UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER QUALITY OF COAL DEPOSITS AND ABANDONED MINES, SAGINAW COUNTY, MICHIGAN

U.S. GEOLOGICAL SURVEY

Open-File Report 82-511

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by A. H. Handy

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Lansing, Michigan
1982

UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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CONVERSION FACTORS

The inch-pound units used in this report can be converted to the metric system of units as follows:

Multiply inch-pound unit	By	To obtain metric unit
inch	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
gallon per minute (gal/min)	6.309×10^{-5}	cubic meter per second (m^3/s)
cubic foot per second	0.0283	cubic meter per second (m^3/s)
ton, short (2,000 lb)	0.907	megagram (Mg) metric ton (t)
micromho per centimeter (μmho/cm)	1.000	microsiemen per centimeter (μS/cm)
Curie (Ci)	3.7×10^{10}	Becquevel (Bq)
degree Fahrenheit (°F)	[(°F)-32]/1.8	degree Celsius (°C)
acre-foot (acre-ft)	1.233×10^{-3}	cubic hectometers (hm^3)

WATER QUALITY OF COAL DEPOSITS AND ABANDONED MINES, SAGINAW COUNTY, MICHIGAN

by

A. H. HANDY

ABSTRACT

Surface water and ground water from an area underlain by coal-bearing rocks in the vicinity of St. Charles, Michigan, were analyzed to determine the quality characteristics of these water resources and to assess the relation between the two. Data for 15 constituents, including boron, phenol, lithium, strontium and manganese, were in such high concentrations that they could be used to differentiate between water from wells drilled into coal-bearing beds and water from streams not directly associated with coal deposits.

Ground water from abandoned mines and undisturbed coal-bearing beds is highly mineralized, and contains higher concentrations of trace metals than surface water. Water from the undistrubed coal-bearing beds and abandoned mines is not suitable for domestic, public supply, or agricultural uses. Large amounts of this highly mineralized ground water reaching local streams would have a deleterious effect on surface-water quality.

INTRODUCTION

Coal mining in Michigan began with the discovery of coal west of Jackson in 1835 (fig. 1). Forty-six million tons were produced during the period 1860 to 1949. Greatest production occurred in 1907 when almost 2 million tons were mined (fig. 2). Production steadily declined from 1907 until 1949 when the last large scale commercial mine was closed. Open pit mines were operated in some areas but most production came from underground mines at depths greater than 100 feet.

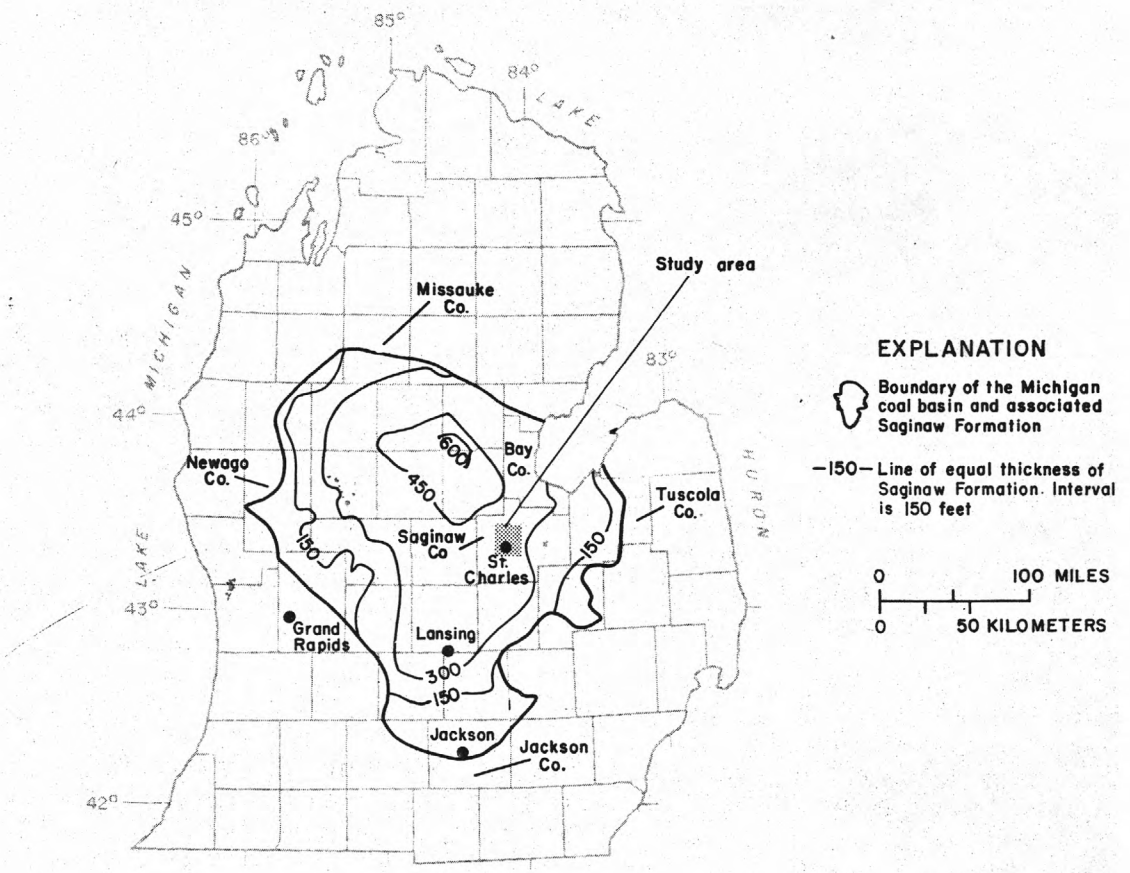

Figure 1.--The Michigan coal basin and the thickness and areal extent of the associated Saginaw Formation.

When the underground mining started in Bay and Saginaw Counties in 1897, coal production became an important industry in Michigan. Competition from large mines in West Virginia, Kentucky, Ohio, and Illinois, increases in production costs due to ground-water flooding, and the nature of the coal deposits caused the demise of Michigan's coal industry. However, new interest is being shown in Michigan's coal because of increasing energy costs and the close proximity of coal deposits to heavy industry.

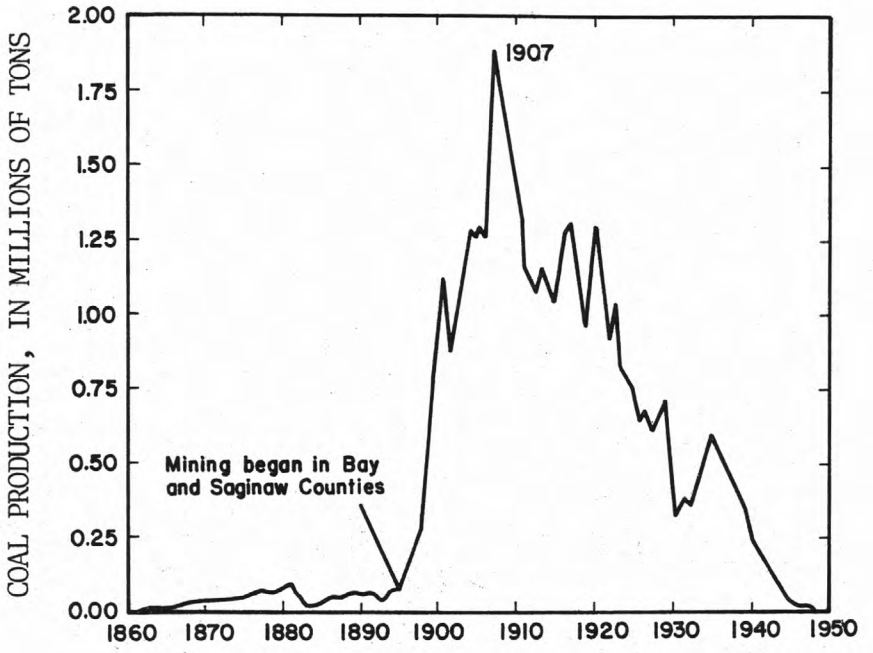

Figure 2.--Coal production in Michigan, 1860-1949.

Purpose and Scope

The purpose of this study was to determine the chemical characteristics of water in coal beds, abandoned mines, and streams and to assess the impact, if any, that the mining operation has had on water resources in the area. Also, the quality of water from abandoned mines was evaluated to determine its suitability for domestic, public supply, and agricultural uses.

Methods of Investigation

The flow of streams in the study area was measured and samples were collected for laboratory analysis at sites upstream and downstream from the mined area (figs. 3 and 4). Analyses are given in table 1. Each site was sampled three times under different hydrologic conditions between June 1980 and June 1981 and a comparison of the chemical and physical characteristics of water made. Bear Creek, a stream that does not flow through the coal area, was sampled at a site near Fergus to aid in evaluating changes in water quality. Ground-water samples were collected from 12 wells that were drilled to determine the chemical and physical characteristics of water in contact with coal beds. Three wells were drilled into abandoned mine drifts and nine wells into undisturbed coal beds. Samples from these wells were analyzed for the same parameters determined on surface water. In addition, analyses were made for dissolved gases that are sometimes associated with coals. Analyses for ground water were compared to those for surface water in order to assess the effect of the coal mining operation on water quality.

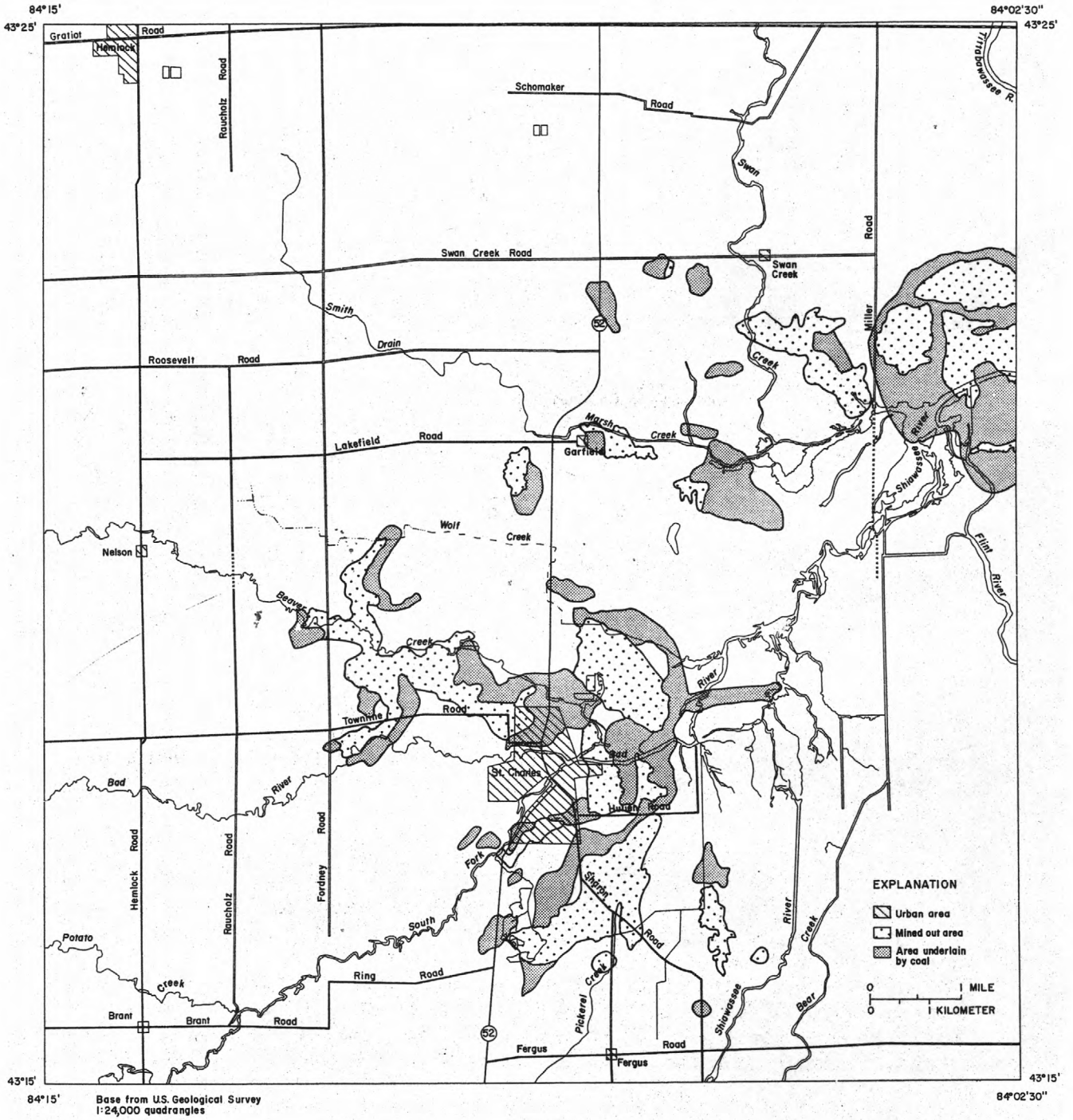

Figure 3.--Areas underlain by coal-bearing rocks and abandoned mine drifts.

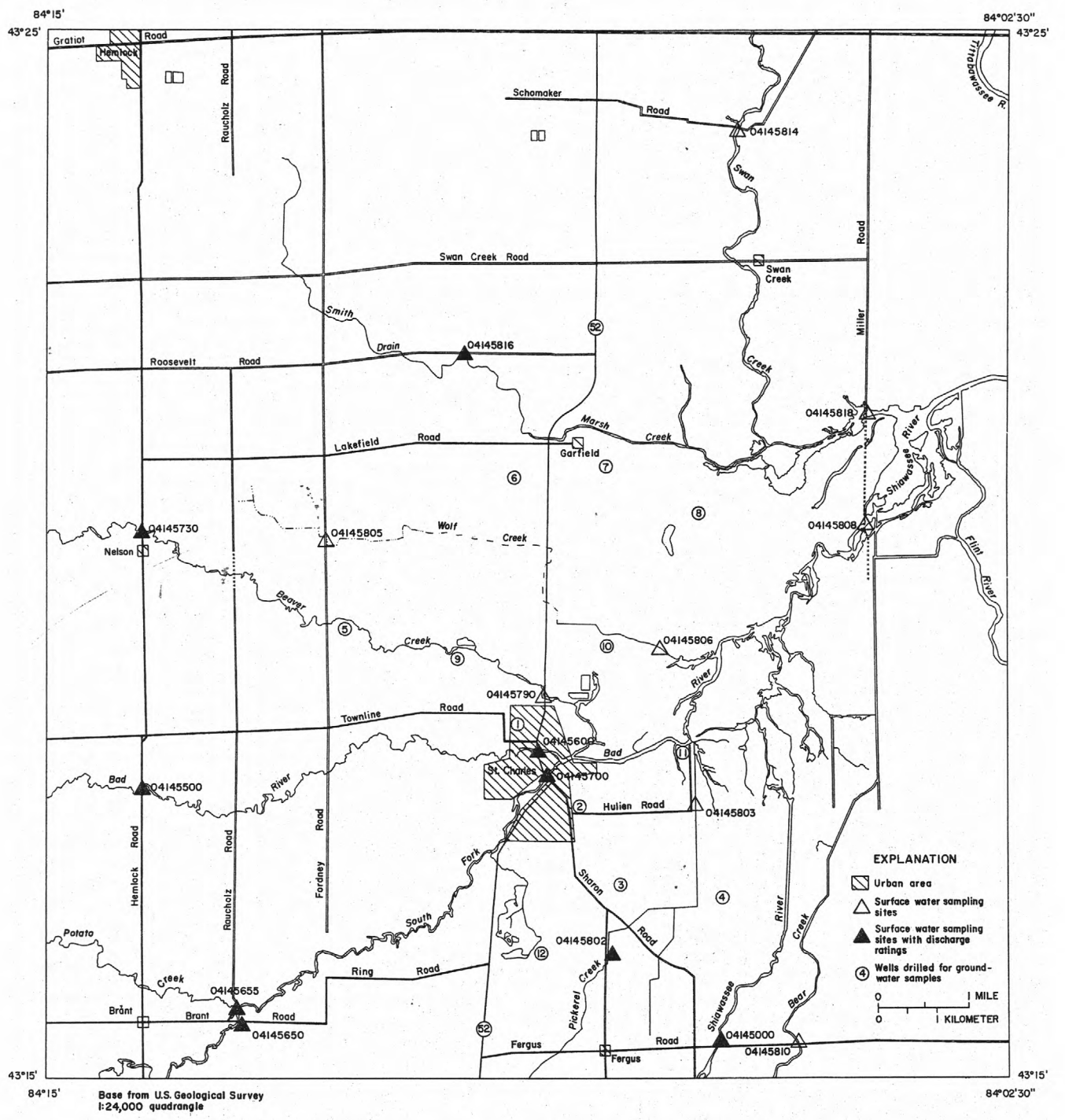

Figure 4.--Surface-water and ground-water sampling sites.

Hydrologic Setting

The study area is drained by the Shiawassee River and its tributaries, the Bad River and Marsh Creek (fig. 4). Downstream from St. Charles and out of the study area, the Shiawassee, Flint, Cass, and Tittabawassee Rivers form the Saginaw River in the Shiawassee Flats--a large wetlands area. Owing to its close proximity to Shiawassee Flats and the lack of topographical relief, the St. Charles area has a high ground-water table and poor drainage. Large drainage canals and pumps must be used to drain the land for farming. Agriculture is one of the major industries of the area.

The average annual precipitation at the St. Charles weather station is 28.9 inches for the 38 years of record; 29 percent of this amount occurs as snow. The average annual temperature for 27 years of record is 47.7°F. The maximum (94°F) occurred in July and the minimum (-6°F) occurred in February for the 1980 calendar year (National Oceanic and Atmospheric Administration, 1980).

Michigan Coal Basin

The Michigan Coal Basin extends from Missaukee and Bay Counties south to Jackson County and from Tuscola County west to Newago County. Saginaw County is near the center of the basin (fig. 1). Most coal mines in Saginaw County were located near St. Charles (fig. 3). They were abandoned early in the 20th century and little evidence of their existence is visible today. A few mine dumps and old shafts may still be identified on farms and in marshes.

Most coal deposits in the study area are at depths greater than 100 feet. Veins are lenticular and varied from 1 to 5 feet in thickness. The room and pillar method of mining was used and 40 percent of the coal was left for safety and to support the overburden. Ground-water seepage had to be pumped from the mine drifts to allow access to the mines to remove the coal.

GEOLOGY OF ST. CHARLES AREA

Glacial Deposits

Lower Michigan was covered by glaciers at least twice during geologic history. The Wisconsin Glaciation during the Pleistocene was the last time this area was covered with ice and the bedrock scoured by glacial movement. This period is well documented in Michigan although the earlier Illinoian Glaciation is not represented except by an unconformity. Deposits representing the Illinoian Glaciation and interglacials are thought to have been removed by scour from the Wisconsin Glaciation (Dorr and Eschman, 1970).

When the Wisconsin glacier retreated, it left bedrock of Pennsylvanian age and red beds of Cretaceous age covered with a thick mantle of glacial sands, gravels, and clays. The glacial deposits

are almost 600 feet deep in several places within the coal basin and from 30 to 150 feet near St. Charles. In buried valleys near Garfield and Nelson (fig. 3), the glacial deposits are about 500 feet thick. Sand and gravel in the buried valleys are good aquifers and generally yield large quantities of good quality water (Kalliokoski and Welch, 1977). However, in areas where clay is abundant, yields are low and quality is poorer.

Saginaw Formation

The entire Michigan coal basin (fig. 1), including Saginaw County, is underlain by the Saginaw Formation of Pennsylvanian age. This bedrock formation consists of alternating and intertonguing beds of sandstone, silt, shale, limestone, and coal. The coal beds are lenticular and range in thickness from 1 to 5 feet. Limestone and shale are the most abundant rock types in the formation.

In Saginaw County and Bay County to the north as many as 14 coal beds have been identified. Three of them, the Saginaw coal, the Upper Verne coal, and the Lower Verne coal, have been successfully mined.

QUALITY OF WATER IN STREAMS

Nine streams have been sampled upstream and seven streams have been sampled downstream from previously mined or known coal bed areas. Samples were also collected from Bear Creek, a stream outside the area underlain by coal (see table 1). Fifty samples were collected in June and August 1980 and in May or June 1981. Care was taken to sample within a two or three day period to minimize differences due to events that would cause major changes in water quality. Examples of such events would be the application of fertilizer to a large cropped area or a heavy rainfall causing dilution of constituents. In 1980, the spring thaw and consequent runoff occurred from April to the first part of June, but in 1981 spring runoff occurred in February to the first part of March (U.S. Geological Survey, 1980, 1981). Samples collected in June 1981 reflect summer conditions rather than spring runoff conditions. Tables 1, 2, and 3 show the chemical and physical analyses of water.

A significant point concerning the quality of water in streams is that water in Bear Creek, which is outside the area underlain by coal beds, does not appear to differ from that in other streams in the study area. However, major differences do occur between upstream and downstream stations on other streams in the study area. This indicates that factors other than coal mining, such as overland runoff, precipitation, shallow ground-water seepage, soil composition, and farming practices may exert more influence on the chemical characteristics of surface water. In addition, none of the streams appear to contain elevated concentrations of constituents such as sulfate, boron, phenol, and strontium as they flow through the mined areas. These constituents have been found in other studies to be indicative of coal deposits or mine drainage.

Major Ions

At every site sampled, dissolved solids and all major ions were less concentrated in the June 1980 samples taken right after spring runoff. The higher flows shown in table 3 for June 1980 result in dilution of all constituents. August 1980 and May 1981 samples were more concentrated. Concentrations at all downstream sites were the same or less than those upstream except for Pickerel Creek and Wolf Creek. This characteristic at downstream sites may have been due to inflow of ground water from shallow depths (less than 8 feet). In general, May-June 1981 values were intermediate between the low June 1980 and the higher August 1980 values (fig. 5).

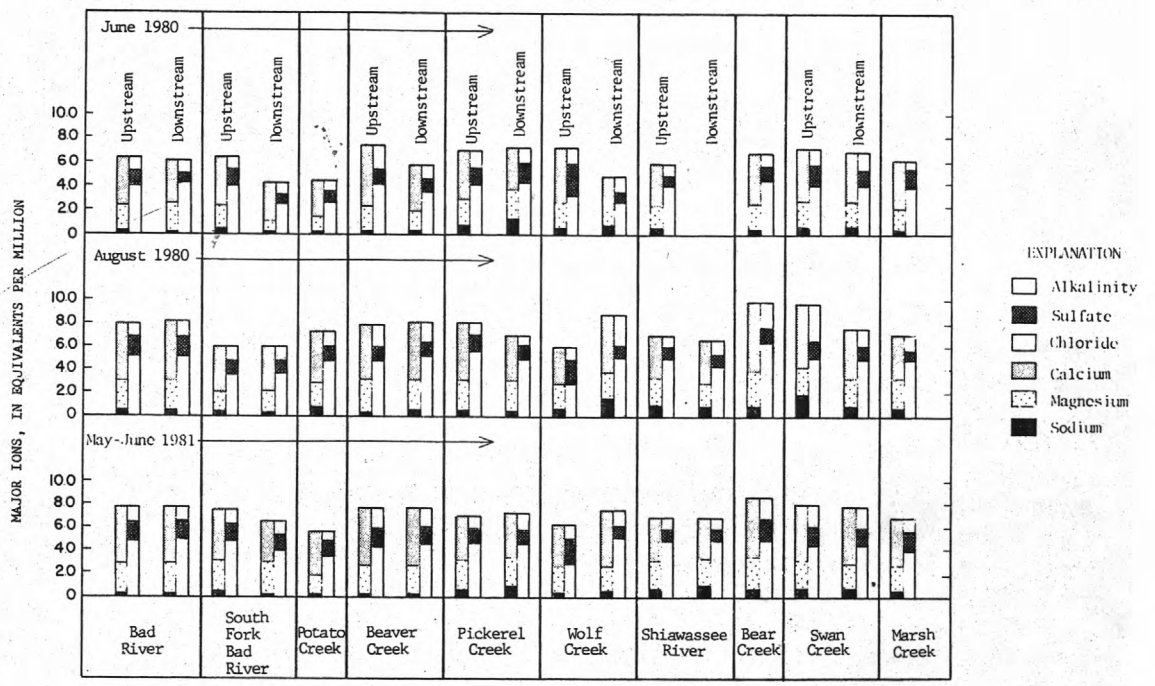

Figure 5.--Comparison of major ions in streams.

Nutrients

Nutrients--total nitrate plus nitrite, total ammonia, and total phosphorus--were affected by seasonal application of fertilizers to fields upstream from the sampling sites (table 3). Total nitrate plus nitrite was from 2 to 20 times higher in June 1980 immediately after the fields were fertilized than in August of the same year. Every stream except Beaver Creek had less nitrate downstream than upstream. Total ammonia in every stream, except in Swan Creek, changed little from June 1980 to August 1980 or in the downstream direction. Total ammonia in May-June 1981 was slightly higher than in 1980. Swan Creek

showed a 2- to 5-fold increase from June 1980 to August 1980 and a 2-fold increase in the downstream direction. May 1981 showed no downstream increase and a partial return to May 1980 concentrations. Total phosphorus in every stream increased in the downstream direction and showed little change except in Bad River and Swan Creek between June 1980 and August 1980. Bad River, Swan Creek and Marsh Creek showed an increase in total phosphorus from June 1980 to August 1980. Swan Creek near Garfield had a 4-fold increase in May 1981 while Bad River and Marsh Creek returned to lower concentrations.

Trace Metals

Twenty-eight trace metals were analyzed each time samples were collected (table 1 and table 3). These elements were selected because they have been found associated with mine drainage or coal deposits in other studies. Thirteen trace metals were analyzed quantitatively. These trace metals are found in table 3 and values for them are more accurate and precise than values for the same metals found in table 1. Copper, mercury, molybdenum, nickel, selenium, silver, and zinc exhibited no seasonal or downstream variation. Values were near detection levels and within analytical variability in every sample. Lead concentrations were 1 to 5 micrograms per liter (µg/L) (mean 3.5) and near detection level except for the Shiawassee River where values were between 5 and 11 µg/L. Concentrations for lead in South Fork Bad River near Brant (9 µg/L) and Pickerel Creek near St. Charles (21 µg/L) were high in June 1980. Lithium concentrations were 0 to 10 µg/L (mean 9.4) except for Shiawassee River near Swan Creek and Swan Creek near Garfield where 20 µg/L concentrations occurred in August 1980. Values of 20 µg/L are not abnormally high for surface water. Strontium occurs in these streams in concentrations ranging from 100 to 500 µg/L (mean 270). Concentrations in August 1980 were higher than June 1980 in all cases except at a site on Pickerel Creek and one on Shiawassee River. The highest concentration was in August 1980 in Swan Creek at Schomaker Road.

Drinking water standards were set by the U.S. Environmental Protection Agency (1977) for 11 of the 28 trace metals discussed. Arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, selenium, silver, and zinc have limits. The concentrations for iron (standard, 300 µg/L) and manganese (standard, 50 µg/L) exceed the standards in some of the streams, Iron is exceeded in at least two out of three samples at every sampling site except for Beaver Creek near Nelson where it is only exceeded once. Manganese is exceeded at both sites on the Shiawassee River and Swan Creek for all samples. Also, Bad River, Beaver Creek, Wolf Creek, and Bear Creek exceed the limits one or two times, generally in August 1980 and May-June 1981. EPA limits for drinking waters are not exceeded by any other trace metal listed above.

Iron and Manganese

Total recoverable concentrations for iron ranged from 260 to 3500 µg/L (mean 1250); the highest concentrations for any trace metals found during this study. The variation in iron concentration seemed to be random rather than due to seasonal or downstream conditions. Dissolved iron concentrations showed the same variability.

Total recoverable concentrations for manganese ranged from 10 to 180 µg/L (mean 75). Total recoverable and dissolved manganese exhibited the same variability as iron. Generally the concentrations for August 1980 were higher than those for June 1980 and several May-June 1981 values were higher than both June 1980 and August 1980.

Total recoverable concentrations are those resulting from using moderate acid digestion of the whole sample. All concentrations from the quantitative determinations are total recoverable values except for iron and manganese which have both dissolved and total recoverable concentrations. Dissolved concentrations express what is actually in solution or that part of the collodial particles that will pass through a 0.45 micrometer filter.

Semiquantitative Trace Metals

Twenty five trace metals were analyzed semiquantitatively using an Inductively Coupled Plasma-jet spectrophotometer (ICP). All concentrations from semiquantitative methods are dissolved (table 1). Silver, boron, barium, beryllium, cadmium, cobalt, copper, chromium, antimony, molybdenum, nickel, titanium, vanadium, and zirconium occurred in low concentrations and all were at or near the detection limits. Germanium, gallium, and aluminum, had ranges of 50 to 300 µg/L, <30 to 100 µg/L and <50 to 700 µg/L, respectively. All high values for gallium and aluminum were found in May-June 1980 and June 1981. Concentrations of tin range from 100 to 3000 µg/L; all high values were found in May-June 1981 and June 1980. Bismuth concentrations are all less than 1000 µg/L except for one sample from Beaver Creek at St. Charles collected in June 1980, which is 7000 µg/L.

Lithium, lead, strontium, zinc, iron, and manganese had ranges of <5 to 10 µg/L, <30 to 300 µg/L, 100 to 500 µg/L, 7 to 30 µg/L, 10 to 700 µg/L, and 7 to 100 µg/L respectively. August 1980 concentrations were lower for lithium, lead and manganese, while strontium, zinc, and iron concentrations did not seem to have a pattern of distribution.

Other Constituents

Cyanide and phenols were not found in significant quantities; concentrations of both were near detection limits (table 3). Dissolved organic carbon was much higher than detection limits (3.4 to 21 mg/L) but was not high enough to be unusual or indicative of coal since unpolluted streams have seasonal concentrations in this range due to decaying vegetation. Wetlands also can contribute large amounts of organic matter.

QUALITY OF GROUND WATER

Water in coal-bearing rocks and abandoned mine drifts

Twelve wells were drilled in the coal-mining area around St. Charles (fig. 4) to obtain hydrologic information. All 12 wells were drilled with a rotary rig and a 4-inch steel casing was installed to depths that isolated the major coal producing zone for sampling (fig. 6). Wells were left open at the bottom and no screens were attached. The wells

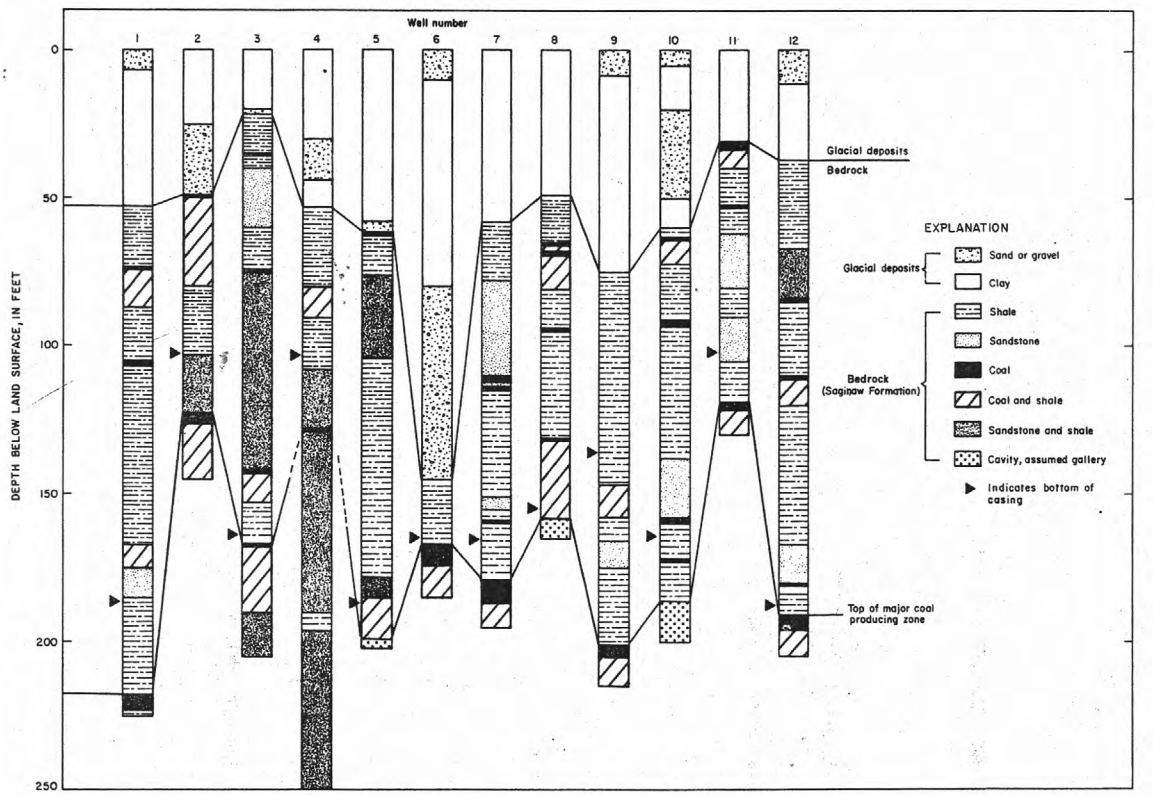

Figure 6.--Lithology of materials in 12 test wells.

tapped undisturbed coal beds and abandoned mine drifts at sites known to be underlain by coal or abandoned mines (fig. 4). Wells 1, 2, 3, 4, 6, 7, 9, 11, and 12 penetrated undisturbed coal beds; wells 5, 8, and 10 penetrated abandoned mine drifts. Figure 6 shows the lithology of the materials in the 12 wells. All wells were pumped or bailed after completion of drilling to remove drilling refuse, including river water used in the drilling process. The wells were capped and locked until sampled. Samples were collected after pumping for 30 minutes. Each well was sampled during May 1981. Large quantities of water were found in the abandoned drifts. For example, well 8 was pumped at 30 gallons per minute for 30 minutes with no measureable drawdown.

Samples of water from wells were analyzed[1/] for methane, hydrogen sulfide, phenolic compounds, and other organic compounds. Methane ranged from 0.007 percent by volume in well 12 to 1.2 in well 7 (mean 0.29% by volume). Hydrogen sulfide ranged from less than 0.02 mg/L in well 1 to 0.08 mg/L in well 8 (mean 0.04 mg/L). Small amounts of dissolved gases were present in all 12 wells. Chrysene or benzo (a) anthracene was the only organic compound identified. This compound was found in all wells but only in concentrations of from 1 to 5 µg/L (mean 2.2 µg/L). None of the above compounds were detectable in concentrations large enough to trace movement of water.

Water from all wells was analyzed to determine chemical quality (table 2). Specific conductance ranged from 4390 to 43,200 micromhos (mean 24,320 µmhos) indicating that the water was a saline or brine solution and that dissolved solids were 5 to 50 times more concentrated than in streams sampled during this project.

Sodium and chloride were the predominant ions (fig. 7). The next most common ions were calcium and sulfate although they had much smaller concentrations than sodium and chloride. Concentrations of nitrogen and phosphorus were low in all wells. Ammonia and organic nitrogen were very high in well 1 and lower in wells 2, 3, 4, 6, 7, 9, and 10.

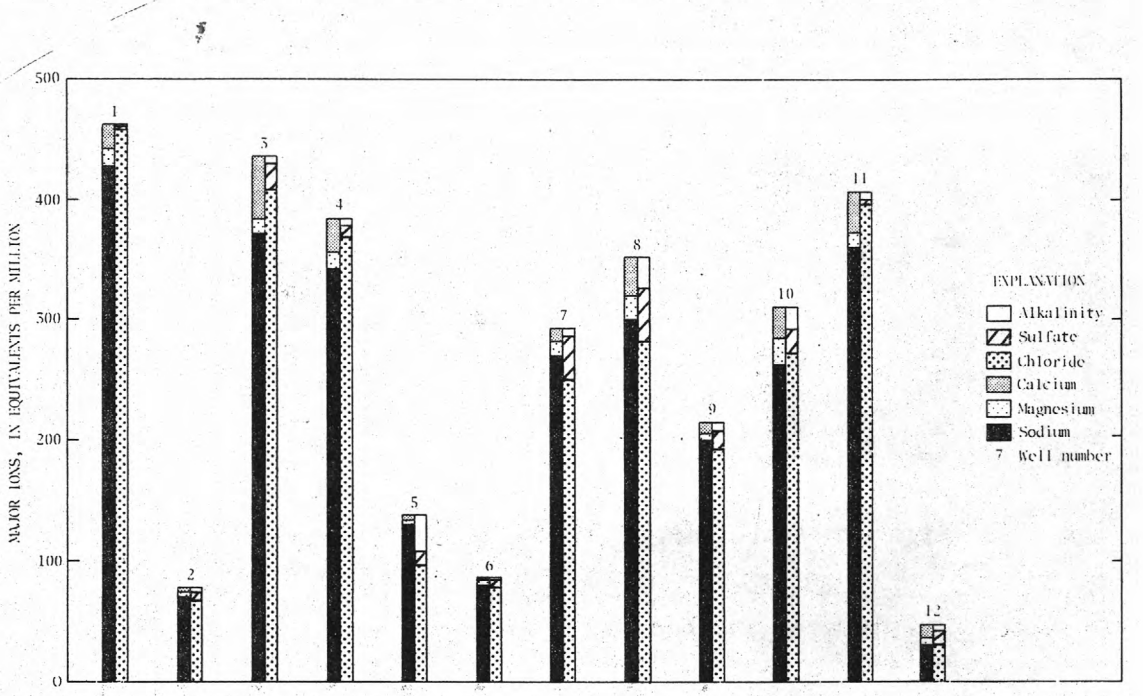

Figure 7.--Comparison of major ions in ground water.

1/ Analyses were by Canton Analytical Laboratory of Ypsilanti, Michigan.

Water quality of coal shafts compared to coal beds

Trace elements in water from mine drifts when compared with those in water from the coal beds showed some trends (table 2). Boron, cobalt, and nickel were higher in the drifts than in the coal beds; whereas, phenol, iron, manganese, copper, lead, molybdenium, and zinc were significantly higher in the coal beds. Aluminum, arsenic, beryllium, cadmium, cobalt, chromium, lithium, selenium, and silver were virtually the same in drifts and undisturbed beds. Turbidity was higher in the coal beds, sulfate was lower, and specific conductance was both higher and lower. Similar results were obtained by semiquantitative analysis of the same trace elements. Other constituents such as germanium, gallium, titanium, tin, and zirconium were virtually the same in drifts and undisturbed beds (table 1).

GROUND WATER COMPARED WITH SURFACE WATER

Ground water from shallow depths (less than 8 feet) in Saginaw County is a major contributor to streamflow at low and intermediate flows. In much of the area, ground water is so near land surface that large, deep drainage canals are needed to lower the water table enough that the land may be used for agriculture. Data from 10 wells sampled from the Saginaw Formation indicate that water from shallow aquifers was relatively good quality (Cummings, 1980). Poor quality ground water associated with the coal beds and abandoned drifts, generally at depths greater than 150 feet, had little effect on the quality of surface water under natural conditions.

Chemical analysis of Michigan's coal is very rare in the published literature. Some data are available on thermal properties and decomposition products but even these data were collected prior to 1950. Data for some of the trace metals in 659 analyses of coal in the eastern United States are given in table 4 (Zubovic and others, 1976). These data, and that for 101 samples from Ohio coal fields (table 4), give an idea of the type and concentration of elements that are likely to occur in Michigan's coal. The coal in Ohio probably formed under conditions similar to that in Michigan. Trace metals in three samples collected by Sorenson (written communication, 1981) from open-pit coal mines about 50 miles southwest of the study area indicate that even higher concentrations of trace metals are present in some Michigan coal.

Analyses of water from the arithmetic means for constituents in 50 samples of surface water and 12 samples of ground water are also given in table 5. The mean values for ground water indicated concentrations for antimony, boron, chromium, copper, gallium, germanium, lithium, lead, manganese, strontium and zinc are larger than the mean values for surface waters. Although zinc was high, it is normally higher in the Saginaw Formation at other places than in these wells. Concentrations of the other trace metals listed above were significantly higher than those for ground water from the Saginaw Formation in other areas (Cummings, 1980). Mean concentrations of trace metals in surface

Table 4.--Trace metals in coal and in water from streams and wells
(Results in milligrams per liter)

Trace metal	Coal, arithmetic mean of 101 samples from Ohio (Zubovic, 1976)	Coal, geometric mean of 659 samples from eastern U.S. (Zubovic, 1976)	Coal, arithmetic mean of three samples from Michigan (Sorenson, 1981)	Ground water, arithmetic mean of 10 samples from Saginaw Formation (Cummings, 1980)	Surface water, arithmetic mean of 50 samples	Ground water from Saginaw Formation, arithmetic mean of 12 samples
Antimony	0.79	0.73	4.5	--	0.037	0.167
Barium	75	48	267	.10	.089	.108
Beryllium	2.2	1.9	80	.005	.002	.003
Boron	54	14	2,500	.37	.097	3.3
Cadmium	.14	.07	1.5	.000	.0004	.001
Chromium	20	14	150	.018	.011	.028
Cobalt	6.0	6.2	250	.008	.0008	.003
Copper	15	15	315	.004	.005	.040
Gallium	6.0	4.8	--	<.01	.034	.16
Germanium	4.3	1.1	633	<.02	.110	.68
Lead	9.3	7.0	610	.014	.004	.019
Lithium	31	15	60	.030	.010	.264
Manganese	36	14	--	.18	.075	1.06
Mercury	.23	.12	.13	.0004	.0001	.0003
Molybdenum	3.1	1.5	38	.006	.002	.006
Nickel	13	12	1,070	.014	.005	.016
Silver	.05	.03	--	.00	.01	.00
Strontium	81	65	167	1.6	.270	32
Vanadium	21	16	200	.02	.010	.031
Zinc	32	14	471	.72	.022	.432
Zirconium	22	13	133	.03	<.005	.007

waters compare favorably with those from shallow ground water. These trace metals could possibly be used to differentiate between shallow ground water, deep ground water and surface water in Saginaw County.

From this study it seems that mineralized ground water in coal-bearing beds in Saginaw County has had little or no effect on the quality of surface water flowing through the area. If, however, the saline waters in the coal-bearing rocks were pumped to the surface to be used for other purposes, there could be a significant increase in the amounts of some compounds in the streams, Concentrations of arsenic, manganese, iron, silver, dissolved solids, sodium, chloride, and phenol are high enough that ground water from coal-bearing beds and especially from abandoned mine drifts are not suitable for domestic or public supply use (U.S. Environmental Protection Agency, 1976). The water could possibly be used to grow selected salt and heavy metal tolerant crops, however.

The ranges and mean concentrations of several constituents in water from streams is compared, in table 5, to concentrations in ground water. Saline water from wells has higher maximum values than does water from streams. Data suggests that turbidity, strontium, manganese, iron, boron, calcium, chloride, magnesium, sulfate, sodium, and phenol are likely to be higher in ground water by several orders of magnitude.

Table 5.--Comparison of ground-water and surface-water quality

Parameter	Surface Water			Ground Water		
	Minimim conc.	Maximum conc.	Mean conc.	Minimim conc.	Maximum conc.	Mean conc.
Specific conductance (umhos at 25°C)	430	950	695	4,390	43,200	24,320
Turbidity (NTU)	0.55	55.0	15	16	180	90.5
Phenol (mg/L)	0	5	1.6	0	100	43
Cyanide (mg/L)	<.01	.01	.00	<.01	<.01	<.01
pH (units)	6.4	8.0	7.6	6.4	8.0	7.0
Water temperature (°C)	10	23	17.6	11.0	14.0	11.9
Sulfate (mg/L)	40	130	66	24	2,100	747
Calcium (mg/L)	60	110	85	65	1,400	423
Magnesium (mg/L)	14	35	25	33	270	133
Sodium (mg/L)	5.7	42	18	720	9,800	5,760
Chloride (mg/L)	19	160	48	1,100	13,000	7,912
Fluoride (mg/L)	0.2	0.5	.25	<0.1	0.6	.18
Silica (mg/L)	0.7	14	6.3	0.3	9.1	3.4
Tot. NH_4 as N (mg/L)	.00	.34	.09	.95	9.2	3.5
Tot. ORGN as N (mg/L)	.61	1.7	1.0	.00	12	2.5
Tot. NO_2 + NO_3 as N (mg/L)	.07	22	4.5	<.01	.05	.02
Phos., ortho as P (mg/L)	.00	.11	.04	<.01	.06	.03
Phos., total as P (mg/L)	.04	1.2	.12	.02	.16	.05
Tot. organic carbon (mg/L)	4.1	22	11.7	<.6	16	4.3
Dis. organic carbon (mg/L)	3.4	21	11.5	<0.3	12	3.5
Susp. organic carbon (mg/L)	0.2	2.0	.8	0.3	3.5	.87
Aluminum (µg/L)	0	2,300	344	200	1,800	492
Antimony (µg/L)	<30	100	36	<30	300	167
Arsenic (µg/L)	1	3	2	0	5	2
Barium (µg/L)	<50	200	89	<50	300	108
Beryllium (µg/L)	0	20	2.4	0	10	3.3
Boron (µg/L)	10	150	97	1,400	6,500	3,330
Cadmium (µg/L)	0	1	.4	1	1	1
Chromium (µg/L)	<10	20	11	10	50	28
Cobalt (µg/L)	0	6	.8	1	12	3
Copper (µg/L)	1	9	4.8	5	110	40
Gallium (µg/L)	<30	100	34	<30	300	165
Germanium (µg/L)	50	300	116	100	1,000	680
Iron (µg/L)	260	3,500	1,250	2,100	120,000	45,230
Lead (µg/L)	0	11	3.5	1	52	19
Lithium (µg/L)	0	20	9.4	50	490	264
Manganese (µg/L)	10	180	75	130	2,400	1,060
Mercury (µg/L)	<0.1	0.3	.13	<0.1	0.6	.3
Molybdenum (µg/L)	0	4	2.2	0	13	6
Nickel (µg/L)	1	17	5.3	8	44	16
Selenium (µg/L)	0	3	.7	0	0	0
Silver (µg/L)	0	5	.1	0	0	0
Strontium (µg/L)	100	500	270	1,100	290,000	31,880
Tin (µg/L)	100	3,000	1,200	3,000	>10,000	>7,900
Titanium (µg/L)	<5	<5	<5	<5	30	9
Vanadium (µg/L)	<10	10	10	<10	100	31
Zinc (µg/L)	10	50	23	30	1,400	432
Zirconium (µg/L)	<5	<5	<5	<5	10	7

Concentrations of silica, organic nitrogen, nitrate plus nitrite, ortho phosphorus, total phosphorus, total organic carbon and dissolved organic carbon are affected by contact with bacteria and other micro-organisms, sunlight, and oxygen. All are higher in water from streams. Addition of fertilizers to the soil or overland flow of water from barnyards to the streams also can cause increases of these constituents. Ammonia nitrogen is higher in ground water due to anerobic conditions found underground (anaerobic simply means that oxygen and sunlight need not be present for bacterial growth). Aluminum, copper, chromium, gallium, germanium, lead, lithium, nickel, tin, titanium, vanadium, and zinc, are higher in ground water than in surface water (table 5).

CONCLUSIONS

Fifty samples of water from 17 stream sites and 12 samples of water from wells drilled into coal beds and abandoned mine drifts in the vicinity of St. Charles, Michigan, indicated that the quality of surface water is unaffected by ground water from coal-bearing beds. Mean dissolved solids concentrations in water in streams were 489 mg/L; whereas, mean concentrations in ground water from coal beds were 15,800 mg/L. The quality of water at sites downstream from the mining area was about the same as sites upstream from the mine areas.

Specific conductance, dissolved solids, sulfate, chloride, calcium, magnesium, sodium, turbidity, phenol, iron, lithium, tin, vanadium, boron, chloride, chromium, copper, gallium, germanium, manganese, and strontium are parameters that may be used to differentiate between ground water that is associated with coal beds in the Saginaw Formation, and surface water that is fed by ground water from shallow depths, by rainfall, and by surface runoff.

Most ground water in abandoned mines and coal-bearing beds is too saline to be used for domestic supplies or agriculture. If water is pumped for other purposes or to dewater the coal beds care should be taken in its disposal. If disposed of in streams in large quantities it could significantly increase the amount of boron, chloride, phenol, iron, manganese, strontium, tin, and other metals in the streams. Small amounts of saline water could be assimilated by the streams by dilution without any lasting effect on water quality.

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TABLES

Table 1.--Trace metal concentrations from semiquantitative analyses, Saginaw County, Michigan. (Analyses by U.S. Geological Survey. Results in milligrams per liter.)

Station number and name	Date	Silver (Ag)	Alum-inum (Al)	Boron (B)	Barium (Ba)	Beryl-lium (Be)	Bis-muth (Bi)	Cadmium (Cd)	Cobalt (Co)	Chro-mium (Cr)	Copper (Cu)	Gallium (Ga)	German-ium (Ge)
04145000 Shiawassee River near Fergus	Aug. 14, 1980	0.01	<0.05	0.07	0.07	<0.001	<1.0	0.003	<0.005	<0.05	0.05	<0.03	0.1
	May 29, 1981	.01	<.05	.07	.07	<.001	0	<.003	<.005	<.05	<.01	<.03	.1
04145808 Shiawassee River near Swan Creek	Aug. 12, 1980	.03	<.05	.07	.07	<.001	<1.0	.001	<.005	<.05	<.01	<.03	.1
	May 29, 1981	<.01	<.05	.10	.07	<.001	0	<.001	<.005	<.05	<.01	<.03	.1
04145500 Bad River near Brant	Aug. 13, 1980	<.01	<.05	.07	.05	<.001	<1.0	.003	<.005	<.05	.10	<.03	.3
	June 1, 1981	.01	.10	.05	.05	.001	0	.010	<.005	<.05	.03	.07	.1
04145600 Bad River at St. Charles	June 10, 1980	<.01	<.05	.07	.03	<.001	--	.010	<.005	<.05	.03	<.03	.05
	Aug. 13, 1980	.01	<.05	.07	.05	<.001	<1.0	.003	<.005	<.05	<.01	<.03	.3
	June 2, 1981	.01	.10	.05	.05	.001	0	.010	<.005	.05	.03	.10	.1
04145650 SF Bad River near Brant	Aug. 14, 1980	<.01	<.05	.05	.05	<.001	<1.0	.003	<.005	<.05	<.01	<.03	.1
	June 1, 1981	<.01	<.05	.10	.07	.001	0	<.001	<.005	<.05	<.01	<.03	.07
04145700 SF Bad River at St. Charles	June 10, 1980	<.01	<.05	.05	.05	<.001	--	.010	<.005	<.05	.03	<.03	.05
	Aug. 13, 1980	.01	<.05	.07	.05	<.001	<1.0	.003	<.005	<.05	<.01	<.03	.1
	June 2, 1981	.01	.10	.07	.05	.001	0	.010	.005	<.05	.03	.07	.1
04145655 Potatoe Creek near Brant	June 11, 1980	<.01	<.05	.05	.05	<.001	--	<.001	<.005	<.05	.01	<.03	.05
	Aug. 14, 1980	.03	<.05	.07	.05	<.001	<1.0	.003	<.005	<.05	<.01	<.03	.1
	June 1, 1981	.01	.30	.05	.05	.001	0	.010	.010	<.05	.03	.05	.1
04145730 Beaver Creek near Nelson	June 11, 1981	<.01	<.05	.05	.05	<.001	--	<.001	<.005	<.05	.03	<.03	.07
	Aug. 14, 1981	<.01	<.05	.07	.05	<.001	<1.0	.003	<.005	<.05	<.01	<.03	.3
	June 1, 1981	.03	.10	.07	.05	.001	0	.010	.005	.07	.03	.10	.1
04145790 Beaver Creek at St. Charles	June 10, 1980	<.01	<.05	.07	.05	.001	7.0	<.001	<.005	<.05	<.01	.03	.05
	Aug. 13, 1980	.01	<.05	.07	.05	<.001	<1.0	.003	<.005	<.05	<.01	<.03	.3
	June 2, 1981	.01	.10	.05	.05	.003	0	.010	.005	.07	.03	.10	.1
04145802 Pickerel Creek near Fergus	Aug. 14, 1980	<.01	<.05	.10	.07	<.001	<1.0	.003	<.005	<.05	.07	<.03	.3
	May 27, 1981	<.01	<.05	.10	.07	<.001	0	<.001	<.005	<.05	<.01	<.03	.1
04145803 Pickerel Creek near St. Charles	June 9, 1980	<.01	<.05	.07	.07	.001	--	.010	<.005	<.05	.01	<.03	.07
	Aug. 13, 1980	<.01	<.05	.07	.07	<.001	<1.0	.003	<.005	<.05	<.01	<.03	.3
	May 27, 1981	.01	.05	.07	.07	<.001	1.0	<.001	<.005	<.05	<.01	.03	.1
04145805 Wolf Creek near Nelson	June 10, 1980	<.01	<.05	.07	.05	<.001	--	<.001	<.005	<.05	<.01	.07	.05
	Aug. 12, 1980	.01	<.05	.07	.05	<.001	<1.0	.003	<.005	<.05	<.01	<.03	.1
	May 29, 1981	<.01	<.05	.07	.05	<.001	0	<.001	<.005	<.05	<.01	<.03	.1
04145806 Wolf Creek near St. Charles	June 12, 1980	<.01	<.05	.07	.03	<.001	--	<.001	<.005	<.05	.01	<.03	.05
	Aug. 13, 1980	.01	<.05	.07	.05	<.001	<1.0	.001	<.005	<.05	<.01	<.03	.1
	May 29, 1981	<.01	<.05	.07	.05	<.001	0	<.001	<.005	<.05	<.01	<.03	.1
04145810 Bear Creek near Fergus	June 9, 1980	<.01	.7	.07	.05	<.001	--	<.001	<.005	<.05	.03	<.03	.07
	Aug. 14, 1980	.01	<.05	.10	.07	<.001	<1.0	.003	<.005	<.05	<.01	<.03	.3
	June 1, 1981	<.01	<.05	.10	.10	<.001	0	<.001	<.005	<.05	<.01	<.03	.1
04145814 Swan Creek at Schoemaker Road	June 11, 1980	<.01	<.05	.07	.05	<.001	--	<.001	<.005	<.05	.03	<.03	.07
	Aug. 12, 1980	.03	.07	.10	.05	<.001	<1.0	.003	<.005	<.05	<.01	<.03	.3
	May 29, 1981	<.01	<.05	.07	.05	<.001	0	<.001	<.005	<.05	<.01	<.03	.1
04145816 Marsh Creek near Garfield	June 11, 1980	<.01	<.05	.07	.05	<.001	--	<.001	<.005	<.05	.01	<.03	.07
	Aug. 12, 1980	.03	.05	.07	.05	<.001	<1.0	.003	<.005	<.05	<.01	<.03	.1
	May 29, 1981	<.01	<.05	.07	.05	<.001	0	<.001	<.005	<.05	<.01	<.03	.1
04145818 Swan Creek near Garfield	Aug. 12, 1980	.01	<.05	.07	.05	<.001	<1.0	.001	<.005	<.05	<.01	<.03	.3
	May 28, 1981	<.01	<.05	.07	.07	.001	0	<.001	<.005	<.05	<.01	<.03	.1

Well	Location													
1	10N3E5BAB1	May 26, 1981	0.10	0.10	1.0	0.03	0.007	0	0.03	0.10	0.03	0.07	0.30	0.7
2	10N3E5DDB1	May 27, 1981	.05	.07	1.0	.01	.001	0	.00	.03	<.05	.01	.07	.3
3	10N3E9CAD1	May 27, 1981	.30	.30	3.0	.07	.010	0	.03	.70	.07	.05	.30	1.0
4	10N3E10CDB1	May 27, 1981	.10	.10	3.0	.05	.007	0	.00	.70	.07	.03	.30	1.0
5	11N2E36BBA1	May 26, 1981	.05	.10	5.0	.03	.003	0	.01	.01	.01	.05	.10	.1
6	11N3E20BCA1	May 28, 1981	<.01	<.05	3.0	.03	.001	0	<.001	<.005	<.05	<.01	<.03	.3
7	11N3E21BBB1	May 28, 1981	.05	.10	5.0	.05	.005	0	.01	.30	<.05	.01	.10	1.0
8	11N3E22CBD1	May 28, 1981	.05	.10	7.0	.05	.005	0	.01	.03	<.05	.03	.05	1.0
9	11N3E31BDD1	May 26, 1981	.05	.10	3.0	.03	.003	0	.01	.05	<.05	.03	.10	.5
10	11N3E33BCC1	May 26, 1981	.10	.10	3.0	.10	.005	0	.03	.05	.10	.05	.30	.7
11	10N3E4ADA1	May 27, 1981	.10	.30	1.0	.30	.010	0	.03	.70	.10	.10	.30	1.0
12	10N3E17BDB1	May 27, 1981	.03	.07	3.0	.05	.003	0	.007	.50	<.05	<.01	<.03	.5

Table 1.--Semiquantitative analyses of surface and ground waters, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey. Results in milligrams per liter.)

Station number and name	Date	Lithium (Li)	Molybdenum (Mo)	Nickel (Ni)	Lead (Pb)	Antimony (Sb)	Tin (Sn)	Strontium (Sr)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)	Iron (Fe)	Manganese (Mn)
04145000 Shiawassee River near Fergus	Aug. 14, 1980	<0.005	<0.01	<0.05	<0.03	<0.03	0.1	0.3	<0.005	<0.01	0.01	<0.005	0.01	0.007
	May 29, 1981	.01	<.01	<.05	<.03	<.03	3.0	.3	<.005	<.01	.01	<.005	.01	.05
04145808 Shiawassee River near Swan Creek	Aug. 12, 1980	<.005	<.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.01	<.005	.03	.03
	May 29, 1981	.01	<.01	<.05	<.03	<.03	3.0	.3	<.005	<.01	.007	<.005	.01	.05
04145500 Bad River near Brant	Aug. 13, 1980	<.005	.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.01	<.005	.03	.03
	June 1, 1981	.01	.05	<.05	.07	.10	3.0	.3	<.005	<.01	.01	<.005	.01	.01
04145600 Bad River at St. Charles	June 10, 1980	<.005	.05	<.05	<.03	.03	1.0	.1	<.005	<.01	.01	<.005	.03	.007
	Aug. 13, 1980	<.005	<.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.01	<.005	.01	.03
	June 2, 1981	.01	.05	.05	.07	.10	3.0	.3	<.005	.01	.01	<.005	.01	.03
04145650 SF Bad River near Brant	Aug. 14, 1980	<.005	<.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.01	<.005	.10	.05
	June 1, 1981	.01	<.01	<.05	<.03	<.03	3.0	.3	<.005	<.01	.007	<.005	.05	.10
04145700 SF Bad River at St. Charles	June 10, 1980	<.005	.05	<.05	<.03	<.03	1.0	.1	<.005	<.01	.01	<.005	.10	.01
	Aug. 13, 1980	<.005	.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.007	<.005	.10	.03
	June 2, 1981	.01	.05	<.05	.07	.10	1.0	.3	<.005	<.01	.01	<.005	.05	.10
04145655 Potatoe Creek near Brant	June 11, 1980	<.005	<.01	<.05	<.03	<.03	1.0	.3	<.005	.01	.01	<.005	.30	.03
	Aug. 14, 1980	<.005	<.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.03	<.005	.10	.05
	June 1, 1981	.01	.05	<.05	.07	.10	1.0	.3	<.005	<.01	.01	<.005	.70	.10
04145730 Beaver Creek near Nelson	June 11, 1981	<.005	<.01	<.05	<.03	<.03	1.0	.1	<.005	.01	.01	<.005	.01	.005
	Aug. 14, 1981	<.005	<.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.01	<.005	.01	.03
	June 1, 1981	.01	.05	.07	.07	.10	3.0	.3	<.005	.01	.01	<.005	.01	.01
04145790 Beaver Creek at St. Charles	June 10, 1980	.01	.01	<.05	.3	.05	3.0	.1	<.005	<.01	.007	<.005	.05	.007
	Aug. 13, 1980	<.005	.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.01	<.005	.05	.05
	June 2, 1981	<.01	.05	.07	.10	.10	3.0	.3	<.005	.01	.03	<.005	.03	.07
04145802 Pickerel Creek near Fergus	Aug. 14, 1980	<.005	<.01	<.05	<.03	<.03	.1	.5	<.005	<.01	.01	<.005	.03	.01
	May 27, 1981	.01	<.01	<.05	<.03	<.03	3.0	.5	<.005	<.01	.01	<.005	.03	.03
04145803 Pickerel Creek near St. Charles	June 9, 1980	.007	.03	<.05	<.03	.07	1.0	.3	<.005	.01	.03	<.005	.01	.01
	Aug. 13, 1980	<.005	<.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.01	<.005	.05	.01
	May 27, 1981	.01	<.01	<.05	<.03	<.03	3.0	.3	<.005	.01	.01	<.005	.07	.03
04145805 Wolf Creek near Nelson	June 10, 1980	.01	.03	<.05	.30	.05	3.0	.3	<.005	<.01	.007	<.005	.01	.03
	Aug. 12, 1980	<.005	.01	<.05	<.03	<.03	.1	.5	<.005	<.01	.01	<.005	.03	.01
	May 29, 1981	.01	<.01	<.05	<.03	<.03	3.0	.5	<.005	<.01	.01	<.005	.03	.05
04145806 Wolf Creek near St. Charles	June 12, 1980	<.005	<.01	<.05	<.03	<.03	1.0	.3	<.005	.01	.01	<.005	.3	.03
	Aug. 13, 1980	<.005	<.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.01	<.005	.1	.10
	May 29, 1981	.01	<.01	<.05	<.03	<.03	1.0	.3	<.005	<.01	.01	<.005	.3	.10
04145810 Bear Creek near Fergus	June 9, 1980	<.005	<.01	<.05	<.03	<.03	1.0	.3	<.005	.01	.03	<.005	.7	.03
	Aug. 14, 1980	<.005	.01	<.05	<.03	<.03	.3	.3	<.005	<.01	.01	<.005	.03	.05
	June 1, 1981	.01	<.01	<.05	<.03	<.03	3.0	.5	<.005	<.01	.01	<.005	.03	.10
04145814 Swan Creek at Schoemaker Road	June 11, 1980	<.005	<.01	<.05	<.03	<.03	1.0	.3	<.005	.01	.03	<.005	.03	.03
	Aug. 12, 1980	<.005	<.01	<.05	<.03	<.03	.1	.5	<.005	<.01	.01	<.005	.07	.10
	May 29, 1981	.01	<.01	<.05	<.03	<.03	3.0	.5	<.005	<.01	.01	<.005	.01	.07
04145816 Marsh Creek near Garfield	June 11, 1980	<.005	<.01	<.05	<.03	<.03	1.0	.3	<.005	<.01	.03	<.005	.07	.03
	Aug. 12, 1980	<.005	.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.007	<.005	.10	.03
	May 29, 1981	.01	<.01	<.05	<.03	<.03	3.0	.3	<.005	<.01	.01	<.005	.05	.05
04145818 Swan Creek near Garfield	Aug. 12, 1980	.007	<.01	<.05	<.03	<.03	.1	.3	<.005	<.01	.01	<.005	.01	.10
	May 28, 1981	.01	<.01	<.05	<.03	<.03	3.0	.5	<.005	<.01	.01	<.005	.01	.07
Well Location														
1 10N3E5BAB1	May 26, 1981	0.10	0.10	0.10	0.10	0.30	>10.0	>10.0	0.01	0.05	0.30	0.01	>10.0	1.0
2 10N3E5DDB1	May 27, 1981	.05	.03	.10	.03	.07	3.0	1.1	<.005	.01	.05	.005	3.0	.30
3 10N3E9CAD1	May 27, 1981	.30	.10	.10	.10	.30	>10.0	>10.0	.03	.03	.30	.01	>10.0	1.0
4 10N3E10CDB1	May 27, 1981	.30	.10	.70	.10	.30	>10.0	>10.0	.01	.01	.30	.01	>10.0	.70
5 11N2E36BBA1	May 26, 1981	.10	.05	.10	.10	.10	3.0	1.0	<.005	.01	.03	.005	.50	.10
6 11N3E20BCA1	May 28, 1981	.10	<.01	<.05	<.03	<.03	5.0	1.0	<.005	<.01	.05	<.005	.01	.30
7 11N3E21BBB1	May 28, 1981	.50	.07	<.05	.03	.10	>10.0	5.0	<.005	.03	.50	<.005	>10.0	.50
8 11N3E22CBD1	May 28, 1981	.50	.10	<.05	.03	.30	>10.0	>10.0	.007	.03	.10	<.005	3.0	.30
9 11N3E31BDD1	May 26, 1981	.10	.05	.10	.05	.10	7.0	3.0	.005	.03	.30	.007	3.0	.30
10 11N3E33BCC1	May 26, 1981	.10	.10	.30	.10	.30	>10.0	>10.0	.01	.05	.10	.01	1.0	1.0
11 10N3E4ADA1	May 27, 1981	.30	.10	.30	.10	<.03	>10.0	>10.0	.01	.10	.30	.01	>10.0	3.0
12 10N3E17BDB1	May 27, 1981	.10	.03	<.05	<.03	.07	7.0	7.0	<.005	.01	.10	<.005	>10.0	.30

Table 2.--Chemical analyses of ground water, Saginaw County, Michigan (Analyses by U.S. Geological Survey)

Well	Location	Date	Time	Sampling depth (ft)	Temperature (°C)	Turbidity (NTU)	Color (platinum-cobalt units)	Specific conductance (micromhos)	pH field (units)	pH lab (units)	Nitrogen, total (mg/L as N)	Nitrogen, organic total (mg/L as N)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, nitrite total (mg/L as N)
1	10N3E5BAB1	May 26, 1981	1400	--	14.0	50	0	35,200	6.7	5.1	21	12	9.20	0.01
2	10N3E5DDB1	May 27	0900	90	11.0	100	0	6,950	7.4	7.6	3.2	1.9	1.30	<.01
3	10N3E9CAD1	May 27	1240	90	11.0	100	0	36,800	6.8	4.7	7.9	4.2	3.70	.01
4	10N3E10CDB1	May 27	1345	90	12.0	180	0	38,500	7.1	5.1	13	6.3	6.70	.02
5	11N2E36BBA1	May 26	1615	90	11.0	35	0	7,180	7.1	7.9	.90	.00	.95	.01
6	11N3E20BCA1	May 28	1200	90	13.0	65	1	7,920	8.0	8.0	1.7	.00	1.60	<.01
7	11N3E21BBB1	May 28	1430	95	14.0	110	1	28,200	7.2	5.9	3.5	1.1	2.30	.01
8	11N3E22CBD1	May 28	1100	55	11.0	75	2	32,000	6.4	6.6	1.7	.20	1.50	.01
9	11N3E31BDD1	May 26	1700	115	11.0	95	0	19,500	7.0	7.5	4.0	3.0	.96	<.01
10	11N3E33BCC1	May 26	1145	50	11.0	16	0	32,000	6.6	7.2	3.7	.90	2.80	<.01
11	10N3E4ADA1	May 27	1030	90	11.5	110	0	43,200	6.8	4.3	6.5	.00	8.90	.01
12	10N3E17BDB1	May 27	1700	90	12.5	150	4	4,390	7.3	7.4	--	.00	1.50	<.01

Well	Nitrogen, nitrate total (mg/L as N)	Nitrogen, ammonia + organic total (mg/L as N)	Nitrogen, NO_2+ NO_3 total (mg/L as N)	Phosphorus, total (mg/L as P)	Carbon, organic dissolved (mg/L as C)	Carbon, organic suspended total (mg/L as C)	Cyanide, total (mg/L as Cn)	Hardness (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Sodium adsorption ratio	Sodium (percent)
1	0.01	21.0	0.02	0.03	4.0	0.8	<.01	1,800	450	160	9,800	101	92
2	--	3.20	.01	.04	<.3	.4	<.01	350	72	42	1,600	37	90
3	.01	7.90	.02	.02	<.3	.3	<.01	4,200	1400	160	8,200	55	81
4	.00	13.0	.02	.02	<.3	.5	<.01	2,100	560	160	7,900	76	89
5	.01	.88	.02	.03	--	.3	<.01	330	78	33	3,000	72	95
6	--	1.60	.05	.06	9.0	2.6	<.01	340	65	44	1,900	45	92
7	.04	3.40	.05	.08	12	3.5	<.01	1,200	200	170	7,500	94	93
8	.00	1.70	.01	.16	1.0	.4	<.01	2,700	680	250	6,800	57	84
9	--	4.00	.01	.07	<.3	.5	<.01	680	150	74	4,600	77	93
10	--	3.70	.01	<.01	12	.3	<.01	2,400	520	270	8,600	76	88
11	.02	6.50	.03	.03	<.3	.5	<.01	2,400	680	160	8,500	76	88
12	--	1.40	<.01	.04	1.9	.3	<.01	860	220	76	720	11	64

Well	Potassium, dissolved (mg/L as K)	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Arsenic, total (µg/L as As)	Barium, total recoverable (µg/L as Ba)	Beryllium, total recoverable (µg/L as Be)	Boron, total recoverable (µg/L) as B)	Cadmium, total recoverable (µg/L as Cd)	Chromium, total recoverable (µg/L as Cr)	Cobalt, total recoverable (µg/L as Co)	Copper, total recoverable (µg/L as Cu)	Iron, suspended recoverable (µg/L as Fe)
1	89	13,000	160	<0.1	.3	1	300	10	1,400	1	50	4	16	22,000
2	21	2,400	360	.2	1.1	5	<50	0	1,700	1	10	2	39	29,000
3	83	13,000	1,100	<.1	.8	2	100	0	3,600	1	30	1	12	0
4	65	9,140	410	.1	2.5	1	100	10	3,800	1	20	1	20	42,000
5	35	2,100	610	.2	9.1	3	100	0	4,900	1	30	3	6	2,600
6	22	2,500	260	.6	.5	2	<50	0	2,300	1	10	1	77	20,000
7	72	9,800	1,700	<.1	3.5	2	<50	10	5,900	1	50	1	110	29,000
8	73	10,000	2,100	<.1	9.1	2	<50	0	6,500	1	20	3	7	5,400
9	53	5,900	730	.3	2.4	4	100	0	3,100	1	20	3	64	65,000
10	83	11,000	920	<.1	7.3	1	100	10	2,600	1	40	12	5	200
11	82	16,000	24	<.1	.8	1	200	0	2,100	1	50	1	110	3,000
12	64	1,100	590	.2	7.0	0	100	0	2,100	1	10	1	13	6,000

Table 2.--Chemical analyses of ground water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Well	Iron, total recoverable (µg/L as Fe)	Iron, dissolved (µg/L as Fe)	Lead, total recoverable (µg/L as Pb)	Manganese, Suspended recov. (µg/L as Mn)	Manganese, total recoverable (µg/L as Mn)	Manganese, dissolved (µg/L as Mn)	Molybdenum, total recoverable (µg/L as Mo)	Nickel, total recoverable (µg/L as Ni)	Silver, total recoverable (µg/L as Ag)	Strontium, total recoverable (µg/L as Sr)	Zinc, total recoverable (µg/L as Zn)	Aluminum, total recoverable (µg/L as Al)	Lithium, total recoverable (µg/L as Li)	Selenium, total (µg/L as Se)	Phenols (µg/L)
1	38000	16000	18	200	2100	1900	7	8	0	13000	640	300	190	0	75
2	32000	3000	18	140	400	260	7	13	0	1100	150	300	50	0	80
3	61000	61000	17	100	1300	1200	11	14	0	290000	250	400	400	0	21
4	120000	78000	17	60	960	900	4	9	0	15000	430	300	480	0	20
5	3200	620	3	30	130	100	4	30	0	1200	30	500	130	0	0
6	20000	20	36	160	380	220	13	10	0	1200	760	400	150	0	100
7	69000	40000	37	360	780	420	9	17	0	4300	1400	300	490	0	83
8	7500	2100	4	200	1800	1600	0	14	0	7600	50	1800	420	0	3
9	68000	3500	52	590	820	230	13	13	0	2700	990	500	200	0	24
10	2100	1900	1	100	1400	1300	3	44	0	13000	40	200	210	0	0
11	76000	73000	23	100	2400	2300	5	9	0	28000	260	700	310	0	78
12	46000	40000	6	70	290	220	1	9	0	5400	190	200	140	0	35

Well	Solids, residue at 180 °C dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Solids, dissolved (tons per ac-ft)	Phosphorus, ortho total (mg/L as P)	Phosphorus, total (mg/L as PO_4)	Nitrogen, total (mg/L as NO_3)	Mercury, total recoverable (µg/L as Hg)	Potassium-40, dissolved (pCi/L)	Specific conductance, lab (µmhos)	Alkalinity, lab (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)
1	22500	23900	--	0.04	0.09	93	0.4	66	35500	19	1800
2	13100	4580	--	.02	.12	14	.3	16	7170	130	220
3	25600	24400	--	.05	.06	35	.3	62	36500	0	4200
4	15800	19900	--	.00	.06	58	.2	48	38200	15	2000
5	5210	6740	7.09	.05	.09	4.0	<.1	26	8690	1450	0
6	4780	4860	--	<.01	.18	7.3	<.1	16	8200	120	220
7	18600	19700	--	.06	.25	15	.2	54	28000	280	920
8	22100	15000	--	.04	.49	7.6	<.1	54	32800	1420	1300
9	10300	11700	--	.02	.21	18	.5	40	17000	230	450
10	21700	21900	--	.03	.03	16	.6	62	33100	880	1500
11	27700	29000	--	.06	.09	29	.4	61	42100	0	2400
12	3040	2950	--	<.01	.12	--	<.1	15	4530	300	560

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan (Analyses by U.S. Geological Survey)

Date	Time	Temperature (°C)	Streamflow, Instantaneous (ft³/s)	Turbidity (NTU)	Color (platinum-cobalt units)	Specific conductance (µmho)	Oxygen, dissolved (mg/L)	Oxygen dissolved (% saturation)	pH field (unit)	pH lab (unit)	Alkalinity, field (mg/L as $CaCO_3$)	Nitrogen, total (mg/L as N)	Nitrogen, organic total (mg/L as N)	Nitrogen, ammonia total (mg/L as N)
04145000 Shiawassee River near Fergus (lat 43°15'17", long 084°06'20")														
June 9, 1980	1000	17.5	672	0.70	35	590	8.2	87	7.5	--	210	3.9	1.6	0.11
Aug. 14,	1400	23.0	161	4.2	22	700	8.7	102	7.4	--	230	2.2	1.4	.10
May 29, 1981	1415	17.5	295	6.7	20	708	8.4	89	8.2	8.5	--	1.7	.84	.07
04145500 Bad River near Brant (lat 43°17'48", long 084°13'46")														
June 11, 1980	1400	12.0	205	6.9	20	700	8.2	80	7.8	--	200	14	0.87	0.05
Aug. 13	1820	19.5	15	15	20	810	8.3	91	7.3	--	250	3.6	.77	.04
June 1, 1981	1600	20.0	15	1.2	20	744	10.4	114	8.1	8.2	--	5.3	.84	.03
04145600 Bad River at St. Charles (lat 43°18'08", long 084°08'38")														
June 10, 1980	1300	11.5	550	0.55	40	520	8.0	79	7.5	--	135	14	1.3	0.06
Aug. 13	1130	20.0	18	40	25	713	6.5	66	7.4	--	260	3.2	.62	.03
June 2, 1981	0930	16.5	15	18	20	744	7.3	75	8.0	8.1	--	6.0	1.1	.07
04145650 South Fork Bad River near Brant (lat 43°15'33", long 084°12'32")														
June 11, 1980	1000	11.5	26	4.5	50	640	8.8	86	7.7	--	200	3.7	0.71	0.02
Aug. 14	1200	19.5	22	9.8	60	710	6.5	71	7.4	--	190	2.9	.91	.02
June 1, 1981	1230	17.0	11	15	42	666	7.8	81	7.9	8.3	--	2.6	1.0	.09
04145655 Potatoe Creek near Brant (lat 43°15'42", long 084°12'33")														
June 11, 1980	1130	11.0	36	4.0	80	430	8.6	83	7.7	--	130	3.9	1.3	0.04
Aug. 14	1030	19.0	19	10	55	648	7.0	76	7.0	--	220	2.8	1.1	.03
June 1, 1981	1345	17.5	4.5	9.1	70	484	7.7	81	7.8	8.0	--	2.5	1.1	.06
04145700 South Fork Bad River at St. Charles (lat 43°17'54", long 084°08'32")														
June 10, 1980	0900	10.0	139	1.8	75	455	6.4	58	7.8	--	130	4.5	1.4	0.06
Aug. 13	0910	19.0	77	22	55	616	6.0	65	7.1	--	190	2.8	1.1	.04
June 2, 1981	1030	17.0	17	24	45	559	6.7	70	7.6	8.3	--	2.6	1.1	.10
04145730 Beaver Creek near Nelson (lat 43°20'13", long 084°13'44")														
June 11, 1980	1500	13.0	97	4.0	15	740	10.0	102	7.8	--	200	18	0.82	0.02
Aug. 14	0900	19.0	4.4	15	15	820	6.4	69	7.5	--	240	2.6	.79	.10
June 1, 1981	1715	20.0	8.6	2.4	13	777	10.8	121	8.0	8.1	--	5.9	1.2	.05
04145790 Beaver Creek at St. Charles (lat 43°18'38", long 084°08'32")														
June 10, 1980	1600	13.0	299	4.0	30	600	7.6	81	7.8	--	150	23	1.3	0.05
Aug. 13	1700	20.0	3.0	15	26	810	3.6	40	6.8	--	260	1.4	.73	.08
June 2, 1981	0830	16.0	--	3.3	22	756	5.0	51	7.7	8.0	--	5.8	.99	.11

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Date	Nitrogen, nitrite total (mg/L as N)	Nitrogen, nitrate total (mg/L as N)	Nitrogen, ammonia + organic total (mg/L as N)	Nitrogen, NO_2+NO_3 total (mg/L as N)	Phosphate, total (mg/L as PO_4)	Phosphorus, total (mg/L as P)	Carbon, organic dissolved (mg/L as C)	Carbon, organic suspended total (mg/L as C)	Cyanide, total (mg/L as Cn)	Hardness (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)
04145000 Shiawassee River near Fergus (lat 43°15'17", long 084°06'20")													
June 9, 1980	0.04	2.2	1.70	2.20	0.21	0.22	11	--	0.00	250	44	66	21
Aug. 14	.03	.71	1.50	.74	.28	.18	9.7	--	.00	300	69	77	26
May 29, 1981	.04	.72	.91	.76	--	.07	9.0	.4	<.01	300	--	75	27
04145500 Bad River near Brant (lat 43°17'48", long 084°13'46")													
June 11, 1980	0.09	13	0.92	13.0	0.18	0.13	9.2	0.4	0.01	320	120	88	24
Aug. 13	.02	2.8	.81	2.80	.18	.10	11	.8	.01	370	150	102	27
June 1, 1981	.04	4.4	.87	4.40	--	.06	6.1	.7	<.01	370	--	100	30
04145600 Bad River at St. Charles (lat 43°18'08", long 084°08'38")													
June 10, 1980	0.12	13	1.40	13.0	0.15	0.18	9.8	1.8	0.00	250	170	70	17
Aug. 13	.02	2.5	.65	2.50	.09	.24	10	1.1	.01	380	140	107	28
June 2, 1981	.03	4.8	1.20	4.80	--	.07	6.5	1.5	<.01	370	--	100	30
04145650 South Fork Bad River near Brant (lat 43°15'33", long 084°12'32")													
June 11, 1980	0.03	3.0	0.73	3.00	0.03	0.06	16	0.4	0.01	290	93	81	22
Aug. 14	.02	2.0	.93	2.00	.00	.06	--	.5	.01	290	100	83	21
June 1, 1981	.04	1.5	1.10	1.50	--	.07	10	1.2	<.01	330	--	87	27
04145655 Potatoe Creek near Brant (lat 43°15'42", long 084°12'33")													
June 11, 1980	0.02	2.6	1.30	2.60	0.03	0.05	19	0.7	0.01	210	77	60	14
Aug. 14	.03	1.7	1.10	1.70	.03	.08	16	.5	.00	320	100	88	25
June 1, 1981	.03	1.3	1.20	1.30	--	.08	15	1.2	<.01	250	--	70	19
04145700 South Fork Bad River at St. Charles (lat 43°17'54", long 084°08'32")													
June 10, 1980	0.04	3.0	1.50	3.00	0.00	0.08	--	1.3	0.00	220	36	61	16
Aug. 13	.03	1.7	1.10	1.70	.06	.10	21	.8	.00	280	90	76	22
June 2, 1981	.04	1.4	1.20	1.40	--	.08	12	1.0	.02	300	--	70	30
04145730 Beaver Creek near Nelson (lat 43°20'13", long 084°13'44")													
June 11, 1980	0.08	17	0.84	17.0	0.15	0.06	10	0.2	0.01	350	150	100	25
Aug. 14	.02	1.7	.89	1.70	.06	.07	14	.7	.01	370	130	99	31
June 1, 1981	.06	4.6	1.20	4.70	--	.05	5.9	.9	<.01	370	--	100	30
04145790 Beaver Creek at St. Charles (lat 43°18'38", long 084°08'32")													
June 10, 1980	0.12	22	1.30	22.0	0.09	0.10	8.7	--	0.01	260	110	72	19
Aug. 13	.03	.58	.81	.61	.18	.09	11	.3	.01	370	110	100	30
June 2, 1981	.11	4.6	1.10	4.70	--	.08	6.9	.8	<.01	370	--	100	30

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Date	Sodium, dissolved (mg/L as Na)	Sodium (adsorption ratio)	Sodium (percent)	Potassium, dissolved (mg/L as K)	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Arsenic, total (µg/L as As)	Barium, total recoverable (µg/L as Ba)	Beryllium, total recoverable (µg/L as Be)	Boron, total recoverable (µg/L) as B)	Cadmium, total recoverable (µg/L as Cd)
04145802 Pickerel Creek near Fergus (lat 43°16'08", long 084°07'44")													
June 9, 1980	17	0.4	11	2.9	40	66	0.3	6.8	1	100	0	100	0
Aug. 14	19	.4	10	3.9	43	68	.3	11	3	100	0	130	0
May 27, 1981	22	.5	13	3.5	40	60	.3	5.3	1	100	0	130	1
04145803 Pickerel Creek near St. Charles (lat 43°17'36", long 084°06'39")													
June 9, 1980	30	0.8	18	3.2	52	80	0.3	7.0	2	100	0	120	0
Aug. 13	19	.5	11	4.2	47	60	.3	11	2	100	0	120	0
May 27, 1981	33	.8	19	3.7	160	61	.3	2.6	1	100	0	100	1
04145805 Wolf Creek near Nelson (lat 43°20'11, long 084°11'22")													
June 10, 1980	17	0.4	10	3.0	43	130	0.3	6.7	1	100	0	80	0
Aug. 12	23	.6	15	3.3	40	100	.3	4.3	1	100	0	110	0
May 29, 1981	19	.5	13	2.9	28	100	.3	1.6	1	100	10	70	1
04145806 Wolf Creek near St. Charles (lat 43°18'57", long 084°06'45")													
June 12, 1980	23	0.7	19	2.7	47	45	0.2	7.3	1	<50	0	110	0
Aug. 13	39	.9	19	3.7	93	44	.3	14	1	<50	0	140	0
May 29, 1981	26	.6	15	3.6	61	57	.2	2.4	1	100	10	100	1
04145808 Shiawassee River near Swan Creek (lat 43°20'17", long 084°04'20")													
Aug. 12, 1980	23	0.6	15	3.6	46	49	0.2	9.6	3	--	0	130	1
May 29, 1981	32	.8	18	2.9	44	48	.2	1.7	2	100	20	150	1
04145810 Bear Creek near Fergus (lat 43°15'19", long 084°05'18")													
June 9, 1980	12	0.3	8	3.4	45	70	0.2	7.8	1	50	0	80	0
Aug. 14	23	.5	11	4.8	60	62	.3	9.8	2	50	0	130	0
June 1, 1981	23	.5	12	3.6	54	90	.2	2.4	2	100	10	110	1
04145814 Swan Creek at Schomaker Road near Garfield (lat 43°24'03", long 084°05'57")													
June 11, 1980	16	0.4	9	3.1	56	83	0.3	5.0	1	<50	0	50	0
Aug. 12	42	1.0	20	4.9	90	74	.3	7.7	1	200	0	140	0
May 29, 1981	25	.6	13	3.5	59	77	.2	1.5	2	100	0	80	1
04145816 Marsh Creek near Garfield (lat 43°21'56", long 084°10'22")													
June 11, 1980	9.7	0.2	7	3.0	31	76	0.2	5.4	1	<50	0	50	0
Aug. 12	15	.4	9	5.9	34	65	.3	13	1	<50	0	130	0
May 29, 1981	15	.4	9	4.5	30	72	.2	2.5	1	100	0	60	1
04145818 Swan Creek near Garfield (lat 43°21'18", long 084°04'20")													
June 12, 1980	15	0.4	9	3.0	45	64	0.2	5.8	2	100	0	100	0
Aug. 12	23	.6	13	3.9	56	62	.3	9.1	3	--	0	130	1
May 28, 1981	22	.5	12	3.3	54	73	.2	2.8	2	100	10	80	1

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Date	Chromium, total recoverable (µg/L as Cr)	Cobalt, total recoverable (µg/L) as Co)	Copper, total recoverable (µg/L as Cu)	Iron, suspended recoverable (µg/L as Fe)	Iron, total recoverable (µg/L as Fe)	Iron, dissolved (µg/L as Fe)	Lead, total recoverable (µg/L as Pb)	Manganese, suspended recov. (µg/L as Mn)	Manganese, total recoverable (µg/L as Mn)	Manganese, dissolved (µg/L as Mn)	Molybdenum, total recoverable (µg/L as Mo)	Nickel, total recoverable (µg/L as Ni)	Silver, total recoverable (µg/L as Ag)	Strontium, total recoverable (µg/L as Sr)
04145000 Shiawassee River near Fergus (lat 43°15'17", long 084°06'20")														
June 9, 1980	10	0	7	3000	3000	30	11	180	180	1	3	4	0	150
Aug. 14	10	0	3	1200	1200	0	6	80	90	10	4	1	0	220
May 29, 1981	10	4	5	870	880	10	6	50	60	10	1	7	0	200
04145500 Bad River near Brant (lat 43°17'48", long 084°13'46")														
June 11, 1980	10	0	5	800	1100	210	3	20	30	10	0	2	0	170
Aug. 13	<10	0	2	750	780	30	0	20	50	30	3	4	0	360
June 1, 1981	10	1	5	270	280	10	2	10	20	10	3	3	0	210
04145600 Bad River at St. Charles (lat 43°18'08", long 084°08'38")														
June 10, 1980	10	0	5	2700	2700	30	3	30	40	7	2	7	0	100
Aug. 13	20	0	4	2200	2200	30	2	0	10	30	3	4	0	320
June 2, 1981	10	1	5	1400	1400	10	4	30	60	30	4	8	0	220
04145650 South Fork Bad River near Brant (lat 43°15'33", long 084°12'32")														
June 11, 1980	10	1	5	1100	1200	100	9	30	70	40	1	2	0	240
Aug. 14	<10	0	4	650	770	120	3	30	80	50	2	5	0	330
June 1, 1981	10	6	5	1300	1300	50	4	30	130	100	4	6	0	300
04145655 Potatoe Creek near Brant (lat 43°15'42", long 084°12'33")														
June 11, 1980	10	0	4	390	620	230	3	10	40	30	0	1	0	200
Aug. 14	10	0	3	880	980	100	3	20	70	50	3	4	0	350
June 1, 1981	20	1	2	500	1200	700	3	30	130	100	3	8	0	220
04145700 South Fork Bad River at St. Charles (lat 43°17'54", long 084°08'32")														
June 10, 1980	<10	0	3	1100	1100	10	3	30	40	10	2	2	0	140
Aug. 13	<10	0	3	1200	1300	90	1	50	80	30	3	3	0	320
June 2, 1981	10	1	6	1700	1700	50	4	60	160	100	3	6	0	290
04145730 Beaver Creek near Nelson (lat 43°20'13", long 084°13'44")														
June 11, 1980	10	0	4	340	350	10	2	10	20	6	0	1	0	180
Aug. 14	10	0	3	640	670	30	0	30	50	20	2	4	0	280
June 1, 1981	10	1	7	480	490	10	3	10	20	10	3	7	5	180
04145790 Beaver Creek at St. Charles (lat 43°18'38", long 084°08'32")														
June 10, 1980	10	1	5	780	810	30	4	20	30	6	2	2	0	110
Aug. 13	<10	0	1	190	260	70	0	10	60	50	3	1	0	320
June 2, 1981	20	1	4	500	530	30	4	0	70	70	3	8	0	200

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Date	Zinc, total recoverable (µg/L as Zn)	Aluminum, total recoverable (µg/L as Al)	Lithium, total recoverable (µg/L as Li)	Selenium, total (µg/L as Se)	Phenols (µg/L)	Solids, residue at 180 °C, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Solids, dissolved (tons per day)	Solids, dissolved (tons per ac-ft)	Phosphorus, ortho total (mg/L as P)	Nitrogen, ammonia total (mg/L as NH_4)	Phosphorus, total (mg/L as PO_4)	Nitrogen, total (mg/L as NO_3)
04145000 Shiawassee River near Fergus (lat 43°15'17", long 084°06'20")													
June 9, 1980	40	250	10	0	1	--	311	564	0.42	0.07	0.13	0.67	17
Aug. 14	20	230	10	0	0	409	378	178	.56	.09	.12	.55	9.9
May 29, 1981	30	400	10	0	0	390	370	311	.53	.04	--	.21	7.4
04145500 Bad River near Brant (lat 43°17'48", long 084°13'46")													
June 11, 1980	10	10	0	1	0	--	354	196	0.48	0.06	0.06	0.40	62
Aug. 13	10	150	10	0	4	520	448	22.0	.71	.06	.05	.31	16
June 1, 1981	20	90	10	1	0	598	411	25.3	.81	.02	--	.18	23
04145600 Bad River at St. Charles (lat 43°18'08", long 084°08'38")													
June 10, 1980	20	0	10	1	0	415	263	616	0.56	0.05	0.07	0.55	64
Aug. 13	20	470	10	0	1	562	451	28.5	.76	.03	.04	.74	14
June 2, 1981	20	680	10	1	0	564	414	22.8	.77	.03	--	.21	27
04145650 South Fork Bad River near Brant (lat 43°15'33", long 084°12'32")													
June 11, 1980	10	40	0	1	0	--	349	24.9	0.47	0.01	0.02	0.18	17
Aug. 14	10	110	10	0	2	420	342	25.3	.57	.00	.02	.18	13
June 1, 1981	30	440	10	0	0	456	399	13.8	.62	.08	--	.21	12
04145655 Potatoe Creek near Brant (lat 43°15'42", long 084°12'33")													
June 11, 1980	10	0	0	1	0	--	239	23.7	0.33	0.01	0.05	0.15	17
Aug. 14	10	190	10	0	1	447	383	22.9	.61	.01	.04	.25	12
June 1, 1981	30	290	10	0	0	396	303	4.82	.54	.03	--	.25	11
04145700 South Fork Bad River at St. Charles (lat 43°17'54", long 084°08'32")													
June 10, 1980	40	40	10	1	2	321	223	120	0.44	0.00	0.07	0.25	20
Aug. 13	20	350	10	0	1	398	332	82.9	.54	.02	.05	.31	12
June 2, 1981	20	680	10	0	0	498	345	22.9	.68	.03	--	.25	12
04145730 Beaver Creek near Nelson (lat 43°20'13", long 084°13'44")													
June 11, 1980	10	20	10	2	0	--	373	98.5	0.51	0.05	0.02	0.18	79
Aug. 14	20	100	10	0	1	534	429	6.37	.73	.02	.12	.21	11
June 1, 1981	20	210	10	1	0	523	137	12.2	.71	<.01	--	.15	26
04145790 Beaver Creek at St. Charles (lat 43°18'38", long 084°08'32")													
June 10, 1980	20	600	10	1	1	--	276	223	0.38	0.03	0.06	0.31	100
Aug. 13	10	50	10	0	1	520	439	4.21	.71	.06	.10	.28	6.3
June 2, 1981	20	280	10	1	0	558	408	--	.76	.02	--	.25	26

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Date	Mercury, total recoverable (µg/L as Hg)	Uranium, dissolved, extraction (µg/L)	Potassium-40, dissolved (pCi/L)	Specific conductance, lab (µmho)	Alkalinity, Lab (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)
04145000 Shiawassee River near Fergus (lat 43°15'17", long 084°06'20")						
June 9, 1980	0.1	1.6	--	--	--	--
Aug. 14	<.1	1.1	--	--	--	--
May 29, 1981	<.1	--	2.0	646	250	48
04145500 Bad River near Brant (lat 43°17'48", long 084°13'46")						
June 11, 1980	0.2	1.8	--	--	--	--
Aug. 13	<.1	2.0	--	--	--	--
June 1, 1981	<.1	--	2.2	732	240	130
04145600 Bad River at St. Charles (lat 43°18'08", long 084°08'38")						
June 10, 1980	0.2	0.80	--	--	--	--
Aug. 13	.1	1.3	--	--	--	--
June 2, 1981	<.1	--	2.2	740	250	120
04145650 South Fork Bad River near Brant (lat 43°15'33", long 084°12'32")						
June 11, 1980	0.2	2.3	--	--	--	--
Aug. 14	.1	1.8	--	--	--	--
June 1, 1981	<.1	--	1.8	671	240	88
04145655 Potatoe Creek near Brant (lat 43°15'42", long 084°12'33")						
June 11, 1980	0.1	1.3	--	--	--	--
Aug. 14	.3	1.9	--	--	--	--
June 1, 1981	<.1	--	1.7	534	180	73
04145700 South Fork Bad River at St. Charles (lat 43°17'54", long 084°08'32")						
June 10, 1980	0.2	1.2	--	--	--	--
Aug. 13	.1	1.5	--	--	--	--
June 2, 1981	<.1	--	1.8	627	210	88
04145730 Beaver Creek near Nelson (lat 43°20'13", long 084°13'44")						
June 11, 1980	0.2	1.3	--	--	--	--
Aug. 14	.1	1.7	--	--	--	--
June 1, 1981	<.1	--	3.1	764	220	150
04145790 Beaver Creek at St. Charles (lat 43°18'38", long 084°08'32")						
June 10, 1980	0.2	0.90	--	--	--	--
Aug. 13	<.1	1.8	--	--	--	--
June 2, 1981	<.1	--	2.7	755	230	140

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Date	Time	Temperature (°C)	Streamflow, Instantaneous (ft³/s)	Turbidity (NTU)	Color (platinum-cobalt units)	Specific conductance (µmho)	Oxygen, dissolved (mg/L)	Oxygen dissolved (% saturation)	pH field (unit)	pH lab (unit)	Alkalinity, field (mg/L as $CaCO_3$)	Nitrogen, total (mg/L as N)	Nitrogen, organic total (mg/L as N)	Nitrogen, ammonia total (mg/L as N)
04145802 Pickerel Creek near Fergus (lat 43°16'08", long 084°07'44")														
June 9, 1980	1500	15.0	--	6.1	25	640	7.8	79	7.5	--	200	8.8	1.1	0.02
Aug. 14	1630	21.0	3.2	8.5	18	810	8.4	94	7.4	--	280	3.1	.75	.00
May 27, 1981	1800	20.0	2.4	6.8	18	666	7.0	74	7.9	8.2	--	3.3	.67	.07
04145803 Pickerel Creek near St. Charles (lat 43°17'36", long 084°06'39")														
June 9, 1980	1700	17.0	--	2.5	15	760	8.2	81	7.5	--	210	4.3	1.1	0.14
Aug. 13	1430	22.0	--	55	25	778	4.7	54	7.1	--	250	3.2	.68	.07
May 27, 1981	1130	19.0	--	35	20	741	6.3	67	7.8	8.0	--	4.4	.77	.13
04145805 Wolf Creek near Nelson (lat 43°20'11", long 084°11'22")														
June 10, 1980	1830	17.0	4.9	2.5	20	800	8.8	96	7.8	--	170	17	1.0	0.09
Aug. 12	1930	23.0	1.3	14	22	660	8.3	98	7.6	--	150	3.3	.65	.02
May 29, 1981	1145	19.0	1.4	24	28	627	10.4	114	7.7	8.0	--	6.1	1.0	.10
04145806 Wolf Creek near St. Charles (lat 43°18'57", long 084°06'45")														
June 12, 1980	1200	15.0	--	4.0	80	520	4.5	47	7.3	--	140	3.2	0.99	0.11
Aug. 13	1540	18.5	--	19	55	853	2.3	24	6.7	--	250	.76	.61	.08
May 29, 1981	1300	20.0	--	8.5	65	741	8.4	94	7.6	7.9	--	3.8	1.4	.15
04145808 Shiawassee River near Swan Creek (lat 43°20'17", long 084°04'20")														
Aug. 12, 1980	1040	20.0	269	45	30	648	5.2	58	7.2	--	210	1.8	0.70	0.20
May 29, 1981	1620	20.0	483	39	27	694	6.0	73	7.9	8.0	--	2.7	1.2	.19
04145810 Bear Creek near Fergus (lat 43°15'19", long 084°05'18")														
June 9, 1980	1330	10.5	11	3.5	17	690	7.2	70	7.4	--	170	15	0.98	0.12
Aug. 14	1520	21.0	2.0	24	25	950	5.0	56	7.3	--	310	4.1	.93	.07
June 1, 1981	1030	15.0	1.4	7.1	26	775	5.0	50	7.7	8.1	--	4.7	.83	.17
04145814 Swan Creek at Schomaker Road near Garfield (lat 43°24'03", long 084°05'57")														
June 11, 1980	1830	16.0	81	16	25	740	8.0	85	7.6	--	200	11	1.1	0.06
Aug. 12	1450	23.0	24	38	25	864	5.7	66	7.3	--	240	1.9	.84	.16
May 29, 1981	0845	18.0	31	55	20	783	5.8	63	7.9	8.0	--	5.5	1.3	.18
04145816 Marsh Creek near Garfield (lat 43°21'56", long 084°10'22")														
June 11, 1980	1700	17.0	9.2	3.5	40	620	10.2	108	8.0	--	190	8.2	1.1	0.04
Aug. 12	1800	21.0	3.9	11	50	690	9.1	102	7.3	--	220	2.5	.76	.06
May 29, 1981	1020	16.0	2.5	4.3	28	586	10.4	107	7.9	7.9	--	4.9	1.4	.09
04145818 Swan Creek near Garfield (lat 43°21'18", long 084°04'20")														
June 12, 1980	1000	15.0	154	37	35	650	--	--	7.5	--	200	8.4	1.5	0.07
Aug. 12,	1320	22.5	78	34	25	778	3.6	42	7.1	--	240	2.3	.86	.34
May 28, 1981	1740	21.0	100	28	20	763	--	--	7.9	7.9	--	5.4	1.7	.15

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Date	Nitrogen, nitrite total (mg/L as N)	Nitrogen, nitrate total (mg/L as N)	Nitrogen, ammonia + organic total (mg/L as N)	Nitrogen, NO_2+NO_3 total (mg/L as N)	Phosphate, total (mg/L as PO_4)	Phosphorus, total (mg/L as P)	Carbon, organic dissolved (mg/L as C)	Carbon, organic suspended total (mg/L as C)	Cyanide, total (mg/L as Cn)	Hardness (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)
04145802 Pickerel Creek near Fergus (lat 43°16'08", long 084°07'44")													
June 9, 1980	0.05	7.7	1.10	7.70	0.03	0.05	12	--	0.00	300	100	78	26
Aug. 14	.01	2.3	.75	2.30	.03	.04	13	0.2	.01	370	88	98	30
May 27, 1981	.07	2.5	.74	2.60	--	.06	11	.4	<.01	310	--	79	28
04145803 Pickerel Creek near St. Charles (lat 43°17'36", long 084°06'39")													
June 9, 1980	0.10	3.0	1.20	3.10	0.03	0.07	19	0.9	0.00	300	88	70	30
Aug. 13	.05	2.4	.75	2.40	.15	.11	12	.5	.01	320	110	87	26
May 27, 1981	.08	3.4	.90	3.50	--	.07	5.7	.7	<.01	300	--	74	28
04145805 Wolf Creek near Nelson (lat 43°20'11", long 084°11'22")													
June 10, 1980	0.09	16	1.10	16.0	0.00	0.04	12	--	--	330	160	90	25
Aug. 12	.04	2.6	.67	2.60	.00	.05	8.6	0.3	0.00	280	130	71	25
May 29, 1981	.15	4.9	1.10	5.00	--	.06	7.3	--	<.01	280	--	69	25
04145806 Wolf Creek near St. Charles (lat 43°18'57", long 084°06'45")													
June 12, 1980	0.08	2.0	1.10	2.10	0.09	0.06	20	0.6	0.01	220	76	60	16
Aug. 13	.01	.06	.69	.07	.34	.19	18	1.0	.01	350	97	96	26
May 29, 1981	.07	2.2	1.50	2.30	--	.12	13	1.0	<.01	310	--	85	24
04145808 Shiawassee River near Swan Creek (lat 43°20'17", long 084°04'20")													
Aug. 12, 1980	0.03	0.91	0.90	0.94	0.25	0.40	3.4	0.7	0.01	280	83	75	23
May 29, 1981	.07	1.2	1.40	1.30	--	.09	11	2.0	<.01	310	--	80	26
04145810 Bear Creek near Fergus (lat 43°15'19", long 084°05'18")													
June 9, 1980	0.15	14	1.10	14.0	0.15	0.12	7.7	--	0.00	310	140	84	24
Aug. 14	.04	3.1	1.00	3.10	.18	.10	16	--	.01	420	110	110	35
June 1, 1981	.12	3.6	1.00	3.70	--	.07	6.4	0.9	<.01	370	--	94	33
04145814 Swan Creek at Schomaker Road near Garfield (lat 43°24'03", long 084°05'57")													
June 11, 1980	0.06	9.7	1.20	9.80	0.12	0.08	13	0.6	0.01	350	150	98	25
Aug. 12,	.03	.83	1.00	.86	.03	.16	16	1.5	.01	350	110	95	28
May 29, 1981	.07	3.9	1.50	4.00	--	.14	7.2	1.2	<.01	350	--	91	29
04145816 Marsh Creek near Garfield (lat 43°21'56", long 084°10'22")													
June 11, 1980	0.03	7.1	1.10	7.10	0.12	0.04	15	0.3	0.01	290	100	83	21
Aug. 12	.02	1.7	.82	1.70	.28	.10	17	.3	.01	320	96	87	24
May 29, 1981	.08	3.3	1.50	3.40	--	.07	7.8	.3	<.01	310	--	82	26
04145818 Swan Creek near Garfield (lat 43°21'18", long 084°04'20")													
June 12, 1980	0.08	6.7	1.60	6.80	0.12	0.13	15	1.5	0.01	310	110	85	24
Aug. 12	.04	1.1	1.20	1.10	.25	.32	11	1.2	.00	330	120	89	26
May 28, 1981	.11	3.5	1.80	3.60	--	1.20	7.5	.3	<.01	330	--	89	27

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Date	Sodium, dissolved (mg/L as Na)	Sodium (adsorption ratio)	Sodium (percent)	Potassium, dissolved (mg/L as K)	Chloride, dissolved (mg/L as Cl)	Sulfate, dissolved (mg/L as SO_4)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Arsenic, total (µg/L as As)	Barium, total recoverable (µg/L as Ba)	Beryllium, total recoverable (µg/L as Be)	Boron, total recoverable (µg/L) as B)	Cadmium, total recoverable (µg/L as Cd)
04145802 Pickerel Creek near Fergus (lat 43°16'08", long 084°07'44")													
June 9, 1980	17	0.4	11	2.9	40	66	0.3	6.8	1	100	0	100	0
Aug. 14	19	.4	10	3.9	43	68	.3	11	3	100	0	130	0
May 27, 1981	22	.5	13	3.5	40	60	.3	5.3	1	100	0	130	1
04145803 Pickerel Creek near St. Charles (lat 43°17'36", long 084°06'39")													
June 9, 1980	30	0.8	18	3.2	52	80	0.3	7.0	2	100	0	120	0
Aug. 13	19	.5	11	4.2	47	60	.3	11	2	100	0	120	0
May 27, 1981	33	.8	19	3.7	160	61	.3	2.6	1	100	0	100	1
04145805 Wolf Creek near Nelson (lat 43°20'11, long 084°14'22")													
June 10, 1980	17	0.4	10	3.0	43	130	0.3	6.7	1	100	0	80	0
Aug. 12	23	.6	15	3.3	40	100	.3	4.3	1	100	0	110	0
May 29, 1981	19	.5	13	2.9	28	100	.3	1.6	1	100	10	70	1
04145806 Wolf Creek near St. Charles (lat 43°18'57", long 084°06'45")													
June 12, 1980	23	0.7	19	2.7	47	45	0.2	7.3	1	<50	0	110	0
Aug. 13	39	.9	19	3.7	93	44	.3	14	1	<50	0	140	0
May 29, 1981	26	.6	15	3.6	61	57	.2	2.4	1	100	10	100	1
04145808 Shiawassee River near Swan Creek (lat 43°20'17", long 084°04'20")													
Aug. 12, 1980	23	0.6	15	3.6	46	49	0.2	9.6	3	--	0	130	1
May 29, 1981	32	.8	18	2.9	44	48	.2	1.7	2	100	20	150	1
04145810 Bear Creek near Fergus (lat 43°15'19", long 084°05'18")													
June 9, 1980	12	0.3	8	3.4	45	70	0.2	7.8	1	50	0	80	0
Aug. 14	23	.5	11	4.8	60	62	.3	9.8	2	50	0	130	0
June 1, 1981	23	.5	12	3.6	54	90	.2	2.4	2	100	10	110	1
04145814 Swan Creek at Schomaker Road near Garfield (lat 43°24'03", long 084°05'57")													
June 11, 1980	16	0.4	9	3.1	56	83	0.3	5.0	1	<50	0	50	0
Aug. 12	42	1.0	20	4.9	90	74	.3	7.7	1	200	0	140	0
May 29, 1981	25	.6	13	3.5	59	77	.2	1.5	2	100	0	80	1
04145816 Marsh Creek near Garfield (lat 43°21'56", long 084°10'22")													
June 11, 1980	9.7	0.2	7	3.0	31	76	0.2	5.4	1	<50	0	50	0
Aug. 12	15	.4	9	5.9	34	65	.3	13	1	<50	0	130	0
May 29, 1981	15	.4	9	4.5	30	72	.2	2.5	1	100	0	60	1
04145818 Swan Creek near Garfield (lat 43°21'18", long 084°04'20")													
June 12, 1980	15	0.4	9	3.0	45	64	0.2	5.8	2	100	0	100	0
Aug. 12	23	.6	13	3.9	56	62	.3	9.1	3	--	0	130	1
May 28, 1981	22	.5	12	3.3	54	75	.2	2.8	2	100	10	80	1

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Date	Chromium, total recoverable (µg/L as Cr)	Cobalt, total recoverable (µg/L) as Co)	Copper, total recoverable (µg/L as Cu)	Iron, suspended recoverable (µg/L as Fe)	Iron, total recoverable (µg/L as Fe)	Iron, dissolved (µg/L as Fe)	Lead, total recoverable (µg/L as Pb)	Manganese, suspended recov. (µg/L as Mn)	Manganese, total recoverable (µg/L as Mn)	Manganese, dissolved (µg/L as Mn)	Molybdenum, total recoverable (µg/L as Mo)	Nickel, total recoverable (µg/L as Ni)	Silver, total recoverable (µg/L as Ag)	Strontium, total recoverable (µg/L as Sr)
04145802 Pickerel Creek near Fergus (lat 43°16'08", long 084°07'44")														
June 9, 1980	10	0	3	500	540	40	0	10	30	20	1	2	0	310
Aug. 14	--	0	4	450	490	40	2	10	30	20	2	2	0	390
May 27, 1981	<10	1	5	1,200	1,200	20	1	10	40	30	2	13	0	420
04145803 Pickerel Creek near St. Charles (lat 43°17'36, long 084°06'39")														
June 9, 1980	10	0	4	1,300	1,300	10	21	30	40	10	4	7	0	250
Aug. 13	20	0	3	1,800	1,800	40	1	40	60	20	3	5	0	240
May 27, 1981	<10	1	4	1,200	1,200	40	1	40	70	30	3	13	0	290
04145805 Wolf Creek near Nelson (lat 43°20'11", long 084°11'22")														
June 10, 1980	10	1	5	1,700	1,700	10	2	40	70	30	4	4	0	--
Aug. 12	<10	0	2	800	830	30	0	20	30	10	--	2	0	470
May 29, 1981	10	2	6	2,100	2,100	10	2	50	90	40	1	10	0	360
04145806 Wolf Creek near St. Charles (lat 43°18'57", long 084°06'45")														
June 12, 1980	10	0	4	420	740	320	2	10	40	30	1	4	0	240
Aug. 13	20	0	2	750	910	160	2	20	120	100	2	8	0	280
May 29, 1981	10	1	4	1,300	1,500	230	1	30	120	90	2	6	0	250
04145808 Shiawassee River near Swan Creek (lat 43°20'17", long 084°04'20")														
Aug. 12, 1980	10	4	4	2,600	2,600	30	10	80	120	40	3	4	0	230
May 29, 1981	10	1	7	3,100	3,100	10	5	100	150	50	1	16	0	200
04145810 Bear Creek near Fergus (lat 43°15'19", long 084°05'18")														
June 9, 1980	<10	0	4	220	790	570	1	0	30	30	2	3	0	180
Aug. 14	10	0	3	460	490	30	3	20	70	50	2	2	0	290
June 1, 1981	10	3	4	1,100	1,100	20	7	0	160	160	3	7	0	290
04145814 Swan Creek at Schomaker Road near Garfield (lat 43°24'03", long 084°05'57")														
June 11, 1980	10	1	27	920	940	20	3	20	50	30	2	1	0	310
Aug. 12	<10	0	4	1,600	1,700	60	3	60	140	80	2	5	0	500
May 29, 1981	10	3	10	3,500	3,500	10	3	90	150	60	2	11	0	380
04145816 Marsh Creek near Garfield (lat 43°21'56", long 084°10'22")														
June 11, 1980	10	0	3	330	400	70	2	10	40	30	0	1	0	250
Aug. 12	<10	0	3	610	700	90	0	20	50	30	2	2	0	350
May 29, 1981	20	1	5	890	920	30	6	20	70	50	2	10	0	300
04145818 Swan Creek near Garfield (lat 43°21'18", long 084°04'20")														
June 12, 1980	10	0	5	2,100	2,100	40	3	40	100	60	2	5	0	270
Aug. 12	10	3	4	1,600	1,600	10	5	60	150	90	3	3	0	250
May 28, 1981	20	1	9	1,400	1,400	10	6	80	140	60	1	17	0	340

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Date	Zinc, total recoverable (µg/L as Zn)	Aluminum, total recoverable (µg/L as Al)	Lithium, total recoverable (µg/L as Li)	Selenium, total (µg/L as Se)	Phenols (µg/L)	Solids, residue at 180 °C, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Solids, dissolved (tons per day)	Solids, dissolved (tons per ac-ft)	Phosphorus, ortho total (mg/L as P)	Nitrogen, ammonia total (mg/L as NH_4)	Phosphorus, total (mg/L as PO_4)	Nitrogen, total (mg/L as NO_3)
04145802 Pickerel Creek near Fergus (lat 43°16'08", long 084°07'44")													
June 9, 1980	20	20	10	2	0	--	357	--	0.49	0.01	0.02	0.15	39
Aug. 14	20	100	10	1	0	527	442	4.64	.72	.01	.00	.12	14
May 27, 1981	30	300	10	1	3	469	340	3.10	.64	.03	--	.18	15
04145803 Pickerel Creek near St. Charles (lat 43°17'36", long 084°06'39")													
June 9, 1980	20	0	10	3	1	478	399	--	0.65	0.01	0.17	0.21	19
Aug. 13	20	310	10	1	5	495	416	--	.67	.05	.08	.34	14
May 27, 1981	50	770	10	1	1	692	507	--	.94	.03	--	.21	19
04145805 Wolf Creek near Nelson (lat 43°20'11", long 084°11'22")													
June 10, 1980	20	1000	10	2	2	--	417	5.56	0.57	0.00	0.11	0.12	76
Aug. 12	20	210	10	0	1	398	357	1.40	.54	.00	.02	.15	14
May 29, 1981	30	1400	10	0	0	440	342	1.73	.60	.01	--	.18	27
04145806 Wolf Creek near St. Charles (lat 43°18'57", long 084°06'45")													
June 12, 1980	10	0	10	0	0	--	286	--	0.39	0.03	0.13	0.18	14
Aug. 13	20	240	10	1	5	581	467	--	.79	.11	.10	.58	3.4
May 29, 1981	30	600	10	0	0	490	398	--	.67	.08	--	.37	17
04145808 Shiawassee River near Swan Creek (lat 43°20'17", long 084°04'20")													
Aug. 12, 1980	20	60	20	0	5	432	359	314	0.59	0.08	0.24	1.2	8.1
May 29, 1981	50	1,500	10	0	0	459	385	599	.62	.10	--	.28	12
04145810 Bear Creek near Fergus (lat 43°15'19", long 084°05'18")													
June 9, 1980	50	90	10	1	1	--	340	10.5	0.46	0.05	0.15	0.37	67
Aug. 14	20	40	10	1	1	576	491	3.11	.78	.06	.08	.31	18
June 1, 1981	30	330	10	1	1	527	451	2.08	.72	.03	--	.21	21
04145814 Swan Creek at Schomaker Road near Garfield (lat 43°24'03", long 084°05'57")													
June 11, 1980	10	30	10	2	0	--	402	88.0	0.55	0.04	0.07	0.25	49
Aug. 12	20	600	10	0	1	570	486	36.9	.78	.01	.19	.49	8.2
May 29, 1981	40	2300	10	1	0	561	425	47.6	.76	.06	--	.43	24
04145816 Marsh Creek near Garfield (lat 43°21'56", long 084°10'22")													
June 11, 1980	10	0	0	1	1	--	344	8.60	0.47	0.04	0.05	0.12	36
Aug. 12	20	180	10	0	3	412	377	4.43	.56	.09	.07	.31	11
May 29, 1981	20	460	0	0	30	429	353	2.95	.58	.03	--	.21	22
04145818 Swan Creek near Garfield (lat 43°21'18", long 084°04'20")													
June 12, 1980	10	10	10	2	0	--	362	151	0.49	0.04	0.08	0.40	37
Aug. 12	20	160	20	0	4	533	424	113	.72	.08	.41	.98	10
May 28, 1981	50	820	10	1	0	492	410	133	.67	.07	--	3.7	24

Table 3.--Chemical analyses of surface water, Saginaw County, Michigan--continued
(Analyses by U.S. Geological Survey)

Date	Mercury, total recoverable (µg/L as Hg)	Uranium, dissolved, extraction (µg/L)	Potassium-40, dissolved (pCi/L)	Specific conductance, lab (µmho)	Alkalinity, Lab (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)
04145802 Pickerel Creek near Fergus (lat 43°16'08", long 084°07'44")						
June 9, 1980	0.2	1.8	--	--	--	--
Aug. 14	.2	2.3	--	--	--	--
May 27, 1981	<.1	--	2.6	668	170	140
04145803 Pickerel Creek near St. Charles (lat 43°17'36", long 084°06'39")						
June 9, 1980	0.2	2.2	--	--	--	--
Aug. 13	.1	1.8	--	--	--	--
May 27, 1981	<.1	--	2.8	716	240	60
04145805 Wolf Creek near Nelson (lat 43°20'11", long 084°11'22")						
June 10, 1980	0.1	3.9	--	--	--	--
Aug. 12	.1	1.9	--	--	--	--
May 29, 1981	<.1	--	2.2	609	160	120
04145806 Wolf Creek near St. Charles (lat 43°18'57", long 084°06'45")						
June 12, 1980	0.1	1.6	--	--	--	--
Aug. 13	.1	1.6	--	--	--	--
May 29, 1981	<.1	--	2.7	729	230	81
04145808 Shiawassee River near Swan Creek (lat 43°20'17", long 084°04'20")						
Aug. 12, 1980	0.1	--	--	--	--	--
May 29, 1981	<.1	--	2.2	660	250	57
04145810 Bear Creek near Fergus (lat 43°15'19", long 084°05'18")						
June 9, 1980	0.2	1.9	--	--	--	--
Aug. 14	.2	2.3	--	--	--	--
June 1, 1981	<.1	--	2.7	784	250	120
04145814 Swan Creek at Schomaker Road near Garfield (lat 43°24'03", long 084°05'57")						
June 11, 1980	<0.1	2.2	--	--	--	--
Aug. 12	.1	1.9	--	--	--	--
May 29, 1981	.1	--	2.6	776	230	120
04145816 Marsh Creek near Garfield (lat 43°21'56", long 084°10'22")						
June 11, 1980	0.1	2.7	--	--	--	--
Aug. 12	<.1	1.5	--	--	--	--
May 29, 1981	<.1	--	3.4	660	220	110
04145818 Swan Creek near Garfield (lat 43°21'18", long 084°04'20")						
June 12, 1980	0.1	1.6	--	--	--	--
Aug. 12	.1	1.9	--	--	--	--
May 28, 1981	<.1	--	2.5	744	230	100