4	0.1	-	<0.1	-	<0.1
29	<10.0	0.6	-	<0.5	-	1.5	-	0.4	0.1	-	<0.1	-	<0.1
30	<10.0	0.6	-	<0.5	-	1.5	-	0.4	0.1	-	<0.1	-	<0.1
31	<10.0	0.6	-	<0.5	-	2.0	-	0.4	0.1	-	<0.1	-	<0.1
32	<10.0	0.5	-	<0.5	-	2.0	-	0.3	0.1	-	<0.1	-	<0.1
33	<10.0	0.6	-	<0.5	-	1.5	-	0.3	0.1	-	<0.1	-	<0.1
34	<10.0	3.9	-	<0.5	-	2.5	-	0.4	0.0	-	<0.1	-	<0.1

July 15, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	22.0	6.40	113	0.5	-	-	8.2	1.1
2	21.5	6.40	123	0.0	-	-	8.9	1.9
3	19.0	6.45	121	0.0	-	-	9.0	1.9
4	18.5	6.45	121	0.0	-	-	9.1	1.3
5	18.0	6.45	123	0.0	-	-	9.1	1.5
6	20.0	6.45	123	0.0	-	-	9.3	1.8
7	17.5	6.45	128	0.0	-	-	9.1	1.1
8	15.0	6.40	137	0.0	-	-	8.9	0.9
9	15.0	6.40	132	0.0	-	-	9.1	1.2
10	12.0	6.40	118	0.0	-	-	8.3	0.8
11	12.0	6.20	264	0.5	-	-	9.6	1.3
12	12.0	6.30	315	0.0	-	-	8.6	1.2
13	11.5	6.25	322	1.0	-	-	8.8	1.6
14	10.5	6.75	130	1.0	-	-	8.7	3.4
15	10.0	7.20	123	0.0	-	-	9.4	1.3
16	10.0	7.20	127	0.0	-	-	9.0	1.1
17	10.0	7.20	123	0.0	-	-	9.0	1.2
18	10.0	7.30	185	2.4	-	-	6.9	1.7
19	9.5	7.15	115	0.0	-	-	9.0	1.2
20	9.5	7.30	115	0.0	-	-	9.0	1.1
21	9.0	7.40	115	0.0	-	-	9.1	1.1
22	8.5	7.45	115	0.0	-	-	9.2	1.2
23	9.0	7.45	112	0.0	-	-	9.5	1.3
24	9.0	7.45	108	0.0	-	-	9.3	1.2
25	9.0	7.60	90	0.0	-	-	9.1	1.2
26	9.0	7.60	76	0.0	-	-	9.2	1.5
27	9.0	7.70	77	0.0	-	-	9.6	1.4
28	9.0	7.75	65	0.0	-	-	9.0	1.4
29	14.0	7.10	48	0.0	-	-	9.0	1.1
30	13.5	7.20	50	0.0	-	-	8.9	1.0
31	13.5	6.70	47	0.0	-	-	7.9	0.6
32	14.5	6.90	46	0.0	-	-	8.8	1.0
33	14.5	6.90	48	0.0	-	-	8.2	0.9
34	14.5	6.90	46	0.5	-	-	7.6	0.5

July 15, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	-	6.2	-	-	<0.1	0.3	1.1	2.7	0.1	2.8	-	-	1.6
2	-	6.2	-	-	<0.1	0.3	0.8	2.7	0.2	2.7	-	-	1.9
3	-	6.8	-	-	0.0	0.4	0.8	2.8	0.1	3.0	-	-	1.8
4	-	7.1	-	-	<0.1	0.3	0.9	2.8	0.2	2.8	-	-	2.0
5	-	6.7	-	-	<0.1	0.2	0.8	2,9	0.2	2.8	-	-	1.9
6	-	6.2	-	-	<0.1	0.2	0.8	2.9	0.2	2.8	-	-	1.7
7	-	6.2	-	-	<0.1	0.2	0.6	2.9	0.4	2.8	-	-	1.9
8	-	7.6	-	-	<0.1	0.3	0.8	2.9	0.4	2.9	-	-	3.0
9	-	6.8	-	-	<0.1	0.2	1.0	3.0	0.4	3.0	-	-	2.7
10	-	6.2	-	-	<0.1	0.2	0.8	3.0	1.2	2.9	-	-	2.7
11	-	13.0	-	-	<0.1	0.4	1.6	5.3	1.3	6.2	-	-	7.5
12	-	15.7	-	-	<0.1	0.2	2.0	6.5	1.4	7.5	-	-	8.1
13	-	16.5	-	-	<0.1	0.3	2.0	6.0	<0.1	7.4	-	-	8.9
14	-	8.9	-	-	<0.1	0.2	1.2	3.1	<0.1	5.4	-	-	1.8
15	-	9.4	-	-	<0.1	0.2	1.2	3.2	<0.1	4.9	-	-	1.4
16	-	9.4	-	-	<0.1	<0.1	0.9	3.0	<0.1	4.3	-	-	1.3
17	-	8.1	-	-	<0.1	0.1	0.9	3.0	<0.1	5.4	-	-	0.6
18	-	9.0	-	-	<0.1	0.2	1.0	2.8	<0.1	20.4	-	-	0.7
19	-	8.7	-	-	<0.1	0.1	1.8	3.1	<0.1	2.3	-	-	1.5
20	-	9.8	-	-	<0.1	0.1	0.9	3.0	<0.1	1.9	-	-	1.3
21	-	8.3	-	-	<0.1	0.1	0.9	3.1	<0.1	2.5	-	-	1.1
22	-	8.1	-	-	<0.1	0.2	0.8	3.1	<0.1	1.9	-	-	1.1
23	-	8.1	-	-	<0.1	0.2	0.6	3.0	<0.1	2.3	-	-	1.2
24	-	7.9	-	-	<0.1	0.2	0.6	3.2	<0.1	2.0	-	-	1.2
25	-	7.1	-	-	<0.1	0.1	0.6	2.7	<0.1	1.9	-	-	0.1
26	-	6.4	-	-	<0.1	0.1	0.6	2.2	0.0	2.5	-	-	<0.1
27	-	6.1	-	-	<0.1	0.1	0.6	2.5	0.0	2.7	-	-	<0.1
28	-	5.9	-	-	<0.1	0.1	0.5	2.2	0.0	1.4	-	-	<0.1
29	-	3.8	-	-	<0.1	0.2	0.6	1.7	<0.1	1.5	-	-	<0.1
30	-	3.7	-	-	<0.1	0.1	0.6	1.8	<0.1	1.3	-	-	<0.1
31	-	3.5	-	-	<0.1	0.1	0.8	1.6	<0.1	1.6	-	-	<0.1
32	-	3.1	-	-	<0.1	0.1	0.6	1.5	0.0	1.4	-	-	<0.1
33	-	2.7	-	-	<0.1	0.1	0.5	1.6	<0.1	1.4	-	-	<0.1
34	-	2.7	-	-	<0.1	0.1	0.6	1.5	<0.1	1.4	-	-	<0.1

August 19, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	20.0	7.20	120	0.0	-	-	7.5	1.3
2	19.5	7.25	170	0.0	-	-	7.6	1.0
3	19.5	7.40	180	0.0	-	-	7.5	0.7
4	19.0	7.40	175	0.0	-	-	7.7	1.0
5	19.0	7.50	170	0.0	-	-	7.7	1.3
6	19.0	7.55	170	0.0	-	-	8.2	0.7
7	17.5	7.55	170	0.0	-	-	8.1	1.2
8	16.0	7.60	170	0.0	-	-	7.6	0.9
9	15.5	7.55	175	0.0	-	-	7.5	1.2
10	17.5	7.55	165	0.0	-	-	8.5	1.0
11	21.0	6.90	365	1.0	-	-	8.2	1.7
12	17.0	6.85	450	0.5	-	-	7.6	1.8
13	17.5	6.55	435	3.0	-	-	8.2	4.5
14	16.5	8.80	180	0.0	-	-	7.9	0.9
15	17.0	9.10	170	0.0	-	-	8.2	1.4
16	16.5	8.90	175	0.0	-	-	7.8	1.1
17	16.5	8.90	180	0.0	-	-	7.3	4.2
18	16.0	9.15	295	2.0	-	-	8.3	2.9
19	18.0	9.50	155	0.0	-	-	8.3	6.5
20	18.0	9.60	150	0.0	-	-	8.2	1.7
21	16.0	7.75	160	6.0	-	-	8.9	2.4
22	16.0	8.60	150	0.0	-	-	8.6	3.4
23	17.5	8.10	155	0.0	-	-	7.8	1.7
24	18.5	8.20	120	0.0	-	-	7.9	1.7
25	18.0	8.80	120	0.0	-	-	7.9	1.8
26	15.0	8.50	105	0.0	-	-	7.9	1.9
28	15.5	8.50	84	0.0	-	-	8.1	1.2
29	20.5	8.70	55	0.0	-	-	8.1	0.9
30	19.0	8.80	60	0.0	-	-	8.2	0.8
31	20.0	8.50	56	0.0	-	-	8.0	1.0
32	17.5	8.40	54	0.0	-	-	8.3	1.0
33	18.5	8.40	53	0.0	-	-	8.1	1.0
34	19.0	8.30	50	0.0	-	-	7.6	0.9

August 19, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	–	11.2	–	–	–	0.2	1.0	3.5	0.5	3.8	–	–	2.6
2	–	11.5	–	–	<0.1	0.2	0.9	3.5	0.5	3.7	–	–	1.8
3	–	14.2	–	–	<0.1	0.2	1.0	3.6	0.5	4.0	–	–	1.7
4	–	12.7	–	–	0.0	0.2	1.0	3.4	0.5	4.0	–	–	1.6
5	–	12.4	–	–	<0.1	0.2	1.0	3.5	0.5	4.2	–	–	1.7
6	–	12.5	–	–	<0.1	0.2	0.9	3.5	0.5	4.1	–	–	1.7
7	–	12.3	–	–	<0.1	0.2	1.0	3.5	0.5	4.1	–	–	1.8
8	–	12.4	–	–	0.0	0.1	1.0	3.4	0.6	4.2	–	–	2.0
9	–	12.7	–	–	0.0	0.1	0.9	3.4	0.5	4.2	–	–	2.0
10	–	11.7	–	–	0.0	0.1	0.9	3.2	0.5	4.4	–	–	1.9
11	–	27.8	–	–	0.0	0.1	2.2	+4.5	1.7	10.4	–	–	5.1
12	–	31.2	–	–	0.0	0.2	2.5	+4.5	2.0	13.5	–	–	6.8
13	–	29.6	–	–	0.0	0.1	2.4	+4.5	2.0	13.8	–	–	6.5
14	–	15.0	–	–	0.0	0.1	1.0	3.6	<0.1	7.2	–	–	0.5
15	–	14.6	–	–	0.0	0.2	1.0	3.7	<0.1	7.4	–	–	0.3
16	–	15.7	–	–	0.0	0.1	1.0	3.7	0.0	7.8	–	–	0.3
17	–	15.1	–	–	<0.1	0.2	1.1	3.7	0.0	10.2	–	–	0.2
18	–	15.3	–	–	<0.1	0.2	1.7	3.6	<0.1	–	–	–	0.2
19	–	15.1	–	–	0.1	0.1	1.0	3.7	0.0	3.4	–	–	0.4
20	–	15.0	–	–	<0.1	0.1	0.9	3.6	0.0	3.4	–	–	0.6
21	–	15.1	–	–	<0.1	0.1	1.0	3.7	0.0	3.5	–	–	0.6
22	–	14.3	–	–	<0.1	0.1	0.9	3.7	<0.1	3.6	–	–	0.7
23	–	14.7	–	–	0.0	0.1	0.9	3.6	<0.1	3.4	–	–	0.8
24	–	15.5	–	–	0.0	0.2	0.9	3.9	<0.1	2.9	–	–	1.0
25	–	13.3	–	–	0.0	0.1	0.8	3.1	0.0	2.6	–	–	1.0
26	–	12.9	–	–	0.0	0.1	0.5	2.6	0.0	1.8	–	–	<0.1
28	–	9.4	–	–	0.0	0.1	0.4	2.7	0.0	1.5	–	–	<0.1
29	–	5.9	–	–	0.0	0.2	0.4	1.8	0.0	1.4	–	–	<0.1
30	–	6.0	–	–	0.0	0.2	0.4	2.0	0.0	1.4	–	–	<0.1
31	–	5.8	–	–	0.0	0.1	0.4	1.8	<0.1	1.4	–	–	<0.1
32	–	5.7	–	–	0.0	0.1	0.3	1.7	0.0	1.4	–	–	<0.1
33	–	5.4	–	–	<0.1	0.1	0.5	1.7	0.0	1.5	–	–	<0.1
34	–	5.3	–	–	0.0	0.2	0.5	1.6	<0.1	1.5	–	–	<0.1

September 13, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	17.5	5.75	36	1.5	0.00	0.06	-	-
2	16.5	5.95	93	0.0	0.24	0.51	9.0	1.6
3	16.5	6.00	103	0.0	0.00	0.06	9.5	1.6
4	16.0	6.01	72	0.0	0.00	0.02	-	-
5	16.5	6.01	76	0.0	0.24	0.45	9.3	1.4
6	16.5	6.15	88	0.0	0.00	0.00	9.0	1.3
7	17.0	6.15	94	0.0	0.00	0.06	8.6	0.7
8	15.5	6.20	97	0.0	0.00	0.00	9.0	1.1
9	15.0	6.20	113	0.0	0.00	0.00	9.0	1.6
10	15.0	6.20	101	0.0	0.00	0.16	9.2	1.2
11	10.0	6.15	181	0.0	0.24	1.14	8.6	1.1
12	11.0	6.15	111	2.0	1.16	0.74	8.6	1.8
13	11.0	6.20	220	0.0	0.24	0.79	8.8	1.4
14	8.5	6.35	92	0.0	0.00	0.56	9.3	1.3
15	8.5	6.65	79	0.5	0.24	0.12	10.2	1.8
16	8.5	6.70	89	0.0	0.00	0.00	9.5	1.5
17	9.0	6.80	100	0.0	0.24	0.00	9.1	1.4
18	9.5	6.95	200	1.0	0.00	0.16	2.5	>2.5
19	8.5	6.95	85	0.5	0.24	0.00	10.7	2.1
20	8.5	6.95	85	0.5	0.24	0.08	10.3	1.6
21	9.0	6.90	68	1.0	0.44	0.22	10.3	1.7
22	8.5	6.90	57	0.0	0.86	0.12	10.0	1.3
23	8.5	6.90	94	0.0	0.00	0.12	10.0	1.7
24	8.0	6.95	82	0.0	0.58	0.06	9.8	1.3
25	8.0	7.00	68	0.0	0.58	0.00	9.8	1.5
26	8.0	7.00	72	0.0	0.58	0.16	9.5	1.6
28	8.0	7.10	69	0.0	0.00	0.08	9.6	1.0
29	13.5	7.15	32	0.0	0.00	0.00	9.0	0.9
30	13.5	7.15	31	0.0	0.24	0.06	9.1	1.0
31	13.5	7.15	27	0.0	0.00	0.00	8.9	1.0
32	13.5	7.20	32	0.0	0.00	0.00	9.3	1.7
33	14.0	7.20	34	0.0	0.00	0.02	8.8	0.5
34	14.0	7.20	29	0.0	0.00	0.06	8.8	0.6

September 13, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	-	2.4	-	-	<0.1	<0.1	0.3	1.4	0.8	1.1	-	<0.1	2.6
2	-	10.7	-	-	<0.1	0.2	1.2	5.0	1.6	4.7	-	<0.1	4.1
3	-	9.4	-	-	<0.1	<0.1	1.1	4.5	1.4	4.4	-	<0.1	3.5
4	-	8.0	-	-	<0.1	<0.1	0.9	4.0	1.0	3.8	-	<0.1	2.7
5	-	7.7	-	-	<0.1	<0.1	0.9	3.7	1.3	3.6	-	<0.1	3.0
6	-	10.1	-	-	<0.1	0.1	1.2	4.6	1.5	4.5	-	<0.1	3.5
7	-	10.1	-	-	<0.1	<0.1	1.3	4.8	1.9	4.7	-	<0.1	4.8
8	-	10.7	-	-	<0.1	<0.1	1.3	5.2	2.1	5.3	-	<0.1	5.3
9	-	10.7	-	-	<0.1	0.2	1.3	5.2	2.1	5.3	-	<0.1	5.3
10	-	8.0	-	-	<0.1	<0.1	1.0	4.2	1.9	4.0	-	<0.1	4.7
11	-	30.0	-	-	<0.1	0.4	2.9	10.5	5.7	12.2	-	<0.1	15.0
12	-	12.8	-	-	<0.1	0.2	0.9	4.5	3.4	4.4	-	<0.1	7.3
13	-	28.0	-	-	<0.1	0.2	2.9	10.2	6.2	12.2	-	<0.1	21.0
14	-	11.9	-	-	<0.1	<0.1	1.5	5.1	0.2	8.5	-	<0.1	2.0
15	-	11.5	-	-	<0.1	<0.1	1.2	4.7	0.2	7.8	-	<0.1	2.1
16	-	10.1	-	-	<0.1	<0.1	1.4	5.0	0.1	8.5	-	<0.1	1.1
17	-	11.5	-	-	<0.1	<0.1	1.4	4.9	0.2	10.7	-	<0.1	1.0
18	-	11.6	-	-	<0.1	<0.1	2.0	4.7	0.6	55.0	-	<0.1	0.9
91	-	12.5	-	-	<0.1	<0.1	1.1	5.2	0.2	3.2	-	<0.1	1.7
20	-	12.5	-	-	<0.1	<0.1	1.1	5.2	0.2	3.3	-	<0.1	1.5
21	-	10.8	-	-	<0.1	0.1	0.8	4.2	0.2	2.7	-	<0.1	1.3
22	-	5.8	-	-	<0.1	<0.1	0.6	2.8	0.1	1.6	-	<0.1	2.4
23	-	11.8	-	-	<0.1	<0.1	1.1	5.2	0.2	3.3	-	<0.1	2.8
24	-	10.1	-	-	<0.1	<0.1	0.9	4.5	0.2	2.7	-	<0.1	2.7
25	-	11.2	-	-	<0.1	0.1	0.9	4.5	<0.1	3.1	-	<0.1	0.3
26	-	9.1	-	-	<0.1	<0.1	1.1	4.4	<0.1	3.8	-	<0.1	0.2
28	-	6.6	-	-	<0.1	<0.1	0.4	3.4	<0.1	1.3	-	<0.1	<0.1
29	-	3.8	-	-	<0.1	<0.1	0.4	2.4	<0.1	1.5	-	<0.1	<0.1
30	-	4.1	-	-	<0.1	<0.1	0.4	2.6	<0.1	1.3	-	<0.1	<0.1
31	-	3.9	-	-	<0.1	0.1	0.4	2.0	<0.1	1.3	-	<0.1	<0.1
32	-	3.6	-	-	<0.1	<0.1	0.4	2.1	<0.1	1.5	-	<0.1	<0.1
33	-	3.5	-	-	<0.1	<0.1	0.4	2.2	<0.1	1.5	-	<0.1	<0.1
34	-	3.4	-	-	<0.1	<0.1	0.5	2.0	<0.1	1.6	-	<0.1	<0.1

October 30, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	8.0	7.10	170	-	-	-	10.6	1.5
2	8.0	7.10	160	-	-	-	-	-
3	8.5	7.10	168	-	-	-	-	-
4	8.0	6.90	182	-	-	-	-	-
5	8.0	6.80	182	-	-	-	-	-
6	8.0	7.10	178	-	-	-	10.1	1.8
7	8.0	7.20	170	-	-	-	-	-
8	9.0	6.80	180	-	-	-	-	-
9	9.0	6.80	180	-	-	-	-	-
10	9.0	7.10	178	-	-	-	10.6	1.7
11	10.0	6.90	382	-	-	-	10.1	1.7
12	9.5	6.40	460	-	-	-	9.3	0.9
13	10.0	6.50	430	-	-	-	9.6	1.7
14	7.5	7.40	190	-	-	-	10.7	1.8
15	7.5	7.30	150	-	-	-	10.5	1.4
16	7.0	7.30	195	-	-	-	10.2	1.3
17	8.0	7.40	195	-	-	-	9.6	1.5
18	7.5	7.40	298	-	-	-	7.4	2.5
19	7.2	7.20	182	-	-	-	10.6	2.5
20	7.0	7.30	178	-	-	-	-	-
21	7.0	7.20	180	-	-	-	10.7	2.8
22	7.0	6.80	170	-	-	-	10.6	2.3
23	7.0	6.90	180	-	-	-	10.8	2.9
24	8.0	7.60	170	-	-	-	-	-
25	7.5	8.40	125	-	-	-	10.6	1.7
26	7.2	7.90	115	-	-	-	10.7	2.9
28	6.5	8.00	90	-	-	-	10.5	1.0
29	7.5	8.00	60	-	-	-	-	-
30	7.0	7.80	52	-	-	-	10.9	1.2
31	8.0	7.70	62	-	-	-	-	-
32	8.0	7.70	60	-	-	-	-	-
33	8.0	7.80	20	-	-	-	-	-
34	8.5	7.90	48	-	-	-	10.4	1.0

October 30, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	-	10.3	-	-	<0.1	0.1	1.3	4.9	1.4	4.2	-	0.1	5.1
2	-	10.5	-	-	<0.1	0.1	1.1	4.9	1.6	4.1	-	0.1	4.8
3	-	11.0	-	-	<0.1	0.1	1.2	5.3	1.8	4.3	-	0.1	5.3
4	-	11.3	-	-	<0.1	<0.1	1.1	5.5	2.0	4.4	-	0.1	6.4
5	-	11.7	-	-	<0.1	0.1	1.2	5.7	2.0	4.4	-	0.1	5.8
6	-	10.7	-	-	<0.1	<0.1	1.2	5.4	1.9	4.4	-	0.1	5.5
7	-	10.7	-	-	<0.1	0.1	1.4	5.2	1.8	4.3	-	0.1	5.3
8	-	11.0	-	-	<0.1	0.1	1.2	5.5	1.9	4.9	-	<0.1	5.3
9	-	11.1	-	-	<0.1	0.1	1.2	5.4	1.9	4.8	-	0.1	5.6
10	-	10.9	-	-	<0.1	0.1	1.3	5.3	1.9	4.4	-	0.1	5.0
11	-	25.8	-	-	<0.1	0.1	3.0	11.7	5.3	10.0	-	<0.1	13.0
12	-	29.7	-	-	<0.1	0.1	3.2	13.6	6.8	11.8	-	<0.1	17.5
13	-	27.4	-	-	<0.1	<0.1	3.2	12.1	6.4	11.0	-	<0.1	17.5
14	-	13.7	-	-	<0.1	<0.1	1.6	6.1	0.3	7.7	-	<0.1	2.7
15	-	13.8	-	-	<0.1	<0.1	1.6	6.0	0.2	7.6	-	<0.1	2.4
16	-	14.2	-	-	<0.1	<0.1	1.6	6.1	0.2	7.6	-	<0.1	2.2
17	-	13.8	-	-	<0.1	<0.1	1.7	5.8	0.2	9.6	-	<0.1	1.2
18	-	14.6	-	-	<0.1	<0.1	2.2	6.0	0.5	35.4	-	<0.1	0.2
19	-	14.2	-	-	<0.1	0.1	1.7	6.1	<0.1	3.8	-	0.1	2.3
20	-	14.5	-	-	<0.1	0.1	1.6	6.0	0.2	3.6	-	0.1	2.7
21	-	14.3	-	-	<0.1	<0.1	1.9	6.0	<0.1	4.4	-	<0.1	2.6
22	-	14.5	-	-	<0.1	<0.1	1.5	5.9	<0.1	4.0	-	<0.1	2.8
23	-	13.5	-	-	<0.1	<0.1	1.4	5.9	0.2	3.8	-	<0.1	2.9
24	-	13.7	-	-	<0.1	<0.1	1.4	6.2	0.3	3.7	-	0.1	2.9
25	-	12.6	-	-	<0.1	<0.1	1.2	4.6	<0.1	3.1	-	0.1	0.2
26	-	9.7	-	-	<0.1	<0.1	1.2	4.2	<0.1	3.7	-	<0.1	0.1
28	-	8.2	-	-	<0.1	<0.1	0.5	3.9	<0.1	1.5	-	<0.1	<0.1
29	-	5.0	-	-	<0.1	<0.1	0.5	2.6	<0.1	1.3	-	<0.1	<0.1
30	-	5.4	-	-	<0.1	<0.1	0.5	2.9	<0.1	1.2	-	0.1	<0.1
31	-	5.1	-	-	<0.1	<0.1	0.5	2.6	<0.1	1.4	-	<0.1	<0.1
32	-	5.0	-	-	<0.1	<0.1	0.5	2.5	<0.1	1.4	-	<0.1	<0.1
33	-	4.7	-	-	<0.1	<0.1	0.6	2.5	<0.1	1.4	-	0.1	<0.1
34	-	4.5	-	-	<0.1	<0.1	0.5	2.2	<0.1	1.4	-	0.1	<0.1

November 24, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	5.0	7.20	96	-	0.4	0.0	11.2	2.8
2	4.5	7.20	92	-	0.2	0.0	11.2	0.3
3	4.0	7.20	91	-	0.0	0.1	11.5	2.4
4	4.0	7.20	93	-	0.0	-	11.7	5.4
5	5.0	7.20	106	-	0.0	0.0	11.3	2.0
6	5.5	7.20	104	-	0.0	0.0	11.0	-
7	5.5	7.20	101	-	0.0	0.0	11.0	1.0
8	4.5	7.10	108	-	0.4	0.2	11.5	6.3
9	4.5	7.15	107	-	0.0	0.0	11.4	1.6
10	4.5	7.20	108	-	0.1	0.0	11.4	1.1
11	5.0	7.00	245	-	0.1	0.9	11.2	2.0
12	5.0	7.00	290	-	0.3	0.2	11.2	4.2
13	5.5	6.80	252	-	0.2	0.9	11.3	4.8
14	3.0	7.10	104	-	0.6	0.0	11.4	-
15	3.0	7.20	106	-	1.5	0.0	12.3	2.7
16	3.0	7.30	107	-	0.5	0.0	11.9	2.3
17	3.0	7.40	104	-	0.3	0.4	11.6	2.6
18	3.0	7.40	172	-	-	0.5	9.4	-
19	2.0	7.60	109	-	0.3	0.0	12.7	3.6
20	2.0	7.60	105	-	0.3	0.0	12.3	2.8
21	2.0	7.60	110	-	0.6	0.0	12.4	4.5
22	1.5	7.60	109	-	0.0	0.1	12.7	3.5
23	1.5	7.70	105	-	0.3	0.0	12.3	3.8
24	1.5	7.85	83	-	0.5	-	12.4	3.9
25	1.0	7.60	65	-	0.1	0.1	12.4	3.3
26	1.0	7.60	70	-	0.0	0.3	12.5	3.1
28	1.0	7.75	52	-	0.0	0.0	12.0	3.0
29	3.0	7.60	34	-	0.0	0.0	11.9	3.2
30	3.0	7.70	34	-	0.3	0.0	12.1	2.6
31	3.0	7.80	35	-	0.0	0.0	11.8	1.5
32	4.0	7.80	33	-	0.0	0.0	11.7	2.0
33	4.0	7.80	32	-	0.0	0.0	12.2	3.0
34	5.0	7.80	29	-	0.0	0.0	11.4	-

November 24, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	-	10.5	0.04	-	-	0.1	1.2	5.0	1.2	3.9	-	0.1	3.5
2	-	9.8	0.03	-	-	0.1	1.2	4.8	1.2	3.9	-	0.1	3.6
3	-	9.4	0.04	-	-	0.1	1.1	4.6	1.2	3.8	-	<0.1	3.7
4	-	10.0	0.04	-	-	0.1	1.1	4.9	1.4	4.2	-	0.1	4.5
5	-	10.7	0.04	-	-	0.1	1.2	5.4	1.4	4.3	-	<0.1	7.0
6	-	10.7	0.07	-	-	0.1	1.1	5.4	1.5	4.2	-	<0.1	5.9
7	-	10.5	0.05	-	-	0.1	1.1	5.2	1.3	4.0	-	<0.1	5.0
8	-	10.2	0.05	-	-	<0.1	1.1	5.3	1.6	4.1	-	<0.1	5.3
9	-	10.4	0.05	-	-	<0.1	1.1	5.3	1.3	1.2	-	0.1	5.6
10	-	10.1	0.04	-	-	0.1	1.2	5.2	1.1	4.0	-	<0.1	5.0
11	-	24.5	0.30	-	-	<0.1	2.4	11.4	4.5	9.2	-	<0.1	12.0
12	-	36.6	0.30	-	-	<0.1	2.8	15.3	5.0	11.3	-	0.1	11.8
13	-	27.3	0.45	-	-	<0.1	2.5	12.3	5.0	10.2	-	0.1	13.5
14	-	12.6	<0.01	-	-	<0.1	1.5	5.7	0.2	6.9	-	<0.1	3.4
15	-	13.0	<0.01	-	-	<0.1	1.4	5.7	0.2	6.9	-	<0.1	3.4
16	-	13.1	<0.01	-	-	<0.1	1.4	5.8	0.2	7.1	-	<0.1	3.4
17	-	13.4	<0.01	-	-	<0.1	1.3	5.8	0.2	7.5	-	<0.1	2.6
18	-	14.1	<0.01	-	-	<0.1	1.6	5.7	0.6	30.8	-	0.1	3.1
19	-	13.7	0.03	-	-	<0.1	1.3	5.8	0.2	3.4	-	0.1	4.0
20	-	13.9	0.04	-	-	<0.1	1.3	5.9	0.2	3.8	-	<0.1	4.0
21	-	13.3	<0.01	-	-	<0.1	1.3	5.6	<0.1	3.9	-	<0.1	3.3
22	-	13.5	0.02	-	-	<0.1	1.1	5.6	0.2	3.6	-	<0.1	4.0
23	-	13.7	0.02	-	-	<0.1	1.2	5.7	0.2	3.6	-	0.1	4.2
24	-	11.9	<0.01	-	-	<0.1	1.1	4.6	<0.1	3.4	-	0.1	0.5
25	-	9.7	<0.01	-	-	<0.1	1.0	4.3	<0.1	2.7	-	<0.1	0.2
26	-	9.7	<0.01	-	-	<0.1	1.1	4.1	<0.1	4.5	-	<0.1	0.1
28	-	8.1	<0.01	-	-	<0.1	1.2	3.9	<0.1	1.5	-	<0.1	<0.1
29	-	5.0	<0.01	-	-	<0.1	0.6	2.6	<0.1	1.2	-	<0.1	<0.1
30	-	5.3	<0.01	-	-	<0.1	0.5	2.8	<0.1	1.2	-	<0.1	<0.1
31	-	5.0	<0.01	-	-	<0.1	0.6	2.5	<0.1	1.3	-	<0.1	<0.1
32	-	4.8	<0.01	-	-	<0.1	0.5	2.4	<0.1	1.4	-	<0.1	<0.1
33	-	4.8	<0.01	-	-	<0.1	0.5	2.4	<0.1	1.3	-	<0.1	<0.1
34	-	5.2	<0.01	-	-	<0.1	0.5	2.4	<0.1	1.4	-	<0.1	<0.1

December 19, 1969

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	3.0	6.20	-	-	-	-	11.3	2.8
2	3.5	6.40	160	-	-	-	11.4	2.6
3	3.5	6.50	145	-	-	-	11.0	2.5
4	3.5	6.60	130	-	-	-	11.3	2.5
5	3.5	6.70	115	-	-	-	11.2	2.5
6	4.0	6.70	135	-	-	-	10.7	2.3
7	4.0	6.70	140	-	-	-	11.1	2.5
8	4.5	6.70	145	-	-	-	10.9	2.5
9	4.5	6.80	125	-	-	-	10.8	1.6
10	4.5	6.85	155	-	-	-	11.0	2.2
11	6.5	6.70	300	-	-	-	10.5	2.8
12	6.0	6.60	440	-	-	-	10.4	2.3
13	5.5	6.40	400	-	-	-	10.4	3.0
14	3.5	6.90	185	-	-	-	11.9	3.0
15	3.5	7.10	180	-	-	-	11.9	3.0
16	3.5	7.15	180	-	-	-	11.3	2.2
17	3.5	7.15	170	-	-	-	11.2	2.5
18	3.5	7.20	180	-	-	-	11.4	2.3
19	3.5	7.20	190	-	-	-	11.8	3.0
20	3.5	7.30	185	-	-	-	11.8	3.0
21	3.5	7.30	165	-	-	-	11.8	3.5
22	3.5	7.35	160	-	-	-	11.8	3.7
23	3.5	7.40	185	-	-	-	12.0	4.6
24	3.0	7.40	185	-	-	-	11.6	3.3
25	3.0	7.70	120	-	-	-	11.8	2.5
26	3.5	7.75	125	-	-	-	12.4	4.3
28	3.0	7.85	85	-	-	-	13.0	3.6
29	3.0	7.70	53	-	-	-	11.8	2.5
30	2.5	7.65	55	-	-	-	12.4	2.6
31	4.0	7.60	55	-	-	-	12.8	3.3
32	3.5	7.60	55	-	-	-	12.4	2.7
33	3.5	7.60	55	-	-	-	11.6	5.8
34	4.0	7.50	50	-	-	-	12.3	3.0

December 19, 1969 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	-	11.3	0.04	-	-	0.1	1.7	6.2	2.4	5.4	-	<0.1	11.2
2	-	9.6	0.04	-	-	0.1	1.2	5.1	1.6	3.8	-	<0.1	10.3
3	-	8.8	0.03	-	-	0.1	1.1	4.6	1.3	3.4	-	<0.1	5.2
4	-	8.1	0.03	-	-	0.1	1.0	4.3	1.1	3.2	-	<0.1	4.2
5	-	8.4	0.03	-	-	0.1	1.0	4.4	1.2	3.3	-	0.1	3.6
6	-	8.6	0.03	-	-	0.1	1.0	4.5	1.3	3.5	-	0.1	3.9
7	-	8.9	0.03	-	-	0.1	1.0	4.6	1.3	3.5	-	<0.1	3.9
8	-	8.7	0.05	-	-	0.1	1.1	4.7	1.7	3.8	-	0.1	4.5
9	-	9.0	0.05	-	-	0.1	1.1	4.7	1.6	3.7	-	<0.1	4.3
10	-	9.9	0.04	-	-	0.1	1.3	5.2	1.8	4.1	-	<0.1	4.7
11	-	23.7	0.29	-	-	<0.1	2.8	11.0	5.0	9.9	-	<0.1	12.3
12	-	28.5	0.37	-	-	<0.1	3.3	13.8	7.0	12.2	-	<0.1	19.0
13	-	27.4	0.38	-	-	<0.1	3.2	12.4	7.0	11.8	-	<0.1	18.5
14	-	13.3	0.01	-	-	<0.1	1.7	5.8	0.3	8.7	-	<0.1	2.3
15	-	13.5	0.01	-	-	<0.1	1.6	5.8	0.4	8.5	-	<0.1	2.3
16	-	13.1	<0.01	-	-	<0.1	1.7	5.9	0.3	8.6	-	<0.1	2.2
17	-	14.0	<0.01	-	-	<0.1	1.7	6.1	0.4	8.2	-	<0.1	3.0
18	-	14.2	0.03	-	-	<0.1	1.7	6.1	0.4	4.3	-	<0.1	3.9
19	-	14.1	0.02	-	-	<0.1	1.7	6.0	0.4	4.2	-	<0.1	3.9
20	-	13.9	0.03	-	-	<0.1	1.6	6.0	0.3	4.3	-	<0.1	3.7
21	-	14.0	0.04	-	-	<0.1	1.6	5.8	0.4	4.1	-	<0.1	4.0
22	-	13.0	0.03	-	-	<0.1	1.5	5.8	0.4	4.3	-	<0.1	4.1
23	-	13.7	0.03	-	-	<0.1	1.8	5.8	0.4	4.7	-	<0.1	4.4
24	-	13.8	0.04	-	-	<0.1	1.8	6.0	0.2	4.3	-	<0.1	4.4
25	-	12.0	0.02	-	-	<0.1	1.6	4.5	<0.1	3.5	-	<0.1	0.3
26	-	10.3	<0.01	-	-	<0.1	2.0	4.2	<0.1	5.5	-	<0.1	0.3
28	-	7.9	<0.01	-	-	<0.1	0.5	3.6	<0.1	1.4	-	<0.1	<0.1
29	-	4.1	0.02	-	-	<0.1	0.4	2.4	<0.1	1.3	-	<0.1	<0.1
30	-	4.4	<0.01	-	-	<0.1	0.4	2.6	<0.1	1.1	-	<0.1	<0.1
31	-	4.1	<0.01	-	-	<0.1	0.4	2.4	<0.1	1.3	-	<0.1	<0.1
32	-	4.0	<0.01	-	-	<0.1	0.4	2.3	<0.1	1.3	-	<0.1	<0.1
33	-	4.1	<0.01	-	-	<0.1	0.4	2.4	<0.1	1.2	-	<0.1	<0.1
34	-	3.7	<0.01	-	-	<0.1	0.4	2.2	<0.1	1.3	-	<0.1	<0.1

January 26, 1970

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	2.0	8.30	75	-	-	-	11.0	1.5
2	2.0	8.00	72	-	-	-	12.1	2.6
3	2.0	7.80	78	-	-	-	11.7	2.0
4	2.5	7.80	75	-	-	-	11.3	1.3
5	2.5	7.75	74	-	-	-	11.8	2.9
6	2.5	7.70	70	-	-	-	11.7	2.5
7	3.0	7.80	60	-	-	-	11.5	2.1
8	2.5	7.80	78	-	-	-	11.0	1.5
9	2.5	7.70	78	-	-	-	10.8	0.5
10	2.5	7.50	89	-	-	-	10.8	3.9
11	4.5	7.50	172	-	-	-	10.3	2.2
12	4.0	7.20	247	-	-	-	10.9	3.8
13	4.0	7.30	247	-	-	-	10.8	3.7
14	3.5	7.60	162	-	-	-	11.8	1.8
15	3.5	7.70	152	-	-	-	11.5	1.8
16	3.5	7.80	136	-	-	-	11.3	2.4
17	3.5	8.00	147	-	-	-	11.3	2.3
18	3.5	8.00	146	-	-	-	11.5	0.2
19	3.0	8.00	142	-	-	-	11.0	1.7
20	3.0	8.00	139	-	-	-	11.0	1.7
21	3.0	7.70	136	-	-	-	11.3	2.3
22	3.0	8.00	133	-	-	-	11.0	2.0
23	2.5	8.00	140	-	-	-	11.5	1.8
24	2.5	8.10	148	-	-	-	11.0	1.1
25	2.5	8.10	110	-	-	-	11.0	1.1
26	2.5	8.20	101	-	-	-	10.8	2.4
28	2.0	8.20	71	-	-	-	11.5	2.3
29	2.0	8.10	37	-	-	-	11.5	1.5
30	1.5	8.30	41	-	-	-	11.5	1.8
31	2.0	8.30	42	-	-	-	11.5	1.8
32	2.0	8.30	42	-	-	-	11.5	1.4
33	2.0	8.20	38	-	-	-	11.5	1.8
34	2.5	8.00	38	-	-	-	11.8	2.8

January 26, 1970 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	-	5.4	0.02	-	-	0.1	1.0	2.6	0.5	2.1	-	<0.1	1.0
2	-	5.0	0.01	-	-	<0.1	0.9	2.5	0.3	2.0	-	<0.1	0.9
3	-	5.6	0.01	-	-	0.1	1.0	2.6	0.6	2.1	-	<0.1	1.2
4	-	5.5	0.02	-	-	0.1	0.9	2.6	0.4	2.1	-	<0.1	1.2
5	-	5.4	0.02	-	-	0.1	0.9	2.5	0.6	2.2	-	<0.1	1.0
6	-	5.4	0.01	-	-	0.1	0.8	2.5	0.5	2.1	-	<0.1	1.0
7	-	4.3	0.01	-	-	0.1	1.0	2.2	0.4	2.4	-	<0.1	0.7
8	-	5.8	0.02	-	-	<0.1	0.8	2.7	0.3	2.1	-	<0.1	1.1
9	-	5.8	0.02	-	-	<0.1	0.8	2.7	0.7	2.1	-	<0.1	1.1
10	-	6.4	0.02	-	-	<0.1	1.0	2.9	0.4	2.3	-	<0.1	1.3
11	-	11.9	0.05	-	-	0.1	1.6	5.2	1.4	4.6	-	<0.1	3.7
12	-	18.6	0.09	-	-	<0.1	2.1	7.9	2.4	6.6	-	<0.1	6.6
13	-	19.0	0.19	-	-	0.1	2.1	7.6	2.7	6.7	-	<0.1	8.0
14	-	12.0	0.01	-	-	<0.1	1.4	5.5	0.5	5.1	-	<0.1	3.0
15	-	11.2	0.01	-	-	<0.1	1.3	5.2	0.2	4.8	-	<0.1	3.0
16	-	10.9	0.01	-	-	<0.1	1.3	4.5	0.2	4.4	-	<0.1	2.2
17	-	12.5	<0.01	-	-	<0.1	1.3	4.9	0.2	3.8	-	<0.1	3.0
18	-	12.5	0.01	-	-	<0.1	1.3	5.0	0.2	3.0	-	<0.1	3.3
19	-	12.5	0.02	-	-	<0.1	1.3	4.9	0.2	3.0	-	<0.1	3.4
20	-	11.9	0.01	-	-	<0.1	1.2	4.6	0.2	3.0	-	<0.1	3.3
21	-	12.6	0.01	-	-	0.1	1.2	4.5	0.3	3.0	-	<0.1	3.1
22	-	12.2	0.01	-	-	<0.1	1.1	4.3	0.2	2.9	-	<0.1	3.1
23	-	12.2	0.01	-	-	<0.1	1.1	4.5	0.2	3.1	-	<0.1	4.2
24	-	12.6	0.02	-	-	<0.1	1.1	4.9	0.2	3.4	-	<0.1	5.1
25	-	11.5	<0.01	-	-	<0.1	1.0	4.0	<0.1	2.8	-	<0.1	0.5
26	-	9.4	0.01	-	-	<0.1	1.1	3.7	<0.1	3.6	-	<0.1	0.3
28	-	6.8	<0.01	-	-	<0.1	0.5	3.2	<0.1	1.5	-	<0.1	0.1
29	-	3.3	<0.01	-	-	<0.1	0.4	1.9	<0.1	1.2	-	<0.1	<0.1
30	-	3.5	<0.01	-	-	<0.1	0.4	2.0	<0.1	1.1	-	<0.1	<0.1
31	-	3.5	<0.01	-	-	<0.1	0.5	1.9	<0.1	1.3	-	<0.1	<0.1
32	-	3.6	<0.01	-	-	<0.1	0.5	1.9	<0.1	1.3	-	<0.1	<0.1
33	-	3.3	<0.01	-	-	<0.1	0.5	1.8	<0.1	1.2	-	<0.1	<0.1
34	-	3.1	<0.01	-	-	<0.1	0.5	1.7	<0.1	1.2	-	<0.1	<0.1

February 21, 1970

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	5.5	6.70	53	-	-	-	11.0	3.5
2	4.0	6.70	51	-	-	-	11.1	2.6
3	4.0	6.70	51	-	-	-	11.1	3.3
4	4.0	6.70	54	-	-	-	11.1	2.7
5	4.0	6.40	51	-	-	-	11.1	0.0
6	4.0	6.70	52	-	-	-	11.1	3.0
7	4.5	6.70	47	-	-	-	11.1	2.5
8	4.0	6.70	57	-	-	-	11.2	2.7
9	4.0	6.70	55	-	-	-	11.2	2.6
10	4.0	6.90	63	-	-	-	11.2	2.1
11	4.5	6.70	131	-	-	-	10.8	1.7
12	3.5	6.60	170	-	-	-	10.8	2.0
13	4.0	6.50	164	-	-	-	10.8	1.9
14	3.0	6.70	107	-	-	-	11.2	2.3
15	3.0	6.70	94	-	-	-	10.7	2.3
16	3.0	6.80	84	-	-	-	11.2	2.8
17	3.0	6.90	76	-	-	-	10.4	1.5
18	3.0	6.80	127	-	-	-	10.2	1.3
19	2.5	7.40	132	-	-	-	11.1	2.3
20	2.0	7.40	86	-	-	-	11.3	2.2
21	2.0	7.00	104	-	-	-	11.4	2.8
22	2.0	7.50	97	-	-	-	11.4	2.7
23	2.0	7.40	95	-	-	-	11.4	2.9
24	1.5	7.30	111	-	-	-	11.4	2.2
25	1.5	6.70	75	-	-	-	11.4	2.1
26	2.0	7.40	78	-	-	-	11.4	2.8
28	1.5	7.50	58	-	-	-	11.5	3.1
29	3.0	7.70	30	-	-	-	11.7	2.5
30	3.0	7.60	29	-	-	-	11.6	1.6
31	4.0	7.60	29	-	-	-	11.3	1.9
32	3.0	7.50	34	-	-	-	11.3	2.8
33	3.5	7.50	29	-	-	-	11.3	1.6
34	3.5	7.50	27	-	-	-	11.7	2.0

February 21, 1970 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	-	5.9	<0.01	-	-	0.4	1.0	2.6	0.5	2.1	-	0.1	1.0
2	-	5.7	<0.01	-	-	0.3	1.0	2.5	0.6	2.1	-	0.1	1.1
3	-	5.8	<0.01	-	-	0.4	1.1	2.5	0.6	2.2	-	<0.1	1.0
4	-	6.2	<0.01	-	-	0.3	1.0	2.7	0.6	2.2	-	0.1	1.2
5	-	6.1	0.02	-	-	0.2	1.0	2.7	0.5	2.2	-	0.1	1.2
6	-	6.1	0.02	-	-	0.2	0.9	2.6	0.6	2.2	-	0.1	1.1
7	-	5.7	0.02	-	-	0.3	1.0	2.5	0.3	2.3	-	0.1	0.9
8	-	6.5	0.02	-	-	0.2	0.7	2.8	0.4	2.2	-	<0.1	1.4
9	-	6.5	0.02	-	-	0.2	0.7	2.8	0.5	2.2	-	0.1	1.3
10	-	7.3	<0.01	-	-	0.1	1.0	3.1	0.6	2.5	-	0.1	1.6
11	-	14.1	0.03	-	-	0.3	1.6	5.6	1.6	4.6	-	0.1	4.9
12	-	21.5	0.04	-	-	0.3	2.1	7.8	2.4	6.2	-	<0.1	7.2
13	-	19.8	0.06	-	-	0.3	2.1	7.5	2.5	6.2	-	<0.1	7.0
14	-	13.0	<0.01	-	-	0.1	1.4	5.2	0.6	4.5	-	0.1	3.4
15	-	12.3	<0.01	-	-	0.1	1.3	5.2	0.2	4.3	-	<0.1	3.6
16	-	12.2	<0.01	-	-	0.1	1.3	4.5	0.1	4.3	-	<0.1	2.8
17	-	10.5	<0.01	-	-	0.1	1.1	3.9	0.1	4.7	-	0.2	1.5
18	-	12.8	<0.01	-	-	0.2	1.6	4.6	0.4	16.8	-	<0.1	3.1
19	-	13.8	<0.01	-	-	<0.1	1.4	4.9	0.1	2.9	-	<0.1	3.6
20	-	13.2	<0.01	-	-	<0.1	1.4	4.7	0.1	2.8	-	<0.1	3.5
21	-	13.7	<0.01	-	-	<0.1	1.3	4.6	0.1	2.9	-	<0.1	3.5
22	-	13.0	0.02	-	-	0.1	1.2	4.5	0.2	2.9	-	<0.1	3.7
23	-	13.6	0.02	-	-	0.2	1.3	4.6	0.3	3.1	-	<0.1	4.3
24	-	13.5	0.03	-	-	0.1	1.3	4.9	0.2	3.5	-	<0.1	5.0
25	-	12.1	<0.01	-	-	<0.1	1.1	4.1	0.1	2.9	-	<0.1	0.5
26	-	10.9	<0.01	-	-	<0.1	1.3	3.8	0.1	3.8	-	<0.1	0.3
28	-	7.9	<0.01	-	-	<0.1	1.0	3.4	<0.1	1.5	-	<0.1	<0.1
29	-	3.6	<0.01	-	-	<0.1	0.4	1.8	<0.1	1.2	-	<0.1	<0.1
30	-	3.9	<0.01	-	-	0.1	0.4	2.1	<0.1	1.1	-	<0.1	<0.1
31	-	4.1	<0.01	-	-	<0.1	0.5	1.9	<0.1	1.3	-	<0.1	<0.1
32	-	4.0	<0.01	-	-	0.1	0.5	1.9	<0.1	1.4	-	<0.1	<0.1
33	-	3.8	<0.01	-	-	<0.1	0.5	1.8	<0.1	1.2	-	<0.1	<0.1
34	-	3.4	<0.01	-	-	<0.1	0.5	1.7	<0.1	1.2	-	<0.1	<0.1

March 20, 1970

Sample	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
1	4.5	7.70	53	-	-	-	11.6	2.1
2	4.0	7.70	50	-	-	-	12.4	3.3
3	4.0	7.60	51	-	-	-	11.0	1.5
4	4.0	7.60	50	-	-	-	11.0	1.5
5	5.0	7.60	50	-	-	-	11.2	1.7
6	4.5	7.60	50	-	-	-	11.0	2.2
7	5.0	7.55	51	-	-	-	10.6	1.4
8	3.0	7.55	49	-	-	-	11.4	1.8
9	3.0	7.55	50	-	-	-	11.2	1.7
10	3.0	7.55	54	-	-	-	12.0	2.6
11	5.0	7.30	121	-	-	-	11.4	2.0
12	3.5	7.10	172	-	-	-	11.2	2.3
13	4.0	6.90	180	-	-	-	11.2	1.9
14	4.0	7.00	112	-	-	-	12.0	2.6
15	4.0	7.10	93	-	-	-	12.2	2.9
16	4.0	7.20	90	-	-	-	11.8	2.0
17	4.0	7.30	80	-	-	-	12.2	3.0
18	4.0	7.40	144	-	-	-	11.4	3.7
19	3.5	7.35	98	-	-	-	12.3	3.1
20	3.0	7.30	92	-	-	-	12.2	3.0
21	3.0	7.30	96	-	-	-	11.2	2.2
22	3.0	7.30	92	-	-	-	11.4	2.1
23	2.5	7.30	94	-	-	-	11.4	2.2
24	3.0	7.30	96	-	-	-	11.6	2.0
25	3.0	7.50	79	-	-	-	11.6	2.0
26	3.5	7.60	75	-	-	-	10.8	1.9
28	3.0	7.80	56	-	-	-	11.2	1.8
29	3.0	7.90	29	-	-	-	11.6	1.5
30	3.0	7.90	29	-	-	-	11.4	1.9
31	4.0	7.90	32	-	-	-	11.4	1.6
32	3.0	7.90	31	-	-	-	11.8	2.6
33	3.0	7.90	30	-	-	-	11.6	1.6
34	4.0	7.90	27	-	-	-	11.7	1.7

March 20, 1970 cont.

Sample	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
1	-	5.9	0.01	-	-	0.3	0.9	2.4	0.4	2.0	-	<0.1	0.8
2	-	5.9	0.02	-	-	0.2	0.8	2.4	0.4	1.9	-	<0.1	0.8
3	-	5.9	0.01	-	-	0.2	0.8	2.4	0.4	2.0	-	<0.1	0.9
4	-	5.9	<0.01	-	-	0.2	0.7	2.4	0.3	2.0	-	<0.1	0.9
5	-	6.0	<0.01	-	-	0.1	0.7	2.5	0.4	2.0	-	<0.1	0.8
6	-	6.2	<0.01	-	-	0.1	0.7	2.5	0.3	2.0	-	<0.1	0.9
7	-	6.2	0.01	-	-	0.1	0.7	2.5	0.4	2.0	-	<0.1	1.0
8	-	5.9	<0.01	-	-	0.1	0.7	2.5	0.4	1.9	-	<0.1	1.0
9	-	6.0	<0.01	-	-	0.1	0.7	2.5	0.4	2.0	-	<0.1	1.0
10	-	6.6	<0.01	-	-	0.1	0.7	2.7	0.3	2.1	-	<0.1	1.2
11	-	13.1	0.03	-	-	0.2	1.5	5.2	1.3	4.8	-	<0.1	4.2
12	-	18.4	0.05	-	-	0.4	1.9	7.2	2.0	6.8	-	<0.1	6.6
13	-	18.8	0.04	-	-	0.3	1.9	7.0	2.2	7.0	-	<0.1	7.7
14	-	12.8	<0.01	-	-	0.1	1.3	4.7	0.4	4.8	-	<0.1	2.3
15	-	11.2	<0.01	-	-	0.1	1.1	4.4	0.1	4.3	-	<0.1	2.3
16	-	11.3	<0.01	-	-	0.1	1.1	4.2	0.1	4.3	-	<0.1	1.7
17	-	9.6	<0.01	-	-	0.1	1.0	3.6	0.1	5.1	-	<0.1	0.5
18	-	13.0	<0.01	-	-	0.2	1.5	4.5	0.3	18.2	-	<0.1	0.1
19	-	12.9	0.02	-	-	0.1	1.2	4.6	0.1	2.7	-	<0.1	2.7
20	-	12.3	0.02	-	-	0.1	1.1	4.3	0.1	2.5	-	<0.1	2.4
21	-	13.1	0.02	-	-	0.3	1.1	4.4	0.1	2.7	-	<0.1	2.2
22	-	12.9	0.02	-	-	0.1	1.1	4.3	0.1	2.6	-	<0.1	2.4
23	-	12.8	0.03	-	-	0.1	1.2	4.5	0.1	2.7	-	<0.1	3.2
24	-	12.4	0.04	-	-	0.1	1.3	4.5	0.2	3.1	-	<0.1	3.8
25	-	11.9	<0.01	-	-	<0.1	1.3	4.1	<0.1	2.7	-	<0.1	0.4
26	-	10.7	<0.01	-	-	<0.1	1.2	3.9	<0.1	3.0	-	<0.1	0.2
28	-	8.5	<0.01	-	-	0.1	0.5	3.6	<0.1	1.5	-	<0.1	<0.1
29	-	4.2	<0.01	-	-	0.1	0.4	2.0	<0.1	1.1	-	<0.1	<0.1
30	-	4.4	<0.01	-	-	<0.1	0.4	2.1	<0.1	1.0	-	<0.1	<0.1
31	-	4.6	<0.01	-	-	0.1	0.5	2.0	<0.1	1.2	-	<0.1	<0.1
32	-	4.5	<0.01	-	-	0.1	0.4	2.0	<0.1	1.2	-	<0.1	<0.1
33	-	4.3	<0.01	-	-	<0.1	0.4	1.9	<0.1	1.1	-	<0.1	<0.1
34	-	3.9	<0.01	-	-	<0.1	0.4	1.7	<0.1	1.1	-	<0.1	<0.1

Elk Well Wallace, Idaho

Date	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
July 8, 1969	17.0	6.90	115	-	-	-	-	-
July 15, 1969	16.0	6.45	105	3.3	-	-	7.4	1.1
Aug. 19, 1969	15.5	7.60	125	2.5	-	-	-	-
Oct. 30, 1969	14.0	6.40	140	-	-	-	-	-
Nov. 24, 1969	11.0	7.70	-	-	-	-	-	-

Zanetti Well Osburn, Idaho

Date	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
June 12, 1969	-	6.10	173	4.5	-	-	-	-
July 8, 1969	10.5	6.15	216	-	-	-	-	-
July 15, 1969	10.0	6.45	188	1.9	-	-	7.5	0.7
Aug. 19, 1969	12.5	6.80	280	1.5	-	-	-	-
Oct. 30, 1969	11.5	6.30	205	-	-	-	-	-
Nov. 24, 1969	10.0	6.80	-	-	-	-	-	-

Lions Well Pinehurst, Idaho

Date	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
Aug. 19, 1969	14.5	6.10	95	0.0	-	-	5.9	0.7

Page Well Smelterville, Idaho

Date	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
July 8, 1969	16.5	6.75	275	-	-	-	-	-

Elk Well Wallace, Idaho, cont.

Date	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
July 8, 1969	<10.0	10.8	-	<0.5	0.1	0.2	-	2.6	0.1	-	<0.1	-	0.1
July 15, 1969	-	11.9	-	-	<0.1	-	<0.1	2.7	-	<0.1	-	-	0.1
Aug. 19, 1969	-	27.6	-	-	-	-	0.7	2.5	0.1	3.0	-	<0.1	0.1
Oct. 30, 1969	-	10.5	-	-	<0.1	0.1	0.5	2.9	0.1	2.6	-	<0.1	0.1
Nov. 24, 1969	-	-	-	-	-	-	-	-	-	-	-	-	-

Zanetti Well Osburn, Idaho, cont.

Date	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
June 12, 1969	<10.0	12.0	-	-	<0.1	<0.1	-	9.0	0.1	-	<0.1	<0.1	17.0
July 8, 1969	<10.0	13.0	-	<0.5	0.1	0.1	-	4.5	0.1	-	<0.1	-	15.0
July 15, 1969	-	14.4	-	-	<0.1	-	<0.1	4.1	0.1	<0.1	-	-	13.8
Aug. 19, 1969	-	37.2	-	-	<0.1	0.2	1.9	4.0	0.1	2.7	-	-	7.4
Oct. 30, 1969	-	12.6	-	-	<0.1	<0.1	1.8	4.6	0.1	3.0	-	0.1	11.3
Nov. 24, 1969	-	-	-	-	0.1	-	-	-	-	-	-	-	-

Lions Well Pinehurst, Idaho, cont.

Date	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
Aug. 19, 1969	-	7.2	-	-	<0.1	0.3	0.9	1.6	0.1	2.4	-	<0.1	1.1

Page Well Smelterville, Idaho, cont.

Date	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
July 8, 1969	<10.0	22.0	-	<0.5	0.1	1.5	-	6.2	0.9	-	<0.1	-	<0.1

Date	Temp.	pH	E.C.	Cl	NO_3	PO_4	D.O.	B.O.D.
Morning Mine								
June 12, 1969	-	7.60	910	18	-	-	-	-
July 8, 1969	19.0	7.55	700	-	-	-	-	-
July 26, 1969	18.5	7.70	710	0.0	-	-	-	-
Aug. 3, 1969	18.5	7.75	700	0.0	-	-	-	-
Aug. 19, 1969	19.0	7.80	800	0.0	-	-	-	-
Silver Buckle								
Aug. 19, 1969	-	-	-	-	-	-	-	-
Feb. 21, 1970	-	-	295	-	-	-	-	-
Moe Mine								
July 8, 1969	8.5	7.90	242	-	-	-	-	-
Aug. 19, 1969	-	-	-	-	-	-	-	-
Feb. 21, 1970	-	-	86	-	-	-	-	-

Morning Mine, cont.

Date	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
June 12, 1969	<10.0	59.0	-	-	<0.1	-	-	66.0	0.1	-	<0.1	-	1.0
July 8, 1969	<10.0	41.0	-	<0.5	0.1	0.2	-	47.0	0.2	-	<0.1	-	<0.1
July 26, 1969	-	48.2	-	-	<0.1	<0.1	4.6	>25.0	<0.1	20.8	-	-	0.5
Aug. 3, 1969	-	39.0	-	-	<0.1	<0.1	1.1	>10.0	<0.1	1.2	-	-	0.3
Aug. 19, 1969	-	46.4	-	-	<0.1	0.5	1.9	> 4.5	0.1	4.0	-	-	0.5

Silver Buckle, cont.

Date	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
Aug. 19, 1969	-	35.7	-	-	<0.1	0.1	0.8	1.9	3.0	3.0	-	-	<0.1
Feb. 21, 1970	-	63.8	<0.02	-	-	0.1	5.0	18.9	2.1	2.1	-	0.1	<0.1
July 15, 1969 1970*	-	-	-	-	-	-	-	-	-	-	-	<0.1	-

Moe Mine, cont.

Date	As	Ca	Cd	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Zn
July 8, 1969	<10.0	19.5	-	<0.5	0.2	0.3	-	15.0	0.1	-	<0.1	-	<0.1
Aug. 19, 1969	-	19.1	-	-	<0.1	<0.1	0.7	> 4.5	0.1	8.7	-	-	0.1
Feb. 21, 1970	-	12.2	<0.02	-	-	0.5	4.5	5.0	0.1	4.6	-	<0.1	<0.1
Aug. 19, 1969 1970*	-	-		-	-	-	-	-	-	-	-	0.1	-

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*Sample collected during summer of 1970 after completion of regular sampling period.