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Assessment and Comparison of 1976-77 and 2002 Water Quality in Mineshafts in the Picher Mining District, Northeastern Oklahoma and Southeastern Kansas

Water-Resources Investigations Report 03–4248

U.S. Department of the Interior
U.S. Geological Survey

Cover: Photograph of Royal Mineshaft taken by Kelli DeHay, U.S. Geological Survey.

DeHay, K.L.—Assessment and Comparison of 1976-77 and 2002 Water Quality in Mineshafts in the Picher Mining District, Northeastern Oklahoma and Southeastern Kansas—USGS/WRIR 03–4248

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UNITED STATES GOVERNMENT PRINTING OFFICE: OKLAHOMA CITY 2003

CONTENTS

FIGURES

TABLES

Conversion Factors and Datum

Multiply	By	To obtain
Length		
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
square mile (mi^2)	2.590	square kilometer (km^2)
Volume		
liter (L)	0.2642	gallon (gal)
Mass		
ton, short (2,000 lb)	0.9072	megagram (Mg)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$°F = (1.8 \times °C) + 32$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Assessment and Comparison of 1976-77 and 2002 Water Quality in Mineshafts in the Picher Mining District, Northeastern Oklahoma and Southeastern Kansas

By Kelli L. DeHay

Abstract

The Picher mining district was the site of lead and zinc mining from about 1900 to the mid-1970's. The primary sources of lead and zinc were the sulfide minerals, galena and sphalerite, disseminated in the cherty limestone of the Boone Formation. Water was pumped from the mines while still in operation; however, when mining ceased the mines began to fill with water. Elevated concentrations of metals with depth indicate there may be a substantial quantity of dissolved metals in the ground water. There is concern that the mine water may continue to seep to adjoining portions of the Boone aquifer and to creeks and streams in the area.

Water was sampled from abandoned mineshafts in 2002 in the Picher mining area to assess water quality in the mines and to determine how water quality has changed since the late 1970s when similar sampling was conducted. Specific conductance in 2002 increased with depth in the mineshafts. The increases in specific conductance were very slight until the bottom 20 to 40 feet of the shaft where substantial increases occurred. The pH values in 2002 were generally uniform at the top of the water column and were generally neutral. The lowest pH values were measured at the base of most mineshafts. Concentrations of metals and major ions from samples in 2002 varied with depth and between shafts.

Specific conductance in 2002 samples was less than in 1976-77 samples. The 1976-77 and 2002 data sets for pH had similar median values; however, the pH values from the 1976-77 had a much greater range. Concentrations of metals, except copper, from water samples collected from the mineshafts in 2002 were significantly less than concentrations of metals from samples in 1976-77.

Introduction

The Picher mining district of northeastern Oklahoma and southeastern Kansas, was the site of lead and zinc mining from about 1900 until the mid-1970s (Christenson, 1995). The primary sources of lead and zinc were sulfide minerals disseminated in the cherty limestone of the Boone Formation[1]. Sulfide minerals from the Boone Formation include: galena, sphalerite, and the accessory minerals chalcopyrite, enargite, luzonite, marcasite, and pyrite (McKnight and Fischer, 1970). Exposure of these minerals to oxygenated water, such as when the mines were in operation or filling with water, can create acidic solutions resulting in elevated concentrations of sulfate and metals in the ground water, surface water, and sediments. However, after the mines filled with water and contact with the atmosphere was negligible, the environment became reducing as indicated by large concentrations of ferrous iron. The following reaction describes the water in the Picher mining area as a result of the two environments (Parkhurst, 1986).

$$4\,FeS_2 + 15O_2 + 8CaCO_3 + 18H_20 \Rightarrow 8CaSO_4 * 2H_2O + 4FeOOH + 8CO_2 \quad (1)$$

Playton and others (1980) reported that water quality in 1976-77 was stratified in mined voids, with specific conductance, dissolved solids, sulfate, and metals increasing and pH decreasing with depth. Mine water contains large concentrations of calcium, magnesium, sulfate, fluoride, cadmium, copper, iron, lead, manganese, nickel, and zinc (Christenson and others, 1994). Increasing concentrations of metals with depth indicate that there may be a substantial quantity of dissolved metals in ground water in the mining district.

The Boone Formation is an important aquifer in the region and is the source of base flow to streams in the Picher mining

[1]Geological names and stratigraphic ages in this report are accepted by the Oklahoma Geological Survey and not necessarily the same as those used by the U.S. Geological Survey.

district (Luza, 1986). Elevated metals concentrations in ground water may seep to adjoining portions of the Boone aquifer, creeks and streams in hydraulic connection with the aquifer, and the underlying Roubidoux aquifer. The U.S. Geological Survey (USGS), in cooperation with the Oklahoma Department of Environmental Quality, conducted a study in 2002 to re-evaluate the water quality in abandoned mineshafts in the Picher mining district and determine whether the water quality had changed with time. The information will better quantify the effects of abandoned mines on aquifers, will provide water resources information that will be used by multiple parties for planning and operational purposes, and will contribute data to national data bases used to advance the understanding of regional and temporal variations in hydrologic conditions.

Purpose and Scope

The purpose of this report is to assess water quality in abandoned mineshafts in the Picher mining district in 2002, to compare water quality in 2002 to water quality in 1976-77, and to determine how the water quality has changed with time. The scope of the work included sampling seven abandoned mineshafts at selected depths for analysis of water properties and dissolved metals to compare to past water-quality data. USGS personnel attempted to sample the same mineshafts that were sampled in the 1976-77 study; however, many of these were inaccessible so other nearby shafts were sampled for the study described in this report (2002 study) (fig. 1).

Description of Study Area

The study area encompasses areas of the Picher mining district in northeastern Oklahoma (fig. 1) and southeastern Kansas where abandoned mineshafts were sampled in 1976-77 (Playton and others, 1980). The abandoned mines are in the Mississippian Age Boone Formation, which consists of chert, limestone, jasperoid, and dolomite (McKnight and Fischer, 1970). The Boone Formation ranges from 350 to 400 feet thick in the Picher area (Luza, 1986).

Ore production in the Picher mining district was active for more than half of the 20th century. Lead and zinc ores were first discovered in the Picher mining district in 1901, but the main body of the ore was not discovered until 1912. Production of ores increased rapidly between 1915 and 1920 due partly to demand created by World War I (Playton and others, 1980). Production reached a peak by 1925 with 387,000 tons of recoverable zinc and 101,000 tons of recoverable lead being produced (McKnight and Fischer, 1970). The mines maintained moderate production levels until the 1950s when yields began to decline. Most of the large mining operations then abandoned the area, and only a small amount of ore was produced until the mid-1970s (Christenson, 1995).

As the mines developed, a large network of underground mine workings was created. The mines were dewatered during mining operations, but once operations ceased, the underground mine workings began to refill with water. The water entered the mines from ground-water seepage and from runoff flowing into mineshafts and air vents. The mines filled completely with water by the late 1970s and began discharging mine water at the surface.

Acknowledgments

Sincere thanks goes to John Mott, a local Picher resident, and John Dalgarn, with the Bureau of Indian Affairs. Mr. Mott provided his time and assistance in locating mineshafts. Mr. Dalgarn also was helpful in locating sampling sites and in providing access to sites on Indian trust land. The author also thanks numerous individuals within the USGS for their assistance in various phases of the study. Special thanks to Kyle Davis and Scott Strong for their help with the data collection, to Barbara Pickup for providing training on sampling procedures, and to Shana Mashburn and Caleb Cope for their assistance with illustrations.

Methods

Water samples were collected in seven mineshafts and hypothesis testing was used to compare water quality in 1976-77 samples to 2002 samples in the abandoned mineshafts. Summary statistics were calculated for the 1976-77 and 2002 data, and the water-quality data were compared using the Wilcoxon rank-sum test.

Field Methods

Seven mineshafts were sampled during the 2002 study; six were in Oklahoma and one was in Kansas (fig. 1). The mineshafts were sampled one time at multiple depths during late July and early August 2002. The mineshafts sampled were the Admiralty #3, Admiralty #4, Federal #5, Baby Jim, Royal, Consolidated #2, and Kansas 2. Sampling sites were selected based on the location of sites sampled in the 1976-77 study. Attempts were made to locate and sample the original mineshafts; however, six of the seven mineshafts were no longer accessible because of fill-ins or collapses. The Consolidated #2 mineshaft was the only site sampled in 1976-77 that was still accessible in 2002 (fig. 1). Alternate sites were selected as near as possible to the 1976-77 sites.

The mineshaft sampling occurred in three phases: (1) mineshaft profile of water properties with depth, (2) sample collection, and (3) sample processing. The mineshafts were typically 8 feet by 8 feet wide and were from 180 to 230 feet deep, with the exception of the Kansas 2 mineshaft that was only 50 feet deep. It is unknown whether the Kansas 2 mineshaft was simply a shallow mineshaft or if it had collapsed below the surface. A multiparameter probe was used to measure vertical profiles of water properties in the mineshafts. Specific conduc-

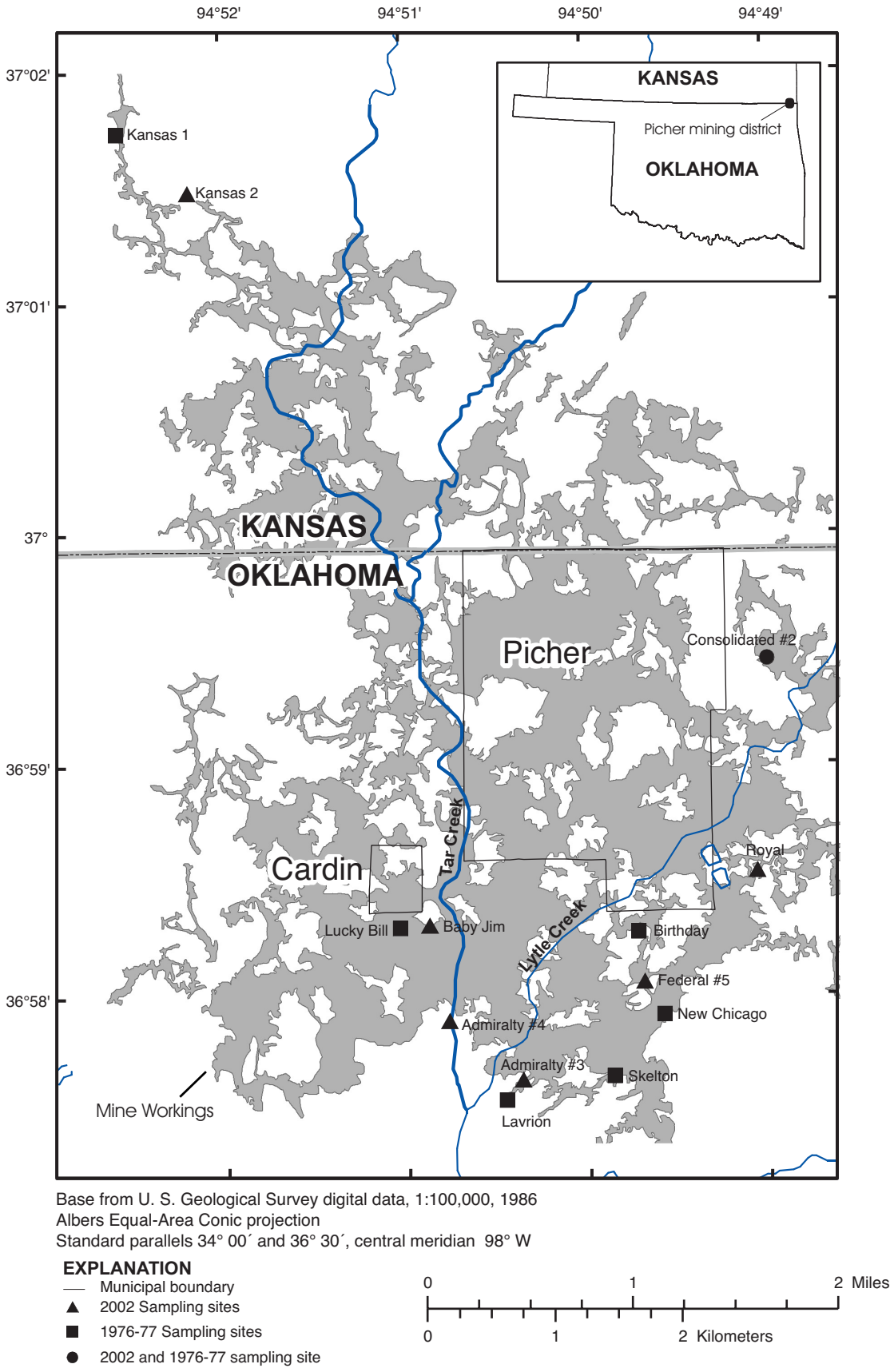

Figure 1. Location of mineshafts sampled in 1976-77 and 2002 in the Picher mining district.

tance, pH, water temperature, and dissolved-oxygen concentrations were measured at 10-foot intervals for the vertical extent of each mineshaft. Near the base of the mineshafts the water properties were measured more frequently than 10-foot intervals if substantial changes occurred in the water properties. The multiparameter probe was calibrated at the beginning of each day, using methods described in the USGS Water-Quality Field Manual (Wilde and Radtke, 1998).

Point samples for the water-quality analyses from the mineshafts were subsequently collected at selected intervals in the vertical profile. Sampling depths within the mineshafts were selected based on significant changes in specific conductance and pH. Six of the seven mineshafts were sampled at six depth intervals. The Kansas 2 mineshaft was only sampled at three depth intervals because of the shallower depth. The mineshafts were sampled using a 2.2-liter Kemmerer sampler made of clear acrylic that was lowered to the selected sampling depths with a rope and reel. These sampling procedures duplicated ones used by Playton and others (1980).

In 1976-77 the mineshafts were sampled multiple times over the course of a year with no areal or seasonal variation in water quality reported (Playton and others, 1980). Therefore, in the 2002 study the mines were only sampled once. In the 1976-77 study, samples were analyzed for both total and dissolved metals. However, samples in 2002 only were analyzed for dissolved metals, so only dissolved concentrations were used in the statistical comparisons in this report.

Water samples were collected and processed using techniques described in the USGS Water-Quality Field Manual (Wilde and Radtke, 1998). All samples were decanted from the Kemmerer sampler and processed in a sealed chamber to prevent dust infiltration. Samples were analyzed for alkalinity, major ions, and metals. Samples for major ions and metals were filtered using a 0.45-micrometer capsule filter. One to two alkalinity titrations were run at each mineshaft for quality assurance. Three blank and three duplicate samples also were collected to evaluate the quality assurance of the environmental samples. All samples were analyzed for alkalinity, major ions, and metals by the USGS National Water Quality Laboratory, Lakewood, Colorado.

Statistical Methods

Water-quality constituents from water samples collected from the mineshafts in 1976-77 were compared to those collected in 2002. Statistical tests and comparisons were calculated only for water properties and constituents that are designated indicators of mine water for this system. These properties and constituents include pH, specific conductance, alkalinity, calcium, magnesium, sulfate, cadmium, copper, iron, lead, manganese, nickel, and zinc. The minewater indicator constituents were compared using the Wilcoxon rank-sum test, also known as the Mann-Whitney test (Helsel and Hirsch, 1992). The Wilcoxon rank-sum test was used because it is a nonparametric test, which does not require normally-distributed data. The Wilcoxon rank-sum test works on the ranks of the data instead of the actual constituent concentrations. Censored data for each constituent were assigned the same rank for calculating the Wilcoxon rank-sum test.

The Wilcoxon rank-sum test has two hypotheses. The null hypothesis was that the concentrations of chemical constituents in the ground-water samples from the mineshafts were the same in 1976-77 and in 2002. The alternative hypothesis was that the concentrations in ground-water samples taken from the mineshafts in 1976-77 and 2002 were significantly different, meaning the 2002 concentrations were either greater or lesser than concentrations in samples from 1976-77. The null hypothesis was rejected if the p-value of the test was less than or equal to 0.05.

A second set of statistical tests also were run comparing 2002 minewater samples collected from depths 150 feet below land surface and deeper to the 1976-77 minewater samples. The condition of the hydrologic system at the time of the 2002 study was different than it was in 1976-77. At that time the mines were still filling with water. The average water level in 1976-77 when the samples were collected was 150 feet below land surface. By 2002 the water levels were stable about 30 feet below land surface. The 1976-77 samples were collected at deeper depths in the mineshaft because of greater depths to water compared to the 2002 samples. Samples collected in 2002 were taken from the upper part of the water column as well as at deeper depths that were sampled in 1976-77. To determine if samples collected from the deeper depths had similar characteristics, statistical tests also were done to compare the 1976-77 data to 2002 data collected from depths of 150 feet below land surface or deeper.

Water Quality in 1976-77

Summary statistics were run on the 1976-77 mine water data, and may differ slightly from the summary statistics in Playton and others (1980). New statistics were calculated because different statistical methodologies were used for comparisons with the 2002 data (table 1).

Playton and others (1980) reported that water quality in mines in the Picher mining district was not uniform with depth. Specific conductance and water temperature generally increased and pH generally decreased with increasing sampling depth. Concentrations of dissolved solids and chemical constituents, such as total and dissolved metals and dissolved sulfate, also increased with depth (Playton and others, 1980).

The mineshafts were sampled multiple times over a course of a year in 1976-77 and no areal or seasonal variation in water quality was found, but Playton and others (1980) reported that water quality in the mines was stratified (Appendix 1).

Playton and others (1980) reported that water levels in the mineshafts were rising in 1976-77. In one well that penetrated the mine workings, the water level rose at an average rate of 1.2

Table 1. Summary statistics of water properties, major ions, and trace elements for water samples collected in 1976-77 from mineshafts in the Picher mining district

[µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; --, no statistic calculated.]

Constituents or water properties	Statistics method[1]	Number of samples	Minimum	Percentiles			Maximum
				25	50	75	
Specific conductance (µS/cm at 25°C)	1	139	740	1,360	2,850	3,820	4,950
pH, field (standard units)	1	147	3.4	5.3	6.4	7.0	8.6
Water temperature (°C)	1	149	13.0	14.5	15.5	16.0	18.0
Hardness, total (mg/L)	1	77	410	780	1,800	2,100	2,500
Alkalinity, lab (mg/L as $CaCO_3$)	1	77	0	0	29	90	308
Dissolved solids (mg/L, residue at 180°C)	1	74	622	1,215	3,130	4,935	5,920
Calcium (mg/L)	1	77	120	250	480	500	600
Magnesium (mg/L)	1	77	13	38	130	220	290
Sodium (mg/L)	1	77	7.1	29	44	68	308
Potassium (mg/L)	1	77	1.3	2.9	3.8	4.6	9.2
Sulfate (mg/L)	1	77	320	760	2,100	3,000	3,500
Chloride (mg/L)	1	77	0.5	4.6	6.8	8.1	85
Fluoride (mg/L)	1	77	0.1	0.7	1.9	5.4	15
Silica (mg/L)	1	77	4.9	8.8	11	13	22
Aluminum (µg/L)	2	77	<10	50	600	5,500	42,000
Arsenic (µg/L)	2	44	0	<1	1	2.25	11
Barium (µg/L)	2	44	0	50	50	50	600
Cadmium (µg/L)	2	77	1	11	80	370	1,200

Table 1. Summary statistics of water properties, major ions, and trace elements for water samples collected in 1976-77 from mineshafts in the Picher mining district—Continued.

[µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; --, no statistic calculated.]

Constituents or water properties	Statistics method[1]	Number of samples	Min-imum	Percentiles			Max-imum
				25	50	75	
Chromium (µg/L)	2	44	0	0	10	20	140
Cobalt (µg/L)	2	44	0	2.75	47	91.75	800
Copper (µg/L)	2	44	1	3	8	51	260
Iron (µg/L)	2	44	5	70	46,000	150,000	330,000
Lead (µg/L)	2	77	0	7	69	250	500
Manganese (µg/L)	1	77	10	160	1,900	5,500	14,000
Molybdenum (µg/L)	3	44	0	--	--	--	2
Nickel (µg/L)	2	77	3	50	700	3,100	5,000
Selenium (µg/L)	2	44	0	<1	<1	1	3
Zinc (µg/L)	1	77	640	8,300	120,000	340,000	490,000

[1] ordinary percentile calculation; 2, censored data present (Helsel and Hirsch (1992)); 3, no calculation, more than 80 percent of the data were censored.

feet per month. Water levels rose at greater than average rates after periods of high rainfall.

Water Quality in 2002

Summary statistics of the chemical analyses were calculated for the water samples collected from the mineshafts in 2002 (table 2). Vertical profiles of the water-quality properties, including specific conductance, pH, water temperature, and dissolved-oxygen concentration, were measured at 10-foot intervals in each mineshaft and more frequently near the base of the mineshafts, if substantial changes in the water properties occurred (figs. 2, 3). For better readability, the water properties in figures 2 and 3 are shown at 20-foot intervals in the upper part of the mineshafts and then at smaller intervals near the bases of the mineshafts.

Specific conductance generally increased with depth (figs. 3, 4a). Increases in specific conductance were typically gradual until the last 20 to 40 feet of the sampling column, below which substantial increases were measured. Most of the mineshafts had specific conductance field values that ranged between 500 and 1,500 microsiemens per centimeter (µS/cm) in the upper part of the mineshafts, and increased to over 2,500 µS/cm near the base of most mineshafts.

Within mineshafts, pH values were typically uniform in the top of the water column and the values were generally neutral; however, the pH did vary between mineshafts (figs. 2, 4b). The Consolidated #2 and Admiralty #3 mineshafts had pH values that were generally greater than in other mineshafts (fig. 2). The lowest pH values were measured in samples collected at the base of most mineshafts, and these samples were associated with greater metals concentrations. The pH values measured in samples from the Federal #5 and Baby Jim increased from near the water surface to a depth midway through the water column and then decreased at the bottom of the mineshaft, and pH values in the Royal mineshaft generally increased with depth. These mineshafts had debris on the surface that may have contributed to the lesser pH at the top of the shaft (figs. 2, 4b).

Water temperatures generally decreased with depth in the mineshafts. Some of the mineshafts had a slight increase in temperature at the bottom of the shaft (fig. 2).

Concentrations of major ions and metals varied between the 2002 mineshafts sampled and with depth in those shafts (Appendix 2). Comparisons of concentrations of the minewater indicator constituents between the mineshafts and with depth are shown in figure 4.

In the Admiralty #3 mineshaft, alkalinity decreased from 150 milligrams per liter (mg/L) to 60 mg/L of $CaCO_3$ in the last 10 feet of the shaft, corresponding to a decrease in pH with depth (figs. 4b, 4c).Concentrations of calcium and magnesium increased with depth (figs. 4e, 4f). Concentrations of sulfate, iron, manganese, nickel, and zinc increased in the lowest 10 feet of the water column; whereas, cadmium and lead concentrations decreased in this last 10 feet (figs. 4d-4m).

The Admiralty #4 mineshaft (fig. 1) is adjacent to Tar Creek in the study area. Dissolved-oxygen concentrations at this site were less than 1.0 mg/L (except near the water surface) and specific conductance was greater than 2,500 µS/cm throughout the mineshaft (fig. 3). The pH remained consistent around 6.1 throughout the shaft (fig. 2). The water column also had fairly consistent concentrations of constituents, with most concentrations substantially greater than concentrations in the other mineshafts (fig. 4). Concentrations throughout the Admiralty #4 were typical of those at greater depths in the other mineshafts. Admiralty #4 is possibly in a discharge area for mine water because the water-quality properties were elevated and remained uniform throughout the shaft (figs. 2, 3).

In the Federal #5 mineshaft the water quality was more variable than the Admiralty #4. Concentrations of most constituents were uniform throughout the mineshaft, except for iron, manganese, and copper. Iron and manganese concentrations increased until midway through the shaft and then began to decrease with depth (figs. 4i, 4k). Copper decreased from 40 micrograms per liter (µg/L) to about 10 µg/L in the first 190 feet of the shaft, increased to 20 µg/L, and then decreased to less than 10 µg/L in the last 20 feet of the shaft.

Water in the Baby Jim mineshaft had increases in most constituent concentrations with depth, except for cadmium and lead, which decreased in concentration with depth (fig. 4). Substantial increases in sulfate, iron, manganese, nickel, and zinc concentrations occurred about 140 feet below land surface. This increase could indicate water in mine rooms, or seepage from contaminated water in the aquifer (fig. 4).

Water in the Royal mineshaft had specific conductance of 1,170 µS/cm near the water surface that gradually declined until 180 feet below land surface, where specific conductance then increased from 850 to 1,200 µS/cm in the next 20 feet. (fig. 4a). Sulfate concentrations in the mineshaft decreased with depth, and cadmium concentrations increased from the water surface to a point midway down the shaft but decreased at the bottom of the shaft. Manganese concentrations decreased from about 1,600 µg/L near the water surface to about 200 µg/L over midway down the shaft and then increased near the bottom of the shaft (fig. 4k). The Royal mineshaft had an abundance of debris floating on the water surface of the mineshaft that could have contributed to the quality of water at the surface.

The Consolidated #2 mineshaft is in the northeastern corner of the study area. The Consolidated #2 had dissolved-oxygen concentrations between 7.4 and 8.6 mg/L throughout the entire mineshaft. Specific conductance remained about 550 µS/cm within most of the shaft but increased to greater than 2,600 µS/cm at the bottom of the shaft (figs. 3, 4a), and pH values were around 7 until decreasing to 6.1 in the last 10 feet of the shaft (figs. 2, 3). Most constituents had consistent concentrations throughout the shaft, and most concentrations were less than concentrations in the other mineshafts. The Consolidated #2 had greater concentrations of cadmium, which decreased with depth, and greater concentrations of iron at the

Table 2. Summary statistics of water properties, major ions, and trace elements for water samples collected in 2002 from mineshafts in the Picher mining district

[µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; MRL, minimum reporting level; --,no statistic calculated; ----, no censored data for this constituent.]

Constituents and physical properties	Statistics method[1]	Number of samples	MRL	Minimum	Percentiles			Maximum
					25	50	75	
Specific conductance (µS/cm at 25°C)	1	39	----	547	883	1,180	2,630	2,800
pH, field (standard units)	1	39	----	5.7	6.1	6.3	6.7	7.5
Dissolved oxygen (mg/L)	1	39	----	0.1	0.3	0.9	5.3	8.7
Water temperature (°C)	1	39	----	15.3	15.4	15.8	16.2	22.5
Hardness, total (mg/L)	1	39	----	270	390	500	965	1,700
Alkalinity, lab (mg/L as $CaCO_3$)	1	39	1	59.0	70.5	88.0	129	167
Dissolved solids (mg/L, residue at 180°C)	1	39	----	384	522	761	1,520	2,660
Calcium (mg/L)	1	39	0.01	88.7	136	152	308	569
Magnesium (mg/L)	1	39	0.008	8.8	13	27.6	44.7	63.6
Sodium (mg/L)	1	39	0.09	2.7	6.2	16.7	26.8	30.2
Potassium (mg/L)	1	39	0.11	0.6	1.1	2.2	3.3	4.6
Sulfate (mg/L)	1	39	0.11	200	255	414	861	1,590
Chloride (mg/L)	1	39	0.33	1.1	2.0	2.2	6.8	11.6
Fluoride (mg/L)	1	39	0.11	0.2	0.3	0.3	1.2	2.8
Bromide (mg/L)	2	39	0.03	<0.01	0.02	0.03	0.05	0.08
Silica (mg/L)	1	39	0.13	9.23	11.2	12.3	17.1	20.4
Aluminum (µg/L)	2	39	1	<1	<1	<1	20	241
Antimony (µg/L)	2	39	0.05	<0.05	0.07	0.12	0.19	0.23

Table 2. Summary statistics of water properties, major ions, and trace elements for water samples collected in 2002 from mineshafts in the Picher mining district—Continued.

[µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; MRL, minimum reporting level; --,no statistic calculated; ----, no censored data for this constituent.]

Constituents and physical properties	Statistics method[1]	Number of samples	MRL	Minimum	Percentiles			Maximum
					25	50	75	
Arsenic (µg/L)	2	39	2	<2	<2	<2	8.5	26
Barium (µg/L)	1	39	1	6.0	8.0	14	17	25
Beryllium (µg/L)	2	39	0.06	<0.06	<0.06	<0.06	0.1	0.3
Cadmium (µg/L)	1	39	0.04	0.10	1.22	8.26	12.7	111
Chromium (µg/L)	3	39	0.8	<0.8	<0.8	<0.8	--	1.7
Cobalt (µg/L)	1	39	0.02	0.29	0.67	10.5	22.2	39.4
Copper (µg/L)	1	39	0.23	1.4	3.9	8.6	17.9	75.7
Iron (µg/L)	2	39	10	<10	<10.	22	27,400	56,300
Lead (µg/L)	2	39	0.08	<0.08	0.1	1.0	4.2	32.7
Manganese (µg/L)	1	39	0.10	0.3	56	375	943	1,550
Molybdenum (µg/L)	2	39	0.20	<0.2	<0.2	0.3	0.85	4.4
Nickel (µg/L)	1	39	.06	7.88	12.8	25.0	141	362
Selenium (µg/L)	2	39	2	<2	<2	<2	--	5
Silver (µg/L)	3	39	1	<1	--	--	--	<1
Zinc (µg/L)	1	39	1	1,040	1,775	2,140	7,300	11,100
Uranium (µg/L)	1	39	0.02	0.1	0.3	0.7	2.4	3.9

[1]Statistical Method 1. ordinary percentile calculation; 2,.censored data present, (Helsel and Hirsch, 1992), 3. no calculation, more than 80 percent of the data were censored.

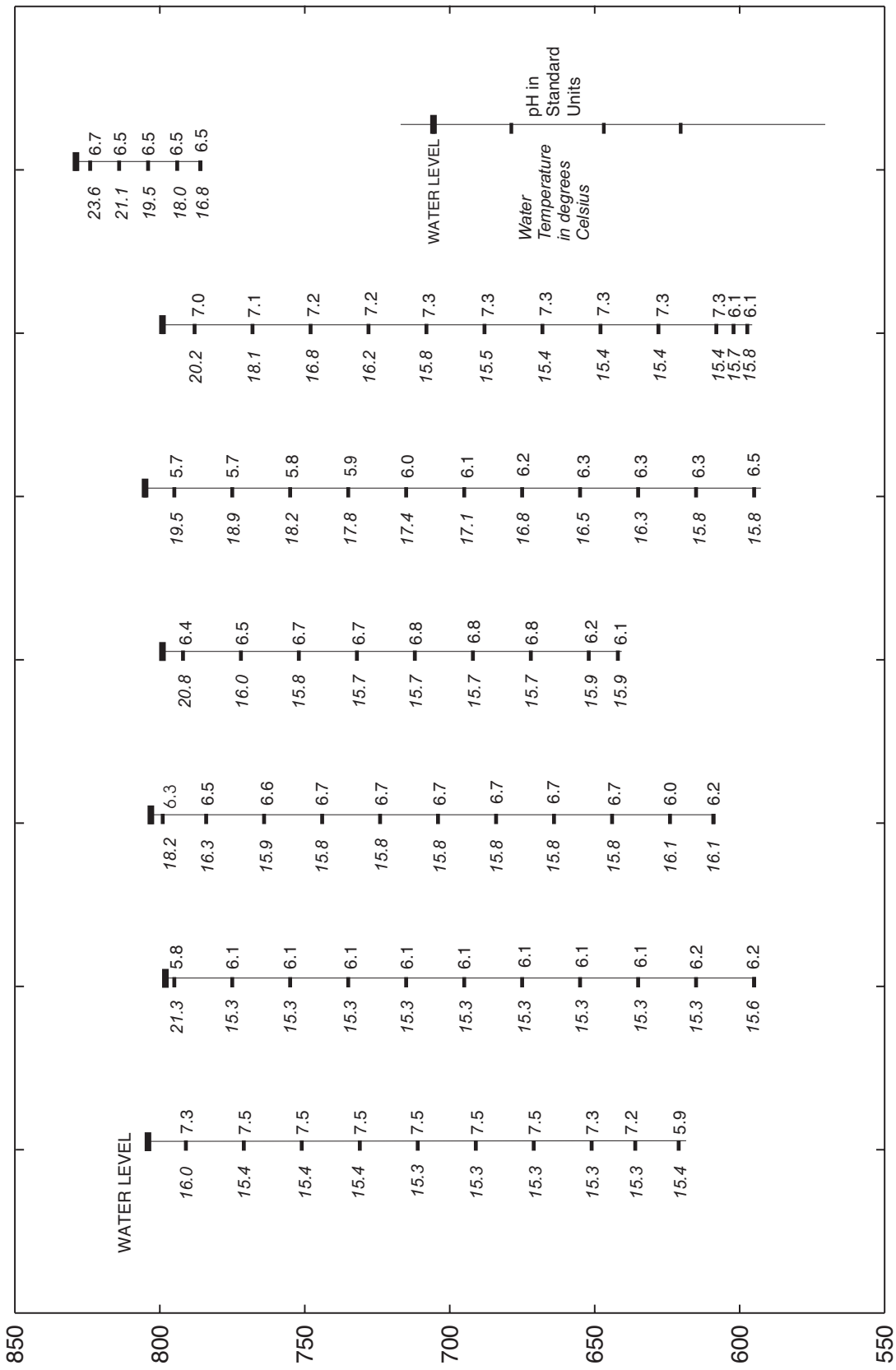

Figure 2. Water levels, pH, and temperature of water at selected depths in mineshafts sampled in 2002, Picher mining district.

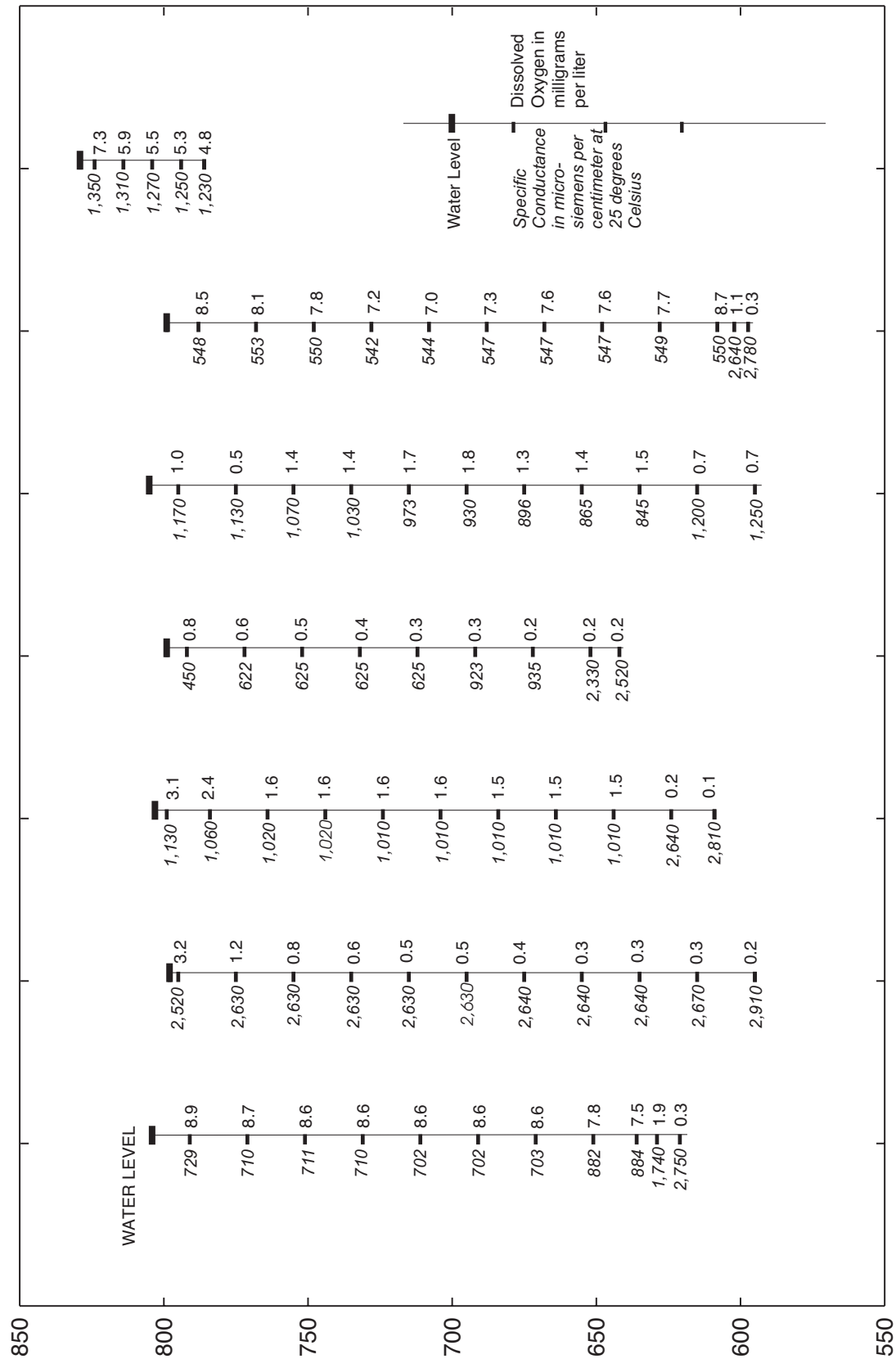

Figure 3. Water levels, specific conductance, and dissolved oxygen of water at selected depths in mineshafts sampled in 2002, Picher mining district.

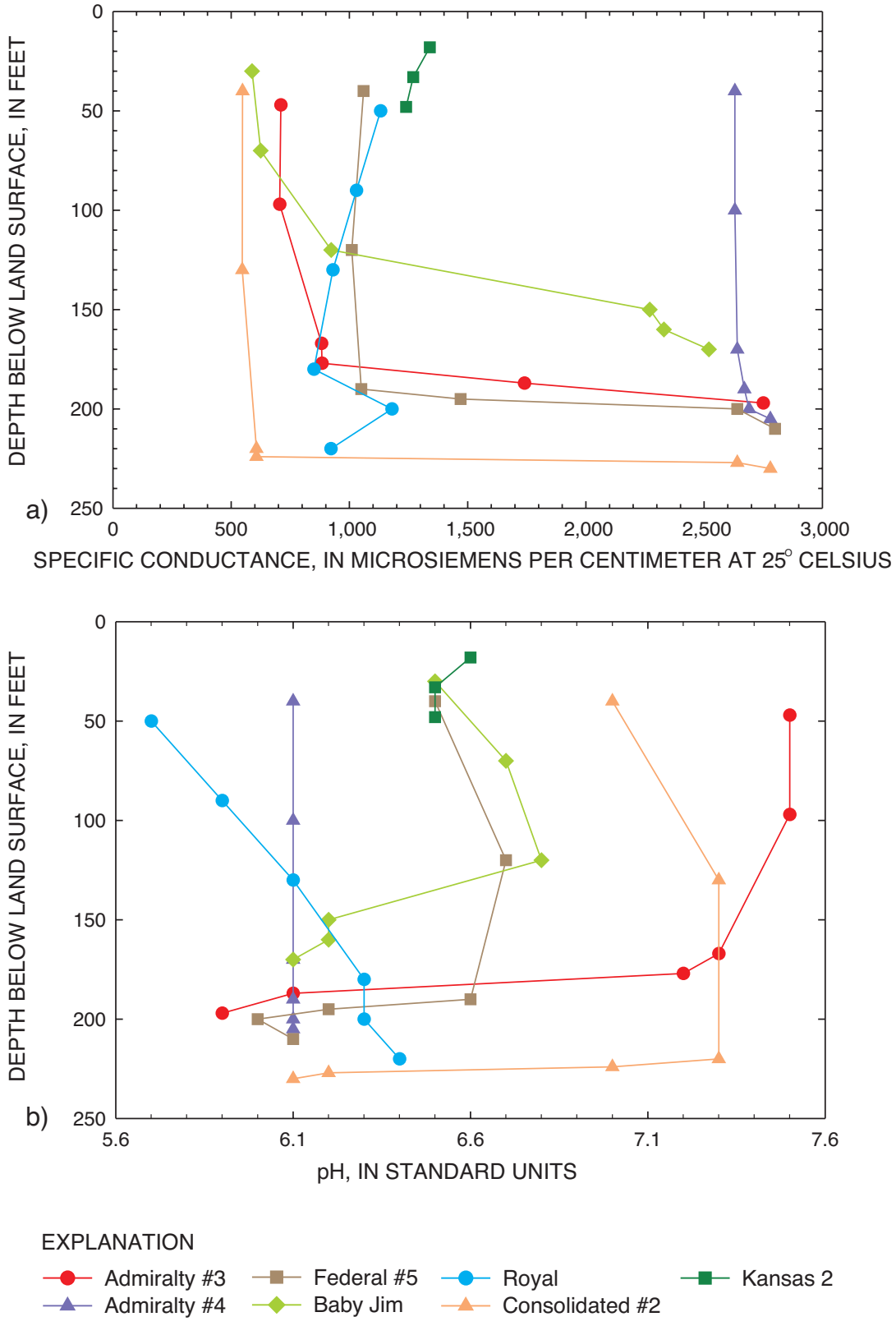

Figure 4. Comparison of water-quality concentrations from water samples collected in mineshafts in 2002, Picher mining district, a) specific conductance and b) pH.

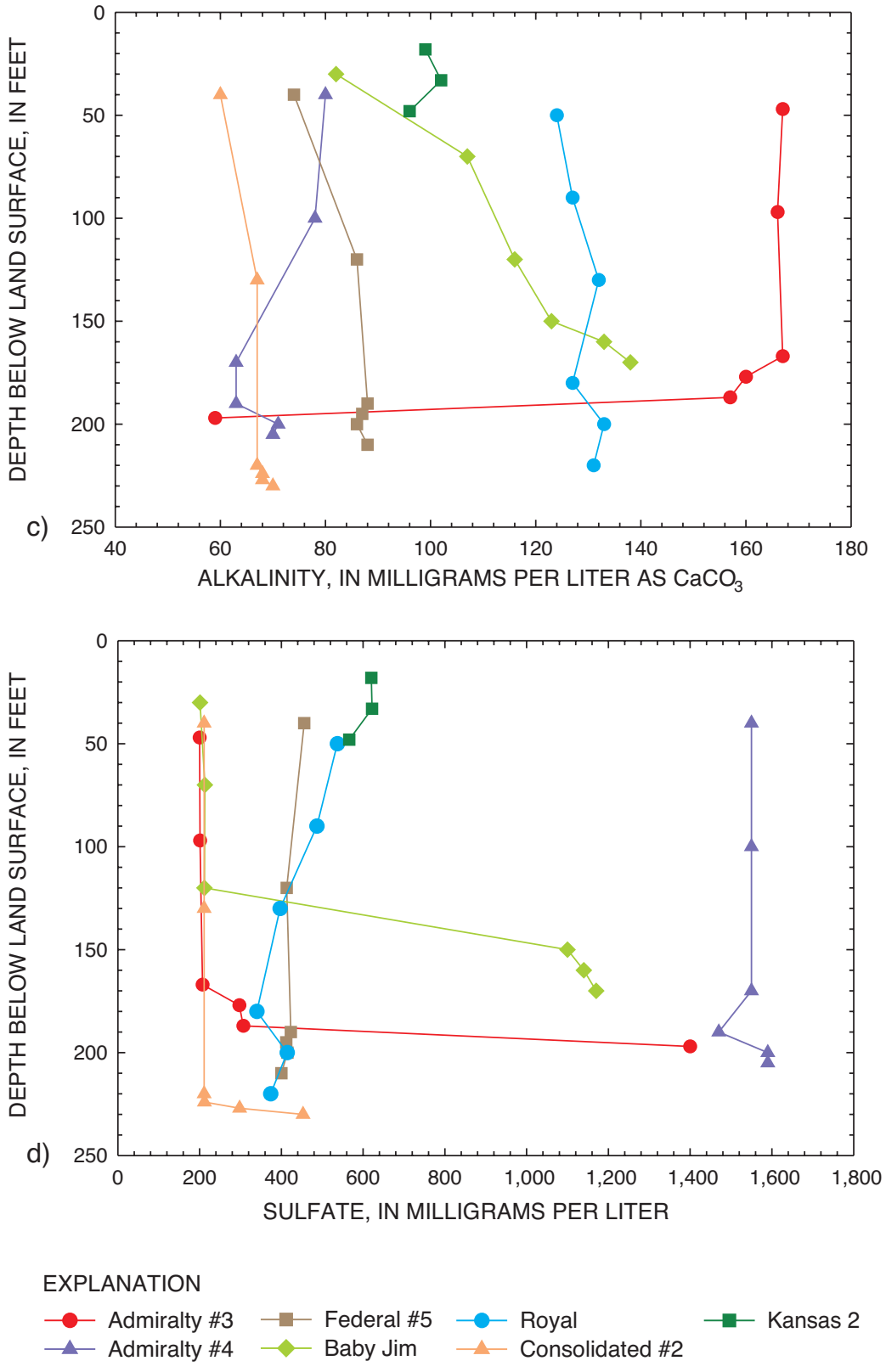

Figure 4. Comparison of water-quality concentrations from water samples collected in mineshafts in 2002, Picher mining district, c) alkalinity and d) sulfate.

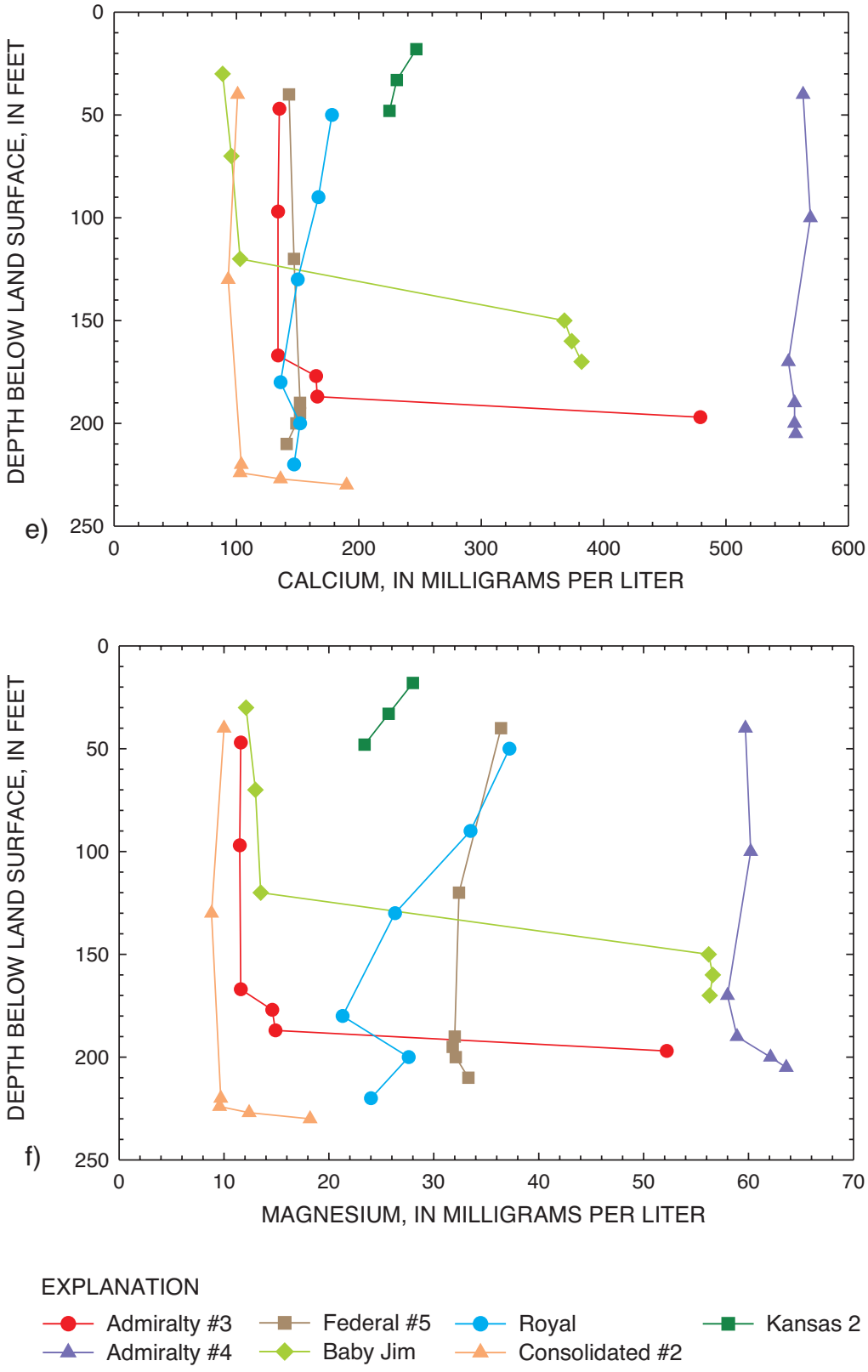

Figure 4. Comparison of water-quality concentrations from water samples collected in mineshafts in 2002, Picher mining district, e) calcium and f) magnesium.

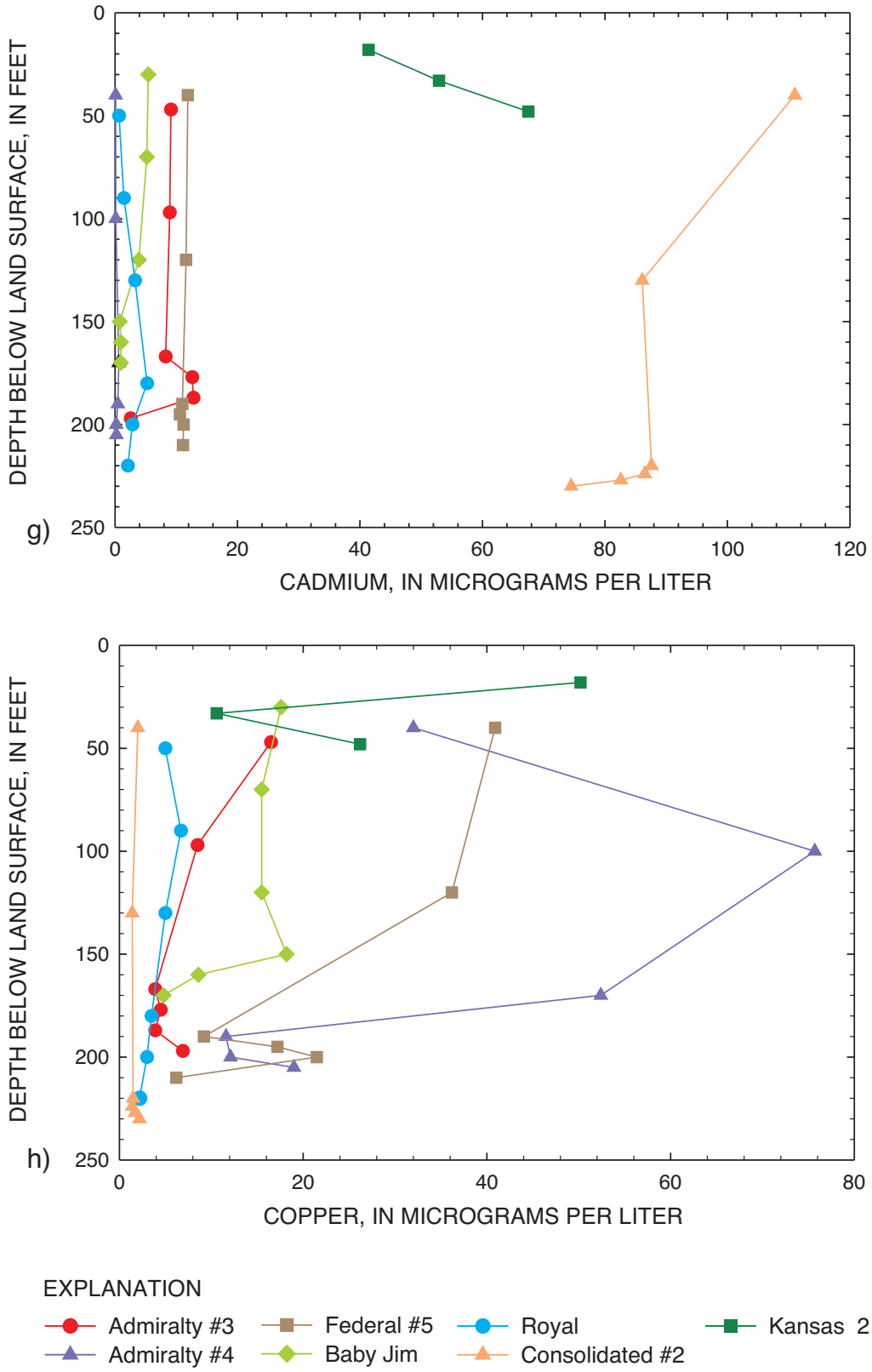

Figure 4. Comparison of water-quality concentrations from water samples collected in mineshafts in 2002, Picher mining district, g) cadmium and h) copper.

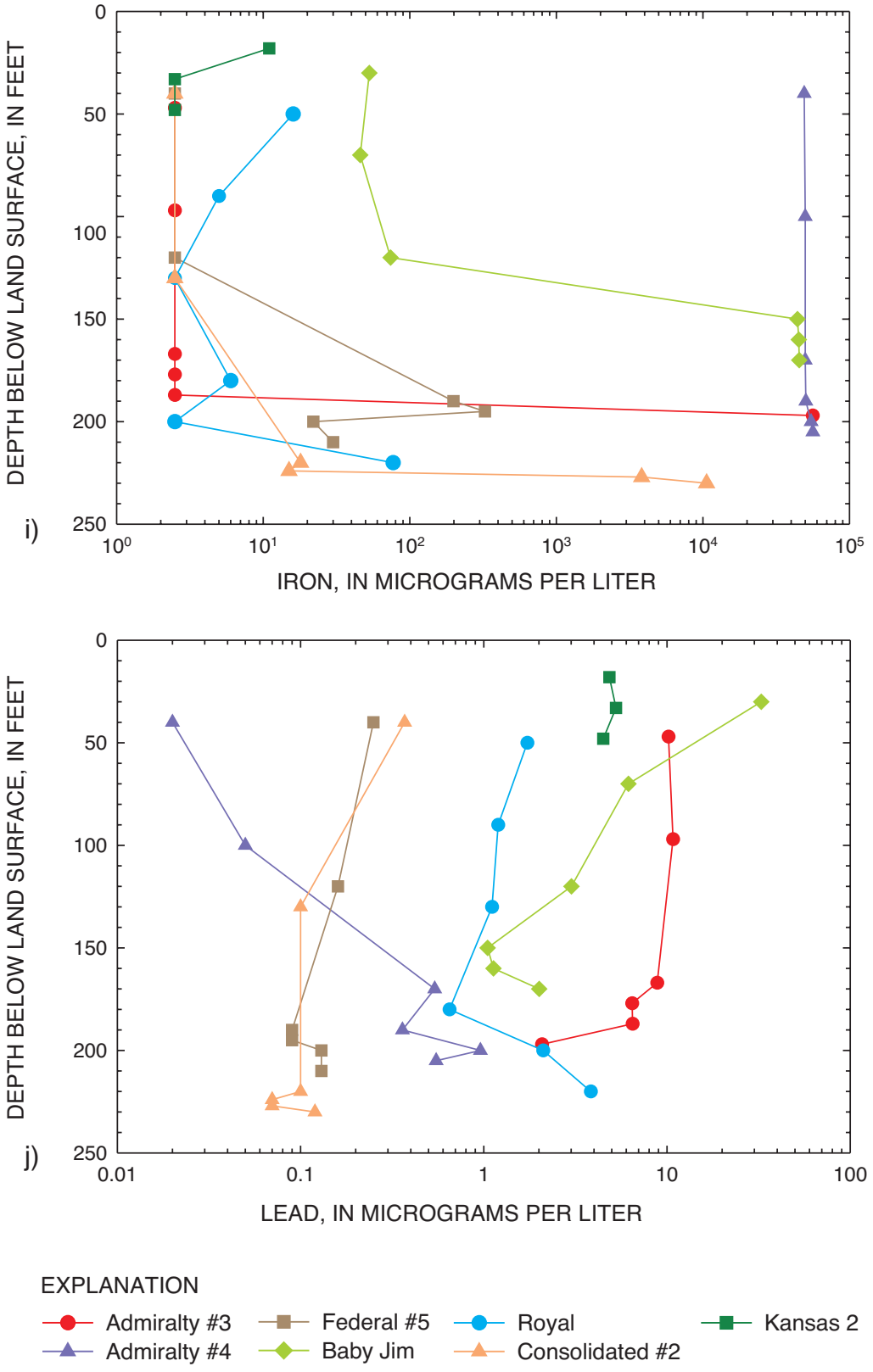

Figure 4. Comparison of water-quality concentrations from water samples collected in mineshafts in 2002, Picher mining district, i) iron and j) lead.

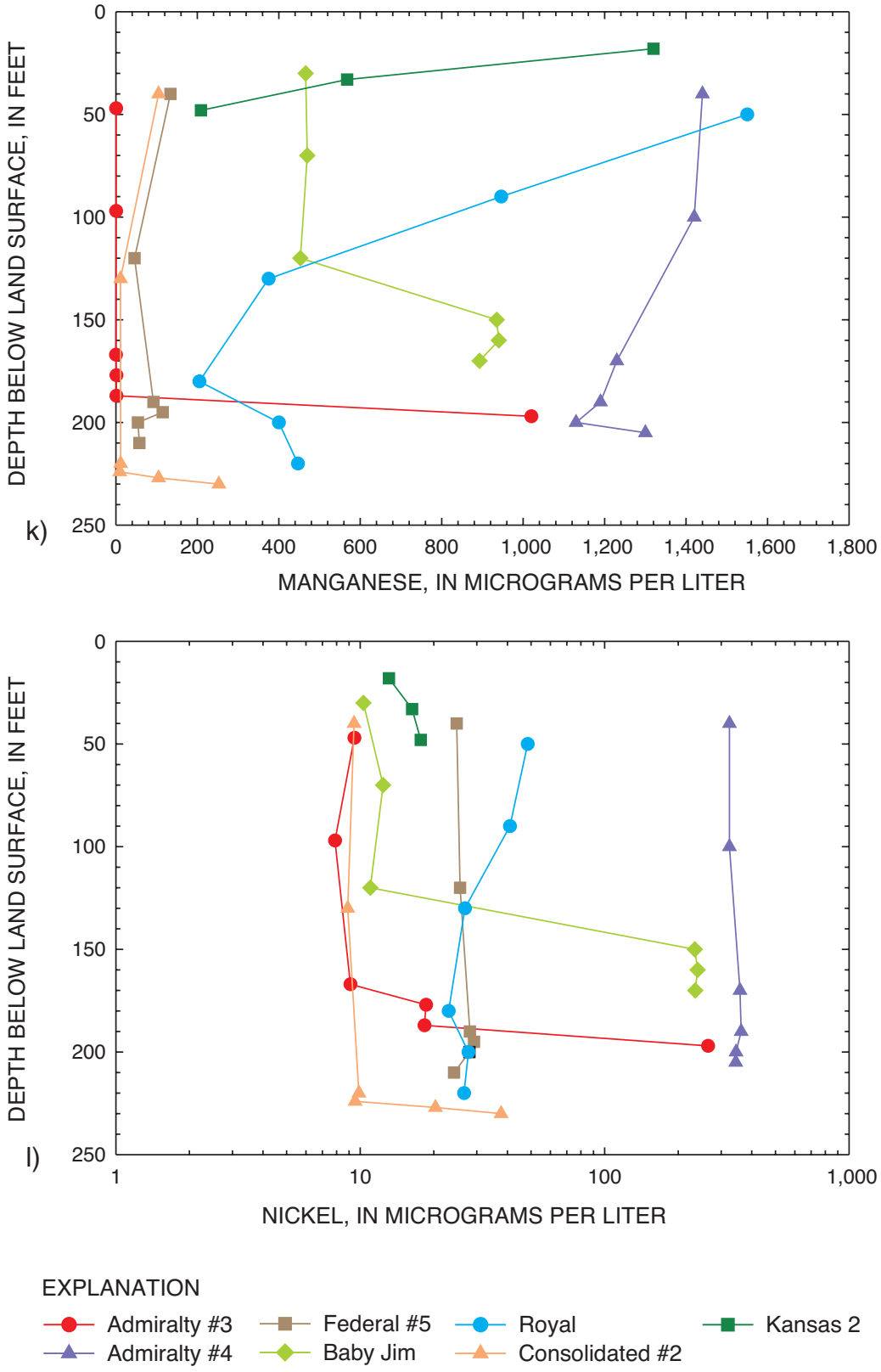

Figure 4. Comparison of water-quality concentrations from water samples collected in mineshafts in 2002, Picher mining district, k) manganese and l) nickel.

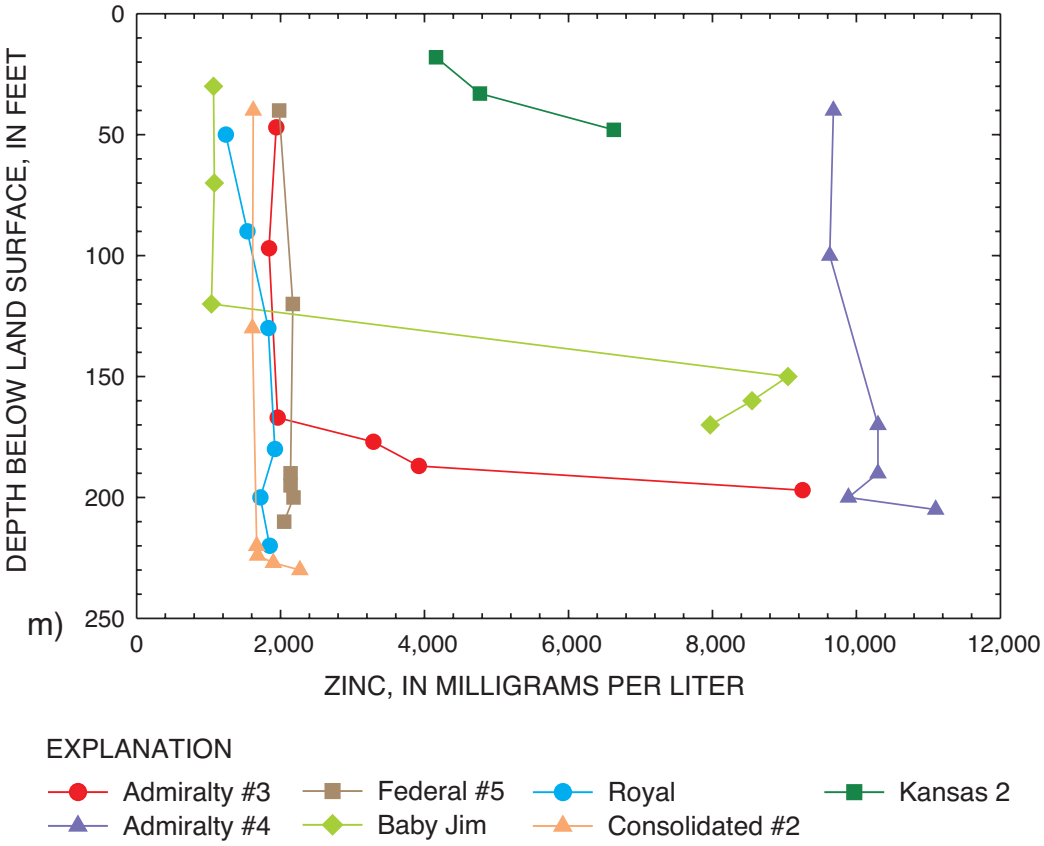

Figure 4. Comparison of water-quality concentrations from water samples collected in mineshafts in 2002, Picher mining district, m) zinc.

bottom of the shaft. Iron concentrations in the bottom of the shaft increased from 15 µg/L to 10,600 µg/L in a 6-foot interval. Zinc concentrations also increased at the bottom of the shaft (fig. 4m).

The Kansas 2 mineshaft (fig. 1) was only sampled at three depths. Most constituent concentrations were consistent throughout the shaft. Concentrations of cadmium and zinc at this site were generally greater when compared to other mineshafts (fig. 4). Dissolved-oxygen concentrations ranged from 7.3 mg/L near the water surface to 4.8 mg/L at the bottom of the shaft; however, the mineshaft was only 50 feet deep.

Comparison of 1976-77 and 2002 Ground-Water Quality

Water-Quality Trends

Water-quality data from all samples collected from mineshafts in 1976-77 were compared to water-quality data from all samples collected from mineshafts in 2002 using the Wilcoxon rank-sum test (Helsel and Hirsch, 1992) which can produce a p-value as a measure of the probability of similarity of data groups. The lesser p-values indicate less likelihood of the null hypothesis being significant.

The samples in 2002 were collected from the upper part of the water column and at depths that corresponded to depth sampled in 1976-77. To determine if samples collected from the deeper depths had similar characteristics, statistical tests also were run for the 1976-77 data and compared to 2002 data that were sampled from the deeper depths.

The Wilcoxon rank sum tests returned similar results for the data from all samples and for the data from only the deeper depths. Therefore, only results from the comparison of all samples collected in 1976-77 and all samples collected in 2002 are discussed in this report.

The Wilcoxon rank-sum tests indicate that the concentrations of most minewater indicator constituents were greater in 1976-77 data than in 2002 data. P-values for the Wilcoxon rank-sum test were less than 0.05 for all minewater indicators except pH and copper (figs. 5, 6). The p-value for pH was 0.2946 indicating that pH was not significantly different in the 1976-77 and 2002 data. The 1976-77 and 2002 data sets had similar median values; however, the pH values from the 1976-77 data had a much greater range. The 2002 data had fewer outlier data, indi-

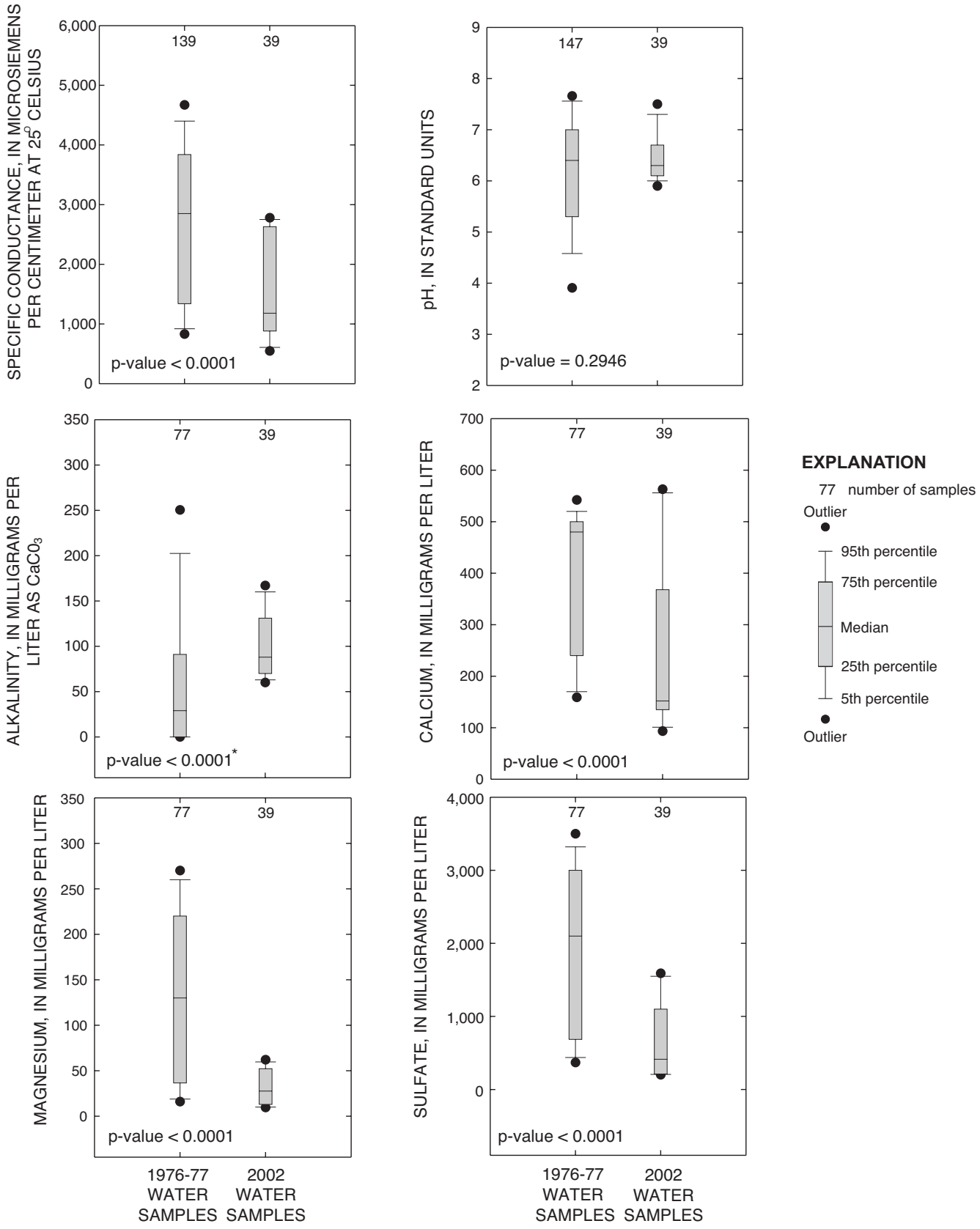

Figure 5. Selected water-quality concentrations from water samples collected in mineshafts in the Picher mining district for periods 1976-77 and 2002. *Alkalinity samples in 1976-77 were whole water samples while alkalinity samples in 2002 were filtered water samples.

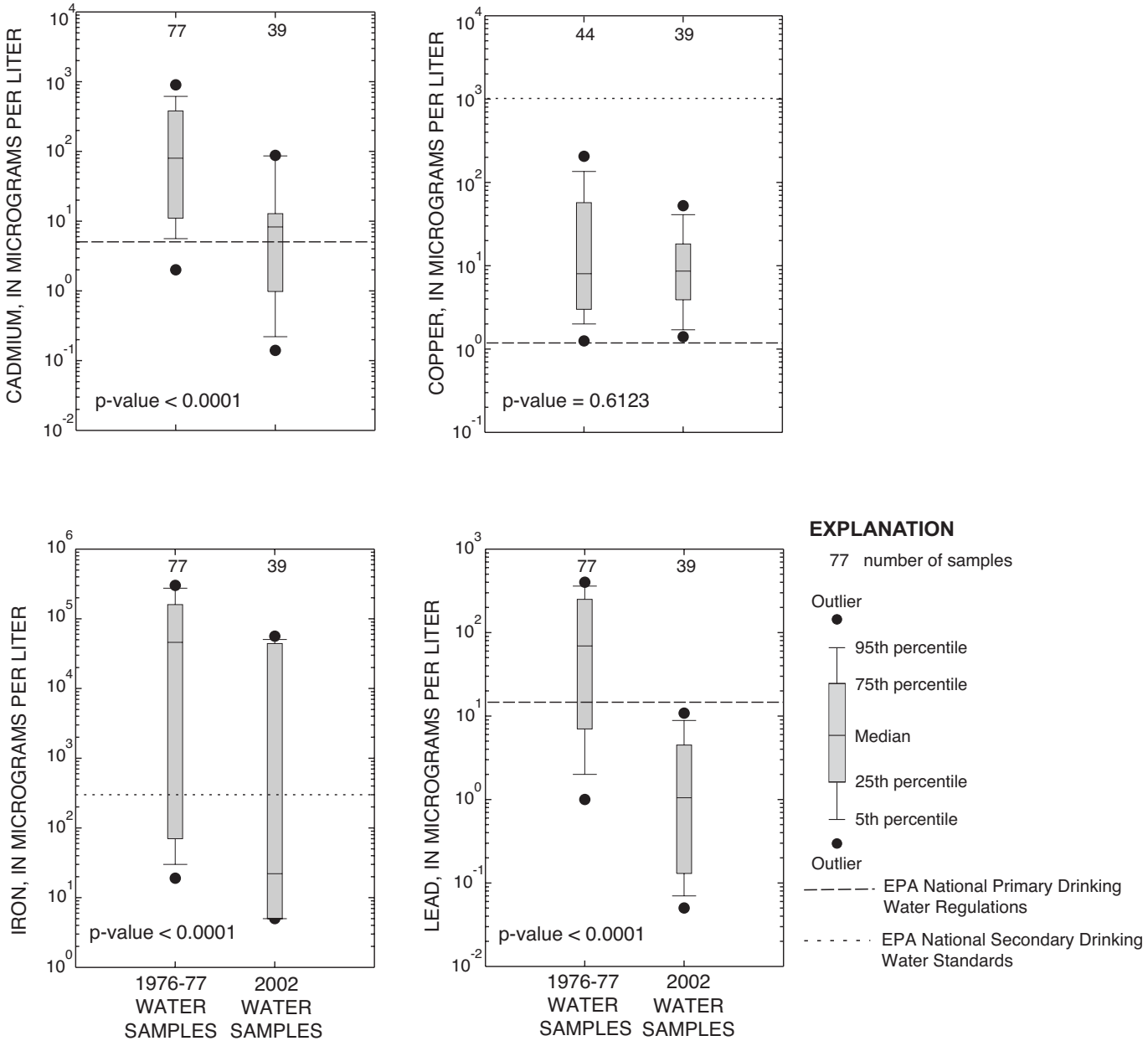

Figure 6. Selected water-quality concentrations from water samples collected in mineshafts in the Picher mining district for periods 1976-77 and 2002.

cating the pH in 2002 samples was more consistent than in 1976-77 samples.

The p-value calculated for copper by the Wilcoxon rank-sum test was 0.6123, indicating that the concentrations were not significantly different in 1976-77 and 2002 data. The median value of copper was similar in both the 1976-77 and 2002 data sets.

With the exception of pH and copper, the other mine water data sets had p-values of less than 0.0001 calculated for the Wilcoxon rank-sum test. The p-value of less than 0.0001 leads to the rejection of the null hypothesis for these constituents, meaning that the concentrations in samples collected in 2002 were different than concentrations in samples collected in 1976-77.

Specific conductance is related to the concentration of dissolved constituents in the water. Specific conductance in 2002 samples was less than in 1976-77 samples (fig. 5 and tables 1, 2).Therefore, the lesser specific conductance indicates lesser dissolved constituents. Playton and others (1980) also reported that specific conductance and concentrations of metals increased and pH decreased with depth.

The concentrations of metals in 2002 within individual shafts were more consistent compared to 1976-77 concentrations, but concentrations varied between mineshafts. The greater concentration of metals near the bases of the mineshafts could represent water from the mine rooms, and not the mine shafts, or could represent seepage from contaminated ground water in other parts of the Boone aquifer. However, without more information it is not possible to determine what is causing the greater concentrations at the bottom of the mineshafts.

Concentrations of sulfate in 2002 samples were less than concentrations in 1976-77 samples (tables 1, 2). The median value for sulfate was 414 mg/L in the 2002 water samples; whereas, the median value was 2,100 mg/L in the 1976-77 samples.

Minewater indicator constituents generally had lesser concentrations in 2002 than in 1976-77 (figs. 6, 7 and tables 1, 2). For example, the median concentration of zinc was 2,140 µg/L in 2002 and it was 120,000 µg/L in 1976-77. There also was variability in concentrations within the mineshafts in 2002. The varying concentrations of metals and ions between mineshafts could indicate differences in the system hydrology. The Consolidated #2 mineshaft and the Admiralty #3 mineshaft had greater dissolved-oxygen concentrations and lesser concentrations of metals and ions throughout the water column compared to other sampled mineshafts which indicates the sites may be recharge zones. The Admiralty #3 had a substantial decrease in dissolved oxygen and increase in metals and ions concentrations at the base of the shaft, indicating that the sample was collected from a mine room and not the mineshafts.

Greater concentrations of iron, manganese, nickel, and zinc were detected in the mineshafts that had less dissolved oxygen in the water. These metals precipitate out of solution to form oxide minerals in the presence of oxygen in the water. Also, in samples with greater concentrations of those metals, concentrations of lead and cadmium tended to be less. Lead and cadmium concentrations tended to be greater at the water surface than at the bottom of some mineshafts.

Water-Quality Standards

Many of the metals sampled in the 2002 study are regulated by the U. S. Environmental Protection Agency (USEPA) to protect human health and the environment. The USEPA (2002) established National Primary Drinking Water Regulations which protect human health, and National Secondary Drinking Water Standards that are designated to maintain the aesthetic quality (odor, taste, color) of the water.

The primary regulations of 5 µg/L for cadmium were exceeded in over 50 percent of the 2002 samples (fig. 6). Also in 2002 the secondary standards of 300 µg/L for iron, 100 µg/L for nickel, and 5,000 µg/L for zinc were exceeded in over 25 percent of the samples, and the secondary standard of 50 µg/L for manganese was exceeded in almost 75 percent of the samples (figs. 6, 7). Lead did not exceed the primary regulations of 15 µg/L; however, lead is not readily soluble in most water.

Contaminated water in the mineshafts may seep to adjoining less contaminated portions of the Boone aquifer, creeks and streams in hydraulic connection with the aquifer, and the underlying Roubidoux aquifer, the sole source of potable ground water in the area.

Summary

The Picher mining district of northeastern Oklahoma and southeastern Kansas was the site of lead and zinc mining from about 1900 until the mid-1970s. The primary sources of lead and zinc were sulfide minerals disseminated in the cherty limestone of the Boone Formation. Sulfide minerals from the Boone Formation include: sphalerite, galena, and the accessory minerals chalcopyrite, enargite, luzonite, marcasite, and pyrite. Exposure of these minerals to oxygenated water can create solutions with elevated concentrations of major ions and metals in ground water, surface water, and sediments.

A 1976-77 study of the ground-water quality in the Boone aquifer through sampling of open mineshafts, concluded that water quality was stratified in mined voids, with specific conductance, dissolved solids, sulfate, and metals increasing and pH decreasing with depth. Greater concentrations of most metals in water in the mineshafts compared to other parts of the Boone aquifer and increasing concentrations of metals with depth indicate that there was a substantial quantity of dissolved metals in ground water in the mining district. The 1976-77 study reported that water in seven mineshafts in the Picher mining district was not uniform with depth. The mines were sampled multiple times over the course of a year and no areal or seasonal variation in water quality was reported, but water in the mines was reported to be stratified. Specific conductance and water temperature tended to increase and pH tended to decrease with depth. Concentrations of dissolved solids and chemical

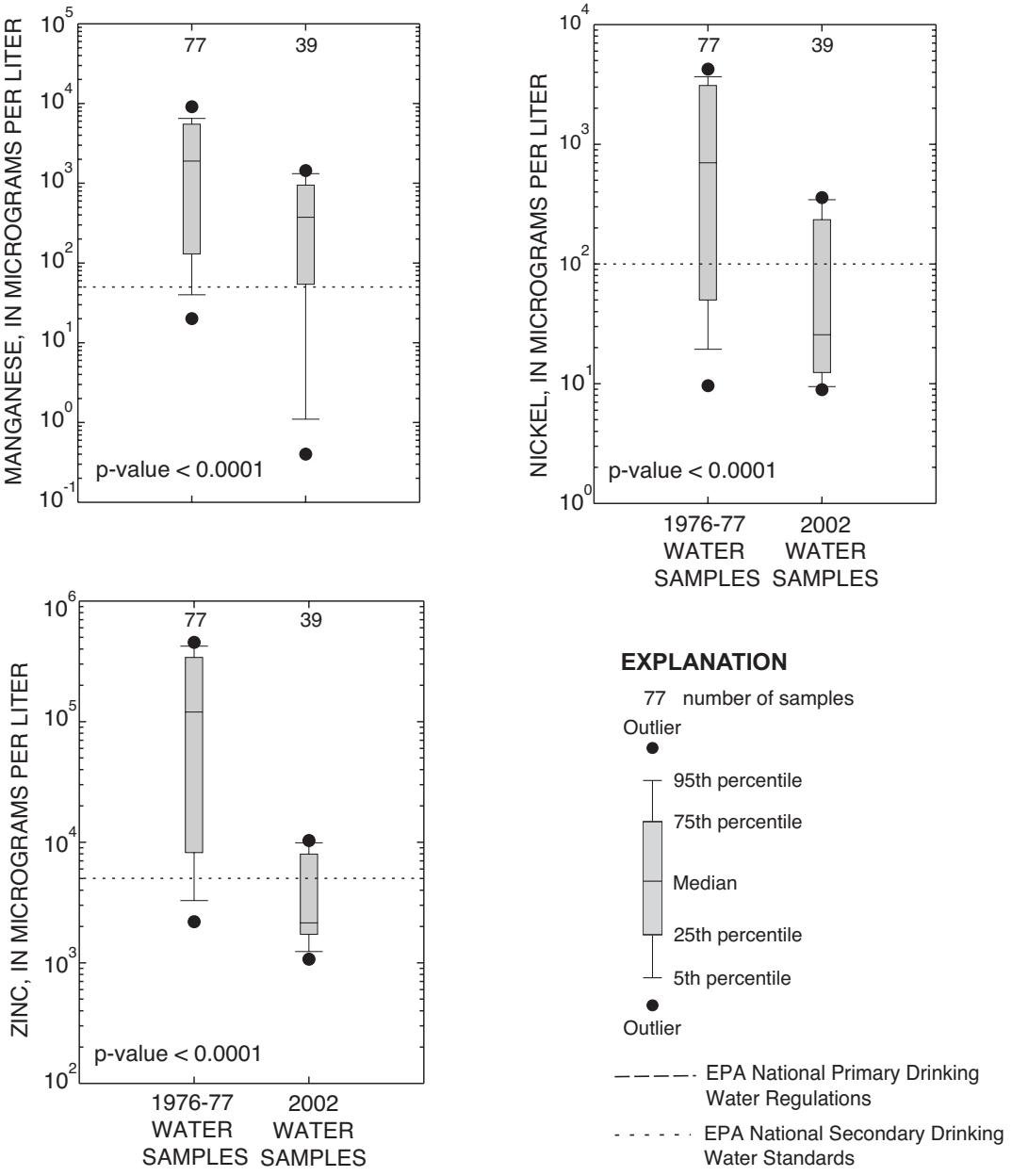

Figure 7. Selected water-quality concentrations from water samples collected in mineshafts in the Picher mining district for periods 1976-77 and 2002.

constituents, such as total and dissolved metals and dissolved sulfate, also increased with depth.

In 2002, seven mineshafts were sampled in the Picher mining area by the U.S. Geological Survey in cooperation with the Oklahoma Department of Environmental Quality. Attempts were made to sample the same sites sampled in 1976-77, but many of these sites were no longer accessible, so alternate sites were selected as near as possible to the sites sampled in 1976-77.

Vertical profiles of specific conductance, pH, water temperature, and dissolved-oxygen concentrations were collected from each mineshaft. Specific conductance tended to increase with depth in the mineshafts. The increases in specific conductance were typically gradual until the last 20 to 40 feet of the sampling column below which substantial increases were measured. In individual mineshafts the pH values were generally consistent within the top of the water column. Lesser pH values were measured at the base of some mineshafts, and at the water surface in some of the mineshafts that had debris on the surface. Water temperatures generally decreased with depth in the mineshafts, though a slight increase in temperature was measured at the very bottom of some shafts.

In 2002, concentrations of major ions and metals varied between the mineshafts and with depth. Most concentrations of metals and ions were consistent through the shafts. Some of the mineshafts had an increase in metals concentrations in the last 20 to 40 feet of the sampling column in the mineshaft. Increases in metals concentrations at the bottom of those shafts could indicate the quality of water in the minerooms rather than in the shafts.

Greater concentrations of iron, manganese, nickel, and zinc were detected in the mineshafts that had less dissolved oxygen in the water. These metals precipitate out of solution to form oxide minerals when in the presence of oxygen in the water. Also, in samples with large concentrations of those metals, concentrations of lead and cadmium tended to be small. Lead and cadmium concentrations tended to be greater near the water surface than at the bottom of some mineshafts.

Wilcoxon rank-sum tests were used to compare water-quality data collected in mineshafts in 1976-77 to water-quality data collected in 2002. The Wilcoxon rank-sum tests indicate that the concentrations of minewater indicator constituents were greater in 1976-77 than 2002 data. Specific conductance in 2002 samples was less than in 1976-77 samples. The 1976-77 and 2002 data sets for pH had similar median values; however, the pH values from the 1976-77 data fall in a much greater range. Concentrations of metals, except copper, from water samples collected from the mineshafts in 2002 were significantly less than concentrations of metals from samples in 1976-77.

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Appendixes

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977

[data from Playton and others, 1980[1]; ANC, acid neutralizing capacity is an unfiltered alkalinity titration; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected; --, no data]

Station number	Date	Time	Sampling depth (feet)	Specific conductance at 25°C, (µS/cm)	pH (standard unit)	Temperature, water (°C)	Hardness total (mg/L as CaCO3)	ANC, unfiltered, field (mg/L as $CaCO_3$)	Solids, residue at 180°C, dissolved (mg/L)
				Lavrion					
365732094502701	04/28/1976	1100	150	2,340	5.5	14.5	--	--	--
365732094502701	04/28/1976	1200	160	3,420	4.8	14.5	1,700	<1	4,080
365732094502701	04/28/1976	1300	170	3,720	4.8	14.5	--	--	--
365732094502701	04/28/1976	1400	182	3,680	3.9	15.0	1,800	<1	4,650
365732094502701	04/28/1976	1600	191	3,900	4.7	15.0	1,800	<1	4,360
				Skelton					
365738094495101	04/26/1976	1200	165	2,250	5.7	16.0	1,300	48	2,120
365738094495101	10/18/1976	1350	160	2,360	5.1	16.0	1,300	7	2,400
365738094495101	06/06/1977	1500	150	2,900	3.9	16.5	--	--	--
365738094495101	06/06/1977	1530	165	3,200	3.4	17.0	1,600	<1	3,480
				New Chicago					
365754094493401	04/29/1976	1100	167	2,520	7.6	16.0	--	--	--
365754094493401	04/29/1976	1200	174	2,500	7.6	16.0	1600	94	2,450
365754094493401	04/29/1976	1230	179	2,520	7.3	16.0	--	--	--
365754094493401	04/29/1976	1300	181	2,520	6.6	16.0	--	--	--
365754094493401	04/29/1976	1330	183	2,680	5.4	16.5	--	--	--
365754094493401	04/29/1976	1400	192	2,520	4.8	17.0	1,600	7	2,750
365754094493401	04/29/1976	1600	197	2,850	4.9	17.5	1,600	5	2,930
365754094493401	08/26/1976	1505	160	--	--	18.0	--	--	--
365754094493401	08/26/1976	1540	174	--	--	18.0	--	--	--
365754094493401	08/26/1976	1555	187	2,850	7.0	18.0	2,000	136	2,990

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977—Continued.

[data from Playton and others, 1980[1]; ANC, acid neutralizing capacity is an unfiltered alkalinity titration; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected; --, no data]

Station number	Date	Time	Sampling depth (feet)	Specific conductance at 25°C, (µS/cm)	pH (standard unit)	Temperature, water (°C)	Hardness total (mg/L as CaCO3)	ANC, unfiltered, field (mg/L as $CaCO_3$)	Solids, residue at 180°C, dissolved (mg/L)
365754094493401	08/26/1976	1605	197	3,840	3.8	17.5	1,800	<1	3,670
365754094493401	10/20/1976	1350	165	3,200	7.6	16.5	2,100	138	3,210
365754094493401	10/20/1976	1410	180	3,200	7.6	16.5	--	--	--
365754094493401	10/20/1976	1430	195	3,200	4.8	16.0	1,900	4	3,480
365754094493401	12/06/1976	1445	165	2,650	7.0	14.5	2,100	77	3,170
365754094493401	12/06/1976	1500	180	2,800	7.1	15.0	--	--	--
365754094493401	12/06/1976	1530	195	2,950	4.7	16.0	1,900	<1	3,410
365754094493401	02/17/1977	1620	165	3,150	6.2	14.5	2,000	20	3,090
365754094493401	02/17/1977	1630	180	3,150	6.2	14.5	--	--	--
365754094493401	02/17/1977	1640	195	3,200	4.2	15.0	1,800	<1	3,330
365754094493401	04/21/1977	1220	165	3,000	7.1	15.0	2,000	90	3,060
365754094493401	04/21/1977	1230	185	3,000	7.1	15.0	--	--	--
365754094493401	04/21/1977	1240	187	3,300	4.4	16.0	--	--	--
365754094493401	04/21/1977	1250	195	3,350	4.3	16.0	2,100	<1	3,630
365754094493401	06/08/1977	0815	160	2,550	7.1	16.0	1,700	150	2,690
365754094493401	06/08/1977	0845	180	3,300	4.6	15.0	1,900	<1	3,850
365754094493401	06/08/1977	0900	187	3,300	4.4	16.0	--	--	--
365754094493401	06/08/1977	0915	195	3,800	3.8	16.0	2,100	<1	4,800
				Lucky Bill					
365817094510201	04/22/1976	1000	178	1,850	6.5	14.0	910	308	1,580
365817094510201	04/22/1976	1030	198	1,850	6.5	14.0	--	--	--
365817094510201	04/22/1976	1115	204	1,750	6.5	14.0	--	--	--
365817094510201	04/22/1976	1200	210	4,210	6.2	14.0	2,100	48	4,380
365817094510201	04/22/1976	1300	216	4,630	5.6	14.0	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977—Continued.

[data from Playton and others, 1980[1]; ANC, acid neutralizing capacity is an unfiltered alkalinity titration; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected; --, no data]

Station number	Date	Time	Sampling depth (feet)	Specific conductance at 25°C, (µS/cm)	pH (standard unit)	Temperature, water (°C)	Hardness total (mg/L as CaCO3)	ANC, unfiltered, field (mg/L as $CaCO_3$)	Solids, residue at 180°C, dissolved (mg/L)
365817094510201	04/22/1976	1400	222	4,950	5.6	14.5	2,200	21	5,470
365817094510201	04/22/1976	1500	230	4,950	5.6	14.5	--	--	--
365817094510201	08/26/1976	1120	170	760	6.9	14.0	--	--	--
365817094510201	08/26/1976	1205	190	795	6.9	14.0	--	--	--
365817094510201	08/26/1976	1220	205	880	6.9	14.0	450	202	687
365817094510201	08/26/1976	1305	218	--	5.9	15.0	--	-	--
365817094510201	08/26/1976	1335	228	4,770	5.8	15.0	2,100	1	--
365817094510201	10/20/1976	0945	160	1,060	6.7	13.0	--	--	--
365817094510201	10/20/1976	1010	190	1,030	6.7	13.0	520	177	830
365817094510201	10/20/1976	1100	210	4,400	6.3	14.0	--	--	--
365817094510201	10/20/1976	1135	225	4,800	6.3	14.0	2,400	9	5,920
365817094510201	12/07/1976	1500	160	1,100	6.5	13.0	--	--	--
365817094510201	12/07/1976	1515	190	1,100	6.5	13.0	580	237	904
365817094510201	12/07/1976	1545	210	1,100	6.4	13.0	--	--	--
365817094510201	12/07/1976	1600	225	4,560	5.9	14.0	2,300	29	5,370
365817094510201	02/17/1977	1400	160	1,400	6.6	13.0	--	--	--
365817094510201	02/17/1977	1415	190	1,380	6.5	13.0	640	254	1,030
365817094510201	02/17/1977	1430	200	1,500	6.5	13.0	--	--	--
365817094510201	02/17/1977	1445	210	4,200	6.1	13.5	--	--	--
365817094510201	02/17/1977	1500	225	4,800	5.8	14.0	2,300	<1	5,230
365817094510201	04/21/1977	1550	160	1,500	6.5	13.5	--	--	--
365817094510201	04/21/1977	1600	190	1,500	6.5	14.0	780	260	1,200
365817094510201	04/21/1977	1615	205	2,900	6.3	14.5	--	--	--
365817094510201	04/21/1977	1640	225	4,800	5.8	15.0	2,400	<1	5,520

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977—Continued.

[data from Playton and others, 1980[1]; ANC, acid neutralizing capacity is an unfiltered alkalinity titration; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected; --, no data]

Station number	Date	Time	Sampling depth (feet)	Specific conductance at 25°C, (µS/cm)	pH (standard unit)	Temperature, water (°C)	Hardness total (mg/L as CaCO3)	ANC, unfiltered, field (mg/L as $CaCO_3$)	Solids, residue at 180°C, dissolved (mg/L)
365817094510201	06/07/1977	1215	155	1,100	6.5	14.0	570	250	910
365817094510201	06/07/1977	1240	190	1,450	6.6	14.0	--	--	--
365817094510201	06/07/1977	1300	205	3,100	6.4	14.0	--	--	--
365817094510201	06/07/1977	1315	225	4,200	5.9	15.0	2,400	5	5,650
Consolidated #2									
365927094485901	04/20/1976	0930	179	920	7.8	16.0	--	--	--
365927094485901	04/20/1976	1000	191	940	7.5	16.0	520	53	795
365927094485901	04/21/1976	1100	210	1,040	7.2	15.5	--	--	--
365927094485901	04/21/1976	1200	227	1,080	6.9	16.0	550	47	841
365927094485901	04/21/1976	1300	229	4,420	5.0	16.0	2,200	<1	5,160
365927094485901	04/21/1976	1400	234	4,600	4.8	16.0	2,300	<1	5,380
365927094485901	08/25/1976	1045	165	810	7.7	17.0	440	66	648
365927094485901	08/25/1976	1120	185	--	7.8	16.5	--	--	--
365927094485901	08/25/1976	1135	215	--	7.7	16.0	--	--	--
365927094485901	08/25/1976	1155	225	--	7.7	16.0	--	--	--
365927094485901	08/25/1976	1310	230	4,670	5.3	16.0	1,300	1	--
365927094485901	08/25/1976	1330	235	--	5.0	16.0	--	--	--
365927094485901	10/19/1976	1125	165	830	6.7	14.5	480	62	722
365927094485901	10/19/1976	1200	215	840	6.7	15.0	--	--	--
365927094485901	10/19/1976	1255	230	4,000	5.3	14.5	2,200	6	5,160
365927094485901	12/07/1976	1000	165	900	7.4	14.5	520	58	768
365927094485901	12/07/1976	1015	215	890	7.4	14.5	--	--	--
365927094485901	12/07/1976	1045	230	4,650	5.5	15.5	2,400	16	5,090
365927094485901	02/17/1977	0945	165	1,030	7.6	13.5	570	47	838

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977—Continued.

[data from Playton and others, 1980[1]; ANC, acid neutralizing capacity is an unfiltered alkalinity titration; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected; --, no data]

Station number	Date	Time	Sampling depth (feet)	Specific conductance at 25°C, (µS/cm)	pH (standard unit)	Temperature, water (°C)	Hardness total (mg/L as CaCO3)	ANC, unfiltered, field (mg/L as $CaCO_3$)	Solids, residue at 180°C, dissolved (mg/L)
365927094485901	02/17/1977	1130	215	1,080	7.5	14.0	--	--	--
365927094485901	02/17/1977	1200	222	4,080	5.7	14.5	--	--	--
365927094485901	02/17/1977	1215	230	4,280	5.3	15.0	2,200	<1	5,180
365927094485901	04/21/1977	0900	152	1,170	6.8	14.5	--	--	--
365927094485901	04/21/1977	0925	165	1,080	7.2	14.5	570	45	845
365927094485901	04/21/1977	0945	215	1,080	7.3	14.5	--	--	--
365927094485901	04/21/1977	1020	220	1,080	7.2	14.5	--	--	--
365927094485901	04/21/1977	1035	230	4,150	5.3	15.5	2,200	<1	4,970
365927094485901	06/07/1977	0830	165	810	7.4	16.0	440	64	622
365927094485901	06/07/1977	0845	215	740	7.6	15.5	--	--	--
365927094485901	06/07/1977	0900	225	810	7.1	16.0	--	--	--
365927094485901	06/07/1977	0915	230	4,100	5.6	16.0	2,200	<1	5,100
				Birthday					
365930094480001	04/23/1976	0930	168	4,100	5.2	16.0	2,200	7	5,150
365930094480001	04/23/1976	1030	172	4,200	5.2	15.5	--	--	--
365930094480001	04/23/1976	1130	175	4,200	5.2	15.5	--	--	--
365930094480001	04/23/1976	1230	182	4,390	5.3	15.0	2,200	20	5,200
365930094480001	08/25/1976	1630	160	1,060	7.2	16.0	540	88	864
365930094480001	08/25/1976	1645	166	--	3.4	17.0	--	--	--
365930094480001	08/25/1976	1655	173	--	3.7	16.5	--	--	--
365930094480001	08/25/1976	1715	177	--	4.2	16.0	--	--	--
365930094480001	08/25/1976	1730	180	3,840	5.8	16.0	1,600	1	--
365930094480001	10/19/1976	1520	162	1,900	6.0	15.0	890	42	1,590
365930094480001	10/19/1976	1610	180	3,800	5.6	15.0	2,100	37	4,620

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977—Continued.

[data from Playton and others, 1980[1]; ANC, acid neutralizing capacity is an unfiltered alkalinity titration; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected; --, no data]

Station number	Date	Time	Sampling depth (feet)	Specific conductance at 25°C, (µS/cm)	pH (standard unit)	Temperature, water (°C)	Hardness total (mg/L as CaCO3)	ANC, unfiltered, field (mg/L as $CaCO_3$)	Solids, residue at 180°C, dissolved (mg/L)
365930094480001	12/07/1976	1220	160	1,550	6.6	14.5	830	92	1,390
365930094480001	12/07/1976	1225	170	3,300	3.8	15.0	--	--	--
365930094480001	12/07/1976	1235	180	4,000	5.7	16.0	2,400	<1	5,000
365930094480001	02/18/1977	0845	145	3,000	5.7	15.0	--	--	--
365930094480001	02/18/1977	0905	160	3,850	5.0	15.0	1,900	<1	4,570
365930094480001	02/18/1977	0920	170	3,850	4.5	15.0	--	--	--
365930094480001	02/18/1977	0935	180	4,050	5.4	15.5	2,100	<1	4,860
365930094480001	04/21/1977	1415	155	1,550	7.2	15.0	730	69	1,260
365930094480001	04/21/1977	1425	167	3,650	5.3	15.5	--	--	--
365930094480001	04/21/1977	1455	170	3,850	5.0	16.0	2,000	<1	4,300
365930094480001	04/21/1977	1515	180	4,400	5.8	16.0	2,500	<1	5,100
365930094480001	06/08/1977	1200	155	830	6.8	16.0	410	77	630
365930094480001	06/08/1977	1220	162	830	6.8	15.5	--	--	--
365930094480001	06/08/1977	1240	166	3,500	5.1	16.0	--	--	--
365930094480001	06/08/1977	1300	170	3,800	5.0	16.0	2,200	<1	4,960
365930094480001	06/08/1977	1325	175	3,800	5.3	16.0	--	--	--
365930094480001	06/08/1977	1345	180	4,100	5.8	16.5	2,500	32	5,340
				Kansas 1					
--	04/27/1976	--	200	1,300	7.6	15.0	620	119	995
--	04/27/1976	--	205	1,340	6.9	16.0	--	--	--
--	04/27/1976	--	211	1,800	6.2	16.0	--	--	--
--	04/27/1976	--	222	2,050	6.2	16.0	1,100	51	1,750
--	04/27/1976	--	230	2,850	6.8	17.0	1,300	204	2,340
--	04/27/1976	--	259	2,800	6.7	17.5	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977—Continued.

[data from Playton and others, 1980[1]; ANC, acid neutralizing capacity is an unfiltered alkalinity titration; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected; --, no data]

Station number	Date	Time	Sampling depth (feet)	Specific conductance at 25°C, (µS/cm)	pH (standard unit)	Temperature, water (°C)	Hardness total (mg/L as CaCO3)	ANC, unfiltered, field (mg/L as $CaCO_3$)	Solids, residue at 180°C, dissolved (mg/L)
--	04/27/1976	--	287	2,850	6.7	17.5	--	--	--
--	04/27/1976	--	298	2,780	6.7	17.5	1,200	212	2,330
--	10/21/1976	--	200	1,200	8.6	16.0	590	125	953
--	10/21/1976	--	220	2,850	7.0	16.5	1,200	187	2,300
--	10/21/1976	--	260	2,850	7.0	16.5	--	--	--
--	10/21/1976	--	298	2,850	7.0	17.0	--	--	--
--	06/09/1977	--	180	1,200	7.5	16.5	--	--	--
--	06/09/1977	--	200	1,200	8.3	16.0	740	130	1,050
--	06/09/1977	--	210	2,350	6.6	16.5	--	--	--
--	06/09/1977	--	220	2,750	7.2	17.0	1,200	190	2,270
--	06/09/1977	--	240	2,650	6.7	17.0	--	--	--
--	06/09/1977	--	260	2,600	6.7	16.5	--	--	--
--	06/09/1977	--	280	2,650	6.7	17.0	--	--	--
--	06/09/1977	--	298	2,650	6.7	17.0	--	--	--

[1]Data retrieved from USGS National Water Information System data base on March 12, 2003. Differences between this data and Playton and other (1980) may be due to rounding.

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)
Lavrion											
365732094502701	04/28/1976	1100	150	--	--	--	--	--	--	--	--
365732094502701	04/28/1976	1200	160	470	120	45	4.0	2,500	7.2	9.8	13
365732094502701	04/28/1976	1300	170	--	--	--	--	--	--	--	--
365732094502701	04/28/1976	1400	182	510	130	55	4.5	2,900	8.0	15	17
365732094502701	04/28/1976	1600	191	520	120	53	4.3	2,700	7.8	14	16
Skelton											
365738094495101	04/26/1976	1200	165	450	38	22	1.8	1,300	4.7	1.8	12
365738094495101	10/18/1976	1350	160	440	45	25	1.6	1,600	4.6	2.9	14
365738094495101	06/06/1977	1500	150	--	--	--	--	--	--	--	--
365738094495101	06/06/1977	1530	165	500	88	33	1.3	2,300	5.0	2.3	18
New Chicago											
365754094493401	04/29/1976	1100	167	--	--	--	--	--	--	--	--
365754094493401	04/29/1976	1200	174	430	130	29	2.9	1,800	4.5	1.0	9.3
365754094493401	04/29/1976	1230	179	--	--	--	--	--	--	--	--
365754094493401	04/29/1976	1300	181	--	--	--	--	--	--	--	--
365754094493401	04/29/1976	1330	183	--	--	--	--	--	--	--	--
365754094493401	04/29/1976	1400	192	490	82	28	1.9	2,000	4.6	2.2	11
365754094493401	04/29/1976	1600	197	500	86	28	1.6	2,100	4.8	2.6	12
365754094493401	08/26/1976	1505	160	--	--	--	--	--	--	--	--
365754094493401	08/26/1976	1540	174	--	--	--	--	--	--	--	--
365754094493401	08/26/1976	1555	187	520	170	34	4.1	1,900	8.8	1.1	14
365754094493401	08/26/1976	1605	197	510	130	36	2.8	2,300	8.1	7.2	16
365754094493401	10/20/1976	1350	165	490	210	140	4.3	2,300	7.4	1.9	12
365754094493401	10/20/1976	1410	180	--	--	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)
365754094493401	10/20/1976	1430	195	510	140	36	3.1	2,300	5.8	5.4	14
365754094493401	12/06/1976	1445	165	500	200	44.0	3.7	2,000	7.0	1.3	12
365754094493401	12/06/1976	1500	180	--	--	--	--	--	--	--	--
365754094493401	12/06/1976	1530	195	510	140	36	3.1	2,600	5.6	2.9	15
365754094493401	02/17/1977	1620	165	490	180	44	3.4	2,000	7.3	1.9	11
365754094493401	02/17/1977	1630	180	--	--	--	--	--	--	--	--
365754094493401	02/17/1977	1640	195	500	140	39	3.2	2,200	14	3.9	14
365754094493401	04/21/1977	1220	165	490	190	45	4.0	1,900	7.3	1.4	13
365754094493401	04/21/1977	1230	185	--	--	--	--	--	--	--	--
365754094493401	04/21/1977	1240	187	--	--	--	--	--	--	--	--
365754094493401	04/21/1977	1250	195	600	140	39	3.2	2,500	72	8.0	15
365754094493401	06/08/1977	0815	160	470	130	32	3.2	1,600	4.8	0.9	13
365754094493401	06/08/1977	0845	180	530	140	38	3.5	2,400	5.4	8.3	19
365754094493401	06/08/1977	0900	187	--	--	--	--	--	--	--	--
365754094493401	06/08/1977	0915	195	500	200	57	4.0	3,000	6.2	1.0	19
						Lucky Bill					
365817094510201	04/22/1976	1000	178	300	39	57	8.5	810	10	0.30	19
365817094510201	04/22/1976	1030	198	--	--	--	--	--	--	--	--
365817094510201	04/22/1976	1115	204	--	--	--	--	--	--	--	--
365817094510201	04/22/1976	1200	210	500	210	68	4.5	2,800	13	5.0	8.1
365817094510201	04/22/1976	1300	216	--	--	--	--	--	--	--	--
365817094510201	04/22/1976	1400	222	480	250	87	6.0	3,000	16	9.2	7.6
365817094510201	04/22/1976	1500	230	--	--	--	--	--	--	--	--
365817094510201	08/26/1976	1120	170	--	--	--	--	--	--	--	--
365817094510201	08/26/1976	1205	190	--	--	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)
365817094510201	08/26/1976	1220	205	160	13	16	4.0	320	3.8	0.3	19
365817094510201	08/26/1976	1305	218	--	--	--	--	--	--	--	--
365817094510201	08/26/1976	1335	228	490	220	90	9.2	3,400	21	9.4	9.0
365817094510201	10/20/1976	0945	160	--	--	--	--	--	--	--	--
365817094510201	10/20/1976	1010	190	180	16	19	4.5	380	4.0	0.7	11
365817094510201	10/20/1976	1100	210	--	--	--	--	--	--	--	--
365817094510201	10/20/1976	1135	225	470	290	92	8.2	3,500	23	7.5	7.8
365817094510201	12/07/1976	1500	160	--	--	--	--	--	--	--	--
365817094510201	12/07/1976	1515	190	200	19	23	4.7	430	4.6	0.1	19
365817094510201	12/07/1976	1545	210	--	--	--	--	--	--	--	--
365817094510201	12/07/1976	1600	225	490	260	81	7.0	3,100	20	6.6	8.8
365817094510201	02/17/1977	1400	160	--	--	--	--	--	--	--	--
365817094510201	02/17/1977	1415	190	220	21	29	5.4	510	14	1.2	22
365817094510201	02/17/1977	1430	200	--	--	--	--	--	--	--	--
365817094510201	02/17/1977	1445	210	--	--	--	--	--	--	--	--
365817094510201	02/17/1977	1500	225	480	260	82	6.5	3,300	18	7.4	10
365817094510201	04/21/1977	1550	160	--	--	--	--	--	--	--	--
365817094510201	04/21/1977	1600	190	270	26	36	6.2	610	6.6	0.4	19
365817094510201	04/21/1977	1615	205	--	--	--	--	--	--	--	--
365817094510201	04/21/1977	1640	225	520	270	85	6.8	3,500	15	7.9	11
365817094510201	06/07/1977	1215	155	190	23	26	4.7	420	4.5	0.2	19
365817094510201	06/07/1977	1240	190	--	--	--	--	--	--	--	--
365817094510201	06/07/1977	1300	205	--	--	--	--	--	--	--	--
365817094510201	06/07/1977	1315	225	500	280	86	6.2	3,400	15	7.9	10

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)
						Consolidated #2					
365927094485901	04/20/1976	0930	179	--	--	--	--	--	--	--	--
365927094485901	04/20/1976	1000	191	170	24	10	1.7	460	2.1	0.3	10
365927094485901	04/21/1976	1100	210	--	--	--	--	--	--	--	--
365927094485901	04/21/1976	1200	227	180	25	11	1.8	520	1.7	0.4	9.8
365927094485901	04/21/1976	1300	229	500	240	80	2.2	3,100	6.2	1.9	8.4
365927094485901	04/21/1976	1400	234	520	240	8.0	2.2	3,200	6.8	1.6	9.8
365927094485901	08/25/1976	1045	165	150	16	7.1	1.6	360	0.5	0.4	11
365927094485901	08/25/1976	1120	185	--	--	--	--	--	--	--	--
365927094485901	08/25/1976	1135	215	--	--	--	--	--	--	--	--
365927094485901	08/25/1976	1155	225	--	--	--	--	--	--	--	--
365927094485901	08/25/1976	1310	230	340	100	43	3.4	1,600	9.1	1.7	11
365927094485901	08/25/1976	1330	235	--	--	--	--	--	--	--	--
365927094485901	10/19/1976	1125	165	160	20	8.9	2.0	440	1.1	0.7	11
365927094485901	10/19/1976	1200	215	--	--	--	--	--	--	--	--
365927094485901	10/19/1976	1255	230	510	230	81	4.1	3,400	7.0	2.4	7.7
365927094485901	12/07/1976	1000	165	170	23	9.7	1.9	490	1.3	0.3	12
365927094485901	12/07/1976	1015	215	--	--	--	--	--	--	--	--
365927094485901	12/07/1976	1045	230	560	240	77	3.9	3,500	7.0	1.9	9.2
365927094485901	02/17/1977	0945	165	180	29	12	2.1	510	3.1	0.5	13
365927094485901	02/17/1977	1130	215	--	--	--	--	--	--	--	--
365927094485901	02/17/1977	1200	222	--	--	--	--	--	--	--	--
365927094485901	02/17/1977	1215	230	520	230	81	3.6	3,300	6.8	3.5	8.0
365927094485901	04/21/1977	0900	152	--	--	--	--	--	--	--	--
365927094485901	04/21/1977	0925	165	180	29	12	2.1	500	1.8	0.6	12

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)
365927094485901	04/21/1977	0945	215	--	--	--	--	--	--	--	--
365927094485901	04/21/1977	1020	220	--	--	--	--	--	--	--	--
365927094485901	04/21/1977	1035	230	510	230	77	3.4	3,000	6.3	1.5	8.8
365927094485901	06/07/1977	0830	165	150	16	7.1	1.4	370	1.1	0.4	12
365927094485901	06/07/1977	0845	215	--	--	--	--	--	--	--	--
365927094485901	06/07/1977	0900	225	--	--	--	--	--	--	--	--
365927094485901	06/07/1977	0915	230	510	220	80.0	3.8	3,100	5.9	1.8	8.4
						Birthday					
365930094480001	04/23/1976	0930	168	490	230	52	2.7	3,000	6.7	8.1	11
365930094480001	04/23/1976	1030	172	--	--	--	--	--	--	--	--
365930094480001	04/23/1976	1130	175	--	--	--	--	--	--	--	--
365930094480001	04/23/1976	1230	182	490	240	53	2.6	3,000	6.8	7.2	11
365930094480001	08/25/1976	1630	160	160	35	29	3.7	520	3.2	0.4	6.8
365930094480001	08/25/1976	1645	166	--	--	--	--	--	--	--	--
365930094480001	08/25/1976	1655	173	--	--	--	--	--	--	--	--
365930094480001	08/25/1976	1715	177	--	--	--	--	--	--	--	--
365930094480001	08/25/1976	1730	180	420	130	40	3.8	2,100	9.1	2.9	10
365930094480001	10/19/1976	1520	162	250	64	40	4.9	1,000	4.7	1.8	6.4
365930094480001	10/19/1976	1610	180	490	220	47	4.1	3,100	7.3	2.5	12
365930094480001	12/07/1976	1220	160	230	62	63	6.3	870	5.5	0.5	7.8
365930094480001	12/07/1976	1225	170	--	--	--	--	--	--	--	--
365930094480001	12/07/1976	1235	180	540	260	46	3.0	3,500	6.9	1.1	12
365930094480001	02/18/1977	0845	145	--	--	--	--	--	--	--	--
365930094480001	02/18/1977	0905	160	480	180	54	4.2	2,900	7.4	8.6	13
365930094480001	02/18/1977	0920	170	--	--	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)
365930094480001	02/18/1977	0935	180	490	210	51	3.8	3,200	6.8	6.5	13
365930094480001	04/21/1977	1415	155	200	55	59	4.6	760	3.4	1.1	4.9
365930094480001	04/21/1977	1425	167	--	--	--	--	--	--	--	--
365930094480001	04/21/1977	1455	170	470	190	61	4.6	2,700	6.4	7.6	13
365930094480001	04/21/1977	1515	180	570	270	47	3.2	3,100	6.9	1.2	12
365930094480001	06/08/1977	1200	155	120	27	19	3.7	360	2.3	0.6	6.8
365930094480001	06/08/1977	1220	162	--	--	--	--	--	--	--	--
365930094480001	06/08/1977	1240	166	--	--	--	--	--	--	--	--
365930094480001	06/08/1977	1300	170	500	230	63	5.0	3,200	6.9	8.6	14
365930094480001	06/08/1977	1325	175	--	--	--	--	--	--	--	--
365930094480001	06/08/1977	1345	180	540	270	44	3.5	3,200	7.2	0.4	9.4
						Kansas 1					
--	04/27/1976	--	200	220	18	38	3.4	560	3.1	0.3	8.5
--	04/27/1976	--	205	--	--	--	--	--	--	--	--
--	04/27/1976	--	211	--	--	--	--	--	--	--	--
--	04/27/1976	--	222	270	92	80	4.5	1,200	6.4	1.3	8.5
--	04/27/1976	--	230	340	98	200	7.4	1,300	85	2.1	8
--	04/27/1976	--	259	--	--	--	--	--	--	--	--
--	04/27/1976	--	287	--	--	--	--	--	--	--	--
--	04/27/1976	--	298	330	97	200	7.6	1,300	85	2.1	8
--	10/21/1976	--	200	210	15	36	3.2	520	3.1	0.6	7.8
--	10/21/1976	--	220	320	100	200	7.1	1,400	80	2.2	7.4
--	10/21/1976	--	260	--	--	--	--	--	--	--	--
--	10/21/1976	--	298	--	--	--	--	--	--	--	--
--	06/09/1977	--	180	--	--	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)
--	06/09/1977	--	200	270	16	22	2.9	600	2.3	0.3	9.2
--	06/09/1977	--	210	--	--	--	--	--	--	--	--
--	06/09/1977	--	220	330	92	190	6.9	1,300	80	2.1	8.8
--	06/09/1977	--	240	--	--	--	--	--	--	--	--
--	06/09/1977	--	260	--	--	--	--	--	--	--	--
--	06/09/1977	--	280	--	--	--	--	--	--	--	--
--	06/09/1977	--	298	--	--	--	--	--	--	--	--

[1]Data retrieved from USGS National Water Information System data base on March 12, 2003. Differences between this data and Playton and other (1980) may be due to rounding.

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Aluminum, dissolved (µg/L)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Iron, dissolved (µg/L)
Lavrion											
365732094502701	04/28/1976	1100	150	--	--	--	--	--	--	--	--
365732094502701	04/28/1976	1200	160	14,000	<1	<100	<20	30	40	140	76,000
365732094502701	04/28/1976	1300	170	--	--	--	--	--	--	--	--
365732094502701	04/28/1976	1400	182	29,000	<1	<100	10	60	40	160	130,000
365732094502701	04/28/1976	1600	191	26,000	1	<100	10	60	40	120	130,000
Skelton											
365738094495101	04/26/1976	1200	165	540	<1	<100	M	U	90	M	140
365738094495101	10/18/1976	1350	160	5,500	1	<100	470	<20	50	50	28,000
365738094495101	06/06/1977	1500	150	--	--	--	--	--	--	--	--
365738094495101	06/06/1977	1530	165	30,000	1	200	1,200	140	350	220	60
New Chicago											
365754094493401	04/29/1976	1100	167	--	--	--	--	--	--	--	--
365754094493401	04/29/1976	1200	174	30	<1	<100	10	<20	90	M	40
365754094493401	04/29/1976	1230	179	--	--	--	--	--	--	--	--
365754094493401	04/29/1976	1300	181	--	--	--	--	--	--	--	--
365754094493401	04/29/1976	1330	183	--	--	--	--	--	--	--	--
365754094493401	04/29/1976	1400	192	110	<1	<100	20	U	U	20	100
365754094493401	04/29/1976	1600	197	5,400	<1	<100	130	20	U	40	20,000
365754094493401	08/26/1976	1505	160	--	--	--	--	--	--	--	--
365754094493401	08/26/1976	1540	174	--	--	--	--	--	--	--	--
365754094493401	08/26/1976	1555	187	80	--	--	<20	--	--	--	80
365754094493401	08/26/1976	1605	197	<100	--	--	630	--	--	--	67,000
365754094493401	10/20/1976	1350	165	20	<1	<100	20	<20	M	M	30
365754094493401	10/20/1976	1410	180	--	--	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Aluminum, dissolved (µg/L)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Iron, dissolved (µg/L)
365754094493401	10/20/1976	1430	195	13,000	1	<100	410	30	60	100	55,000
365754094493401	12/06/1976	1445	165	10	--	--	10	--	--	--	30
365754094493401	12/06/1976	1500	180	--	--	--	--	--	--	--	--
365754094493401	12/06/1976	1530	195	14,000	--	--	390	--	--	--	59,000
365754094493401	02/17/1977	1620	165	820	--	--	M	--	--	--	30
365754094493401	02/17/1977	1630	180	--	--	--	--	--	--	--	--
365754094493401	02/17/1977	1640	195	<100	--	--	340	--	--	--	41,000
365754094493401	04/21/1977	1220	165	<100	--	--	60	--	--	--	60
365754094493401	04/21/1977	1230	185	--	--	--	--	--	--	--	--
365754094493401	04/21/1977	1240	187	--	--	--	--	--	--	--	--
365754094493401	04/21/1977	1250	195	26,000	--	--	560	--	--	--	100,000
365754094493401	06/08/1977	0815	160	10	<1	<100	10	<20	M	M	50
365754094493401	06/08/1977	0845	180	24,000	<1	200	510	60	400	130	120,000
365754094493401	06/08/1977	0900	187	--	--	--	--	--	--	--	--
365754094493401	06/08/1977	0915	195	42,000	1	<100	860	140	600	260	210,000
					Lucky Bill						
365817094510201	04/22/1976	1000	178	10	<1	<100	M	U	M	<20	290
365817094510201	04/22/1976	1030	198	--	--	--	--	--	--	--	--
365817094510201	04/22/1976	1115	204	--	--	--	--	--	--	--	--
365817094510201	04/22/1976	1200	210	2,000	2	<100	420	<20	50	M	150,000
365817094510201	04/22/1976	1300	216	--	--	--	--	--	--	--	--
365817094510201	04/22/1976	1400	222	5,700	7	<100	490	<20	40	10	270,000
365817094510201	04/22/1976	1500	230	--	--	--	--	--	--	--	--
365817094510201	08/26/1976	1120	170	--	--	--	--	--	--	--	--
365817094510201	08/26/1976	1205	190	--	--	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Aluminum, dissolved (µg/L)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Iron, dissolved (µg/L)
365817094510201	08/26/1976	1220	205	20	--	--	<20	--	--	--	370
365817094510201	08/26/1976	1305	218	--	--	--	--	--	--	--	--
365817094510201	08/26/1976	1335	228	10,000	--	--	370	--	--	--	330,000
365817094510201	10/20/1976	0945	160	--	--	--	--	--	--	--	--
365817094510201	10/20/1976	1010	190	<100	<1	<100	10	U	M	10	20
365817094510201	10/20/1976	1100	210	--	--	--	--	--	--	--	--
365817094510201	10/20/1976	1135	225	5,000	11	<100	330	<20	40	M	240,000
365817094510201	12/07/1976	1500	160	--	--	--	--	--	--	--	--
365817094510201	12/07/1976	1515	190	<100	--	--	10	--	--	--	150
365817094510201	12/07/1976	1545	210	--	--	--	--	--	--	--	--
365817094510201	12/07/1976	1600	225	5,000	--	--	360	--	--	--	270,000
365817094510201	02/17/1977	1400	160	--	--	--	--	--	--	--	--
365817094510201	02/17/1977	1415	190	<100	--	--	<20	--	--	--	70
365817094510201	02/17/1977	1430	200	--	--	--	--	--	--	--	--
365817094510201	02/17/1977	1445	210	--	--	--	--	--	--	--	--
365817094510201	02/17/1977	1500	225	4,500	--	--	340	--	--	--	300,000
365817094510201	04/21/1977	1550	160	--	--	--	--	--	--	--	--
365817094510201	04/21/1977	1600	190	<100	--	--	140	--	--	--	60
365817094510201	04/21/1977	1615	205	--	--	--	--	--	--	--	--
365817094510201	04/21/1977	1640	225	5,000	--	--	340	--	--	--	290,000
365817094510201	06/07/1977	1215	155	20	<1	<100	M	U	U	M	20
365817094510201	06/07/1977	1240	190	--	--	--	--	--	--	--	--
365817094510201	06/07/1977	1300	205	--	--	--	--	--	--	--	--
365817094510201	06/07/1977	1315	225	5,500	11	600	350	20	800	M	310,000

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Aluminum, dissolved (µg/L)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Iron, dissolved (µg/L)
Consolidated #2											
365927094485901	04/20/1976	0930	179	--	--	--	--	--	--	--	--
365927094485901	04/20/1976	1000	191	10	<1	<100	90	U	U	M	<10
365927094485901	04/21/1976	1100	210	--	--	--	--	--	--	--	--
365927094485901	04/21/1976	1200	227	20	1	<100	100	U	M	M	670
365927094485901	04/21/1976	1300	229	7,700	2	<100	780	20	50	70	130,000
365927094485901	04/21/1976	1400	234	10,000	1	<100	930	30	60	100	130,000
365927094485901	08/25/1976	1045	165	30	--	--	110	--	--	--	80
365927094485901	08/25/1976	1120	185	--	--	--	--	--	--	--	--
365927094485901	08/25/1976	1135	215	--	--	--	--	--	--	--	--
365927094485901	08/25/1976	1155	225	--	--	--	--	--	--	--	--
365927094485901	08/25/1976	1310	230	5,000	--	--	360	--	--	--	210,000
365927094485901	08/25/1976	1330	235	--	--	--	--	--	--	--	--
365927094485901	10/19/1976	1125	165	<100	<1	<100	80	U	M	M	40
365927094485901	10/19/1976	1200	215	--	--	--	--	--	--	--	--
365927094485901	10/19/1976	1255	230	5,000	10	<100	540	<20	60	30	310,000
365927094485901	12/07/1976	1000	165	<100	--	--	70	--	--	--	40
365927094485901	12/07/1976	1015	215	--	--	--	--	--	--	--	--
365927094485901	12/07/1976	1045	230	5,000	--	--	540	--	--	--	290,000
365927094485901	02/17/1977	0945	165	<100	--	--	60	--	--	--	<10
365927094485901	02/17/1977	1130	215	--	--	--	--	--	--	--	--
365927094485901	02/17/1977	1200	222	--	--	--	--	--	--	--	--
365927094485901	02/17/1977	1215	230	1,400	--	--	600	--	--	--	300,000
365927094485901	04/21/1977	0900	152	--	--	--	--	--	--	--	--
365927094485901	04/21/1977	0925	165	10	--	--	80	--	--	--	40

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Aluminum, dissolved (µg/L)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Iron, dissolved (µg/L)
365927094485901	04/21/1977	0945	215	--	--	--	--	--	--	--	--
365927094485901	04/21/1977	1020	220	--	--	--	--	--	--	--	--
365927094485901	04/21/1977	1035	230	4,500	--	--	610	--	--	--	270,000
365927094485901	06/07/1977	0830	165	20	<1.0	<100	80	<20	M	<2	70
365927094485901	06/07/1977	0845	215	--	--	--	--	--	--	--	--
365927094485901	06/07/1977	0900	225	--	--	--	--	--	--	--	--
365927094485901	06/07/1977	0915	230	200	6.0	200	550	30	800	10	53,000
					Birthday						
365930094480001	04/23/1976	0930	168	8,600	1.0	<100	900	20	550	40	110,000
365930094480001	04/23/1976	1030	172	--	--	--	--	--	--	--	--
365930094480001	04/23/1976	1130	175	--	--	--	--	--	--	--	--
365930094480001	04/23/1976	1230	182	8,900	2.0	<100	900	20	580	60	10,000
365930094480001	08/25/1976	1630	160	40	--	--	60	--	--	--	210
365930094480001	08/25/1976	1645	166	--	--	--	--	--	--	--	--
365930094480001	08/25/1976	1655	173	--	--	--	--	--	--	--	--
365930094480001	08/25/1976	1715	177	--	--	--	--	--	--	--	--
365930094480001	08/25/1976	1730	180	4,000	--	--	230	--	--	--	89,000
365930094480001	10/19/1976	1520	162	600	1.0	<100	M	U	70	M	13,000
365930094480001	10/19/1976	1610	180	3,200	<1.0	<100	60	U	70	M	110,000
365930094480001	12/07/1976	1220	160	<100	--	--	<2	--	--	--	710
365930094480001	12/07/1976	1225	170	--	--	--	--	--	--	--	--
365930094480001	12/07/1976	1235	180	2,000	--	--	60	--	--	--	83,000
365930094480001	02/18/1977	0845	145	--	--	--	--	--	--	--	--
365930094480001	02/18/1977	0905	160	13,000	--	--	360	--	--	--	180,000
365930094480001	02/18/1977	0920	170	--	--	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Aluminum, dissolved (µg/L)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Iron, dissolved (µg/L)
365930094480001	02/18/1977	0935	180	7,900	--	--	370	--	--	--	200,000
365930094480001	04/21/1977	1415	155	20	--	--	140	--	--	--	140
365930094480001	04/21/1977	1425	167	--	--	--	--	--	--	--	--
365930094480001	04/21/1977	1455	170	11,000	--	--	300	--	--	--	170,000
365930094480001	04/21/1977	1515	180	1,000	--	--	80	--	--	--	200,000
365930094480001	06/08/1977	1200	155	50	<1	<100	60	<20	M	M	90
365930094480001	06/08/1977	1220	162	--	--	--	--	--	--	--	--
365930094480001	06/08/1977	1240	166	--	--	--	--	--	--	--	--
365930094480001	06/08/1977	1300	170	2,900	3	<100	180	20	700	90	220,000
365930094480001	06/08/1977	1325	175	--	--	--	--	--	--	--	--
365930094480001	06/08/1977	1345	180	<100	6	200	20	20	800	M	230,000
					Kansas 1						
--	04/27/1976	--	200	50	0	0	4	0	0	3	20
--	04/27/1976	--	205	--	--	--	--	--	--	--	--
--	04/27/1976	--	211	--	--	--	--	--	--	--	--
--	04/27/1976	--	222	80	0	0	4	10	170	3	44,000
--	04/27/1976	--	230	20	6	0	2	10	31	3	50,000
--	04/27/1976	--	259	--	--	--	--	--	--	--	--
--	04/27/1976	--	287	--	--	--	--	--	--	--	--
--	04/27/1976	--	298	10	6	0	6	10	36	10	46,000
--	10/21/1976	--	200	60	0	0	4	0	1	6	10
--	10/21/1976	--	220	2,000	8	0	1	0	57	1	57,000
--	10/21/1976	--	260	--	--	--	--	--	--	--	--
--	10/21/1976	--	298	--	--	--	--	--	--	--	--
--	06/09/1977	--	180	--	--	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft^3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Aluminum, dissolved (µg/L)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Iron, dissolved (µg/L)
--	06/09/1977	--	200	30	0	100	8	10	0	2	30
--	06/09/1977	--	210	--	--	--	--	--	--	--	--
--	06/09/1977	--	220	150	6	100	2	10	100	2	54,000
--	06/09/1977	--	240	--	--	--	--	--	--	--	--
--	06/09/1977	--	260	--	--	--	--	--	--	--	--
--	06/09/1977	--	280	--	--	--	--	--	--	--	--
--	06/09/1977	--	298	--	--	--	--	--	--	--	--

[1]Data retrieved from USGS National Water Information System data base on March 12, 2003. Differences between this data and Playton and other (1980) may be due to rounding.

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; mS/cm, microSiemens per centimeter; mg/L, milligrams per liter; (µg/L), micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Lead, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium, dissolved (µg/L)	Zinc, dissolved (µg/L)
Lavrion									
365732094502701	04/28/1976	1100	150	--	--	--	--	--	--
365732094502701	04/28/1976	1200	160	M	4,400	<1	2,300	<1	390,000
365732094502701	04/28/1976	1300	170	--	--	--	--	--	--
365732094502701	04/28/1976	1400	182	M	6,500	<1	3,400	1	420,000
365732094502701	04/28/1976	1600	191	M	6,300	<1	3,100	<1	430,000
Skelton									
365738094495101	04/26/1976	1200	165	<2	670	<1	500	<1	47,000
365738094495101	10/18/1976	1350	160	M	760	<1	600	1	110,000
365738094495101	06/06/1977	1500	150	--	--	--	--	--	--
365738094495101	06/06/1977	1530	165	400	1,600	<1	1,300	1	250,000
New Chicago									
365754094493401	04/29/1976	1100	167	--	--	--	--	--	--
365754094493401	04/29/1976	1200	174	M	310	1	200	<1	16,000
365754094493401	04/29/1976	1230	179	--	--	--	--	--	--
365754094493401	04/29/1976	1300	181	--	--	--	--	--	--
365754094493401	04/29/1976	1330	183	--	--	--	--	--	--
365754094493401	04/29/1976	1400	192	M	1,100	<1	700	1	100,000
365754094493401	04/29/1976	1600	197	100	1,400	<1	1,000	1	120,000
365754094493401	08/26/1976	1505	160	--	--	--	--	--	--
365754094493401	08/26/1976	1540	174	--	--	--	--	--	--
365754094493401	08/26/1976	1555	187	M	380	--	M	--	17,000
365754094493401	08/26/1976	1605	197	500	2,800	--	1,600	--	200,000
365754094493401	10/20/1976	1350	165	<2	200	1	<200	1	6,500
365754094493401	10/20/1976	1410	180	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft3/s, cubic feet per second; mm of Hg, millimeters of mercury; ˚C, degrees Celsius; mS/cm, microSiemens per centimeter; mg/L, milligrams per liter; (µg/L), micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Lead, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium, dissolved (µg/L)	Zinc, dissolved (µg/L)
365754094493401	10/20/1976	1430	195	300	1,500	<1	1,100	1	130,000
365754094493401	12/06/1976	1445	165	<2	420	--	500	--	26,000
365754094493401	12/06/1976	1500	180	--	--	--	--	--	--
365754094493401	12/06/1976	1530	195	200	1,900	--	1,200	--	130,000
365754094493401	02/17/1977	1620	165	M	820	--	500	--	53,000
365754094493401	02/17/1977	1630	180	--	--	--	--	--	--
365754094493401	02/17/1977	1640	195	200	1,800	--	1,100	--	120,000
365754094493401	04/21/1977	1220	165	<200	420	--	200	--	220,00
365754094493401	04/21/1977	1230	185	--	--	--	--	--	--
365754094493401	04/21/1977	1240	187	--	--	--	--	--	--
365754094493401	04/21/1977	1250	195	300	2,500	--	1,600	--	170,000
365754094493401	06/08/1977	0815	160	M	220	<1	<200	<1	7,300
365754094493401	06/08/1977	0845	180	400	3,100	<1	1,700	2	190,000
365754094493401	06/08/1977	0900	187	--	--	--	--	--	--
365754094493401	06/08/1977	0915	195	400	4,600	<1	2,900	1	340,000
					Lucky Bill				
365817094510201	04/22/1976	1000	178	200	60	<1	M	3	68,000
365817094510201	04/22/1976	1030	198	--	--	--	--	--	--
365817094510201	04/22/1976	1115	204	--	--	--	--	--	--
365817094510201	04/22/1976	1200	210	M	5,000	<1	3,000	<1	280,000
365817094510201	04/22/1976	1300	216	--	--	--	--	--	--
365817094510201	04/22/1976	1400	222	400	5,700	<1	4,200	<1	490,000
365817094510201	04/22/1976	1500	230	--	--	--	--	--	--
365817094510201	08/26/1976	1120	170	--	--	--	--	--	--
365817094510201	08/26/1976	1205	190	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; mS/cm, microSiemens per centimeter; mg/L, milligrams per liter; (µg/L), micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Lead, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium, dissolved (µg/L)	Zinc, dissolved (µg/L)
365817094510201	08/26/1976	1220	205	M	20	--	M	--	20,000
365817094510201	08/26/1976	1305	218	--	--	--	--	--	--
365817094510201	08/26/1976	1335	228	400	6,500	--	5,000	--	450,000
365817094510201	10/20/1976	0945	160	--	--	--	--	--	--
365817094510201	10/20/1976	1010	190	200	30	<1	M	2	25,000
365817094510201	10/20/1976	1100	210	--	--	--	--	--	--
365817094510201	10/20/1976	1135	225	400	6,000	1	5,000	<1	440,000
365817094510201	12/07/1976	1500	160	--	--	--	--	--	--
365817094510201	12/07/1976	1515	190	M	50	--	M	--	27,000
365817094510201	12/07/1976	1545	210	--	--	--	--	--	--
365817094510201	12/07/1976	1600	225	200	5,400	--	4,100	--	420,000
365817094510201	02/17/1977	1400	160	--	--	--	--	--	--
365817094510201	02/17/1977	1415	190	M	50	--	M	--	35,000
365817094510201	02/17/1977	1430	200	--	--	--	--	--	--
365817094510201	02/17/1977	1445	210	--	--	--	--	--	--
365817094510201	02/17/1977	1500	225	200	5,500	--	3,900	--	410,000
365817094510201	04/21/1977	1550	160	--	--	--	--	--	--
365817094510201	04/21/1977	1600	190	200	50	--	M	--	49,000
365817094510201	04/21/1977	1615	205	--	--	--	--	--	--
365817094510201	04/21/1977	1640	225	200	5,500	--	4,000	--	412,000
365817094510201	06/07/1977	1215	155	M	20	<1	M	3	39,000
365817094510201	06/07/1977	1240	190	--	--	--	--	--	--
365817094510201	06/07/1977	1300	205	--	--	--	--	--	--
365817094510201	06/07/1977	1315	225	200	6,200	<1	4,500	<1	440,000

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft3/s, cubic feet per second; mm of Hg, millimeters of mercury; ˚C, degrees Celsius; mS/cm, microSiemens per centimeter; mg/L, milligrams per liter; (µg/L), micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Lead, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium, dissolved (µg/L)	Zinc, dissolved (µg/L)
				Consolidated #2					
365927094485901	04/20/1976	0930	179	--	--	--	--	--	--
365927094485901	04/20/1976	1000	191	M	80	<1	M	1	3,200
365927094485901	04/21/1976	1100	210	--	--	--	--	--	--
365927094485901	04/21/1976	1200	227	M	80	<1	M	1	4,000
365927094485901	04/21/1976	1300	229	200	5,700	<1	3,400	<1	310,000
365927094485901	04/21/1976	1400	234	400	5,900	<1	M	<1	380,000
365927094485901	08/25/1976	1045	165	M	100	--	M	--	2,200
365927094485901	08/25/1976	1120	185	--	--	--	--	--	--
365927094485901	08/25/1976	1135	215	--	--	--	--	--	--
365927094485901	08/25/1976	1155	225	--	--	--	--	--	--
365927094485901	08/25/1976	1310	230	200	4,200	--	1,500	--	150,000
365927094485901	08/25/1976	1330	235	--	--	--	--	--	--
365927094485901	10/19/1976	1125	165	M	30	<1	M	1	3,900
365927094485901	10/19/1976	1200	215	--	--	--	--	--	--
365927094485901	10/19/1976	1255	230	300	5,400	<1	3,400	1	290,000
365927094485901	12/07/1976	1000	165	M	40	--	M	--	3,500
365927094485901	12/07/1976	1015	215	--	--	--	--	--	--
365927094485901	12/07/1976	1045	230	400	50	--	3,300	--	280,000
365927094485901	02/17/1977	0945	165	<2	60	--	M	--	3,300
365927094485901	02/17/1977	1130	215	--	--	--	--	--	--
365927094485901	02/17/1977	1200	222	--	--	--	--	--	--
365927094485901	02/17/1977	1215	230	400	5,500	--	3,600	--	300,000
365927094485901	04/21/1977	0900	152	--	--	--	--	--	--
365927094485901	04/21/1977	0925	165	M	100	--	M	--	4,200

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft3/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; mS/cm, microSiemens per centimeter; mg/L, milligrams per liter; (µg/L), micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Lead, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium, dissolved (µg/L)	Zinc, dissolved (µg/L)
365927094485901	04/21/1977	0945	215	--	--	--	--	--	--
365927094485901	04/21/1977	1020	220	--	--	--	--	--	--
365927094485901	04/21/1977	1035	230	400	5,100	--	3,200	--	292,000
365927094485901	06/07/1977	0830	165	U	160	<1	M	<1	2,100
365927094485901	06/07/1977	0845	215	--	--	--	--	--	--
365927094485901	06/07/1977	0900	225	--	--	--	--	--	--
365927094485901	06/07/1977	0915	230	400	5,600	<1	3,400	<1	310,000
					Birthday				
365930094480001	04/23/1976	0930	168	M	5,600	<1	3,300	<1	490,000
365930094480001	04/23/1976	1030	172	--	--	--	--	--	--
365930094480001	04/23/1976	1130	175	--	--	--	--	--	--
365930094480001	04/23/1976	1230	182	M	5,500	<1	3,500	<1	490,000
365930094480001	08/25/1976	1630	160	M	70	--	M	--	9,400
365930094480001	08/25/1976	1645	166	--	--	--	--	--	--
365930094480001	08/25/1976	1655	173	--	--	--	--	--	--
365930094480001	08/25/1976	1715	177	--	--	--	--	--	--
365930094480001	08/25/1976	1730	180	M	7,400	--	1,800	--	260,000
365930094480001	10/19/1976	1520	162	M	930	<1	500	1	65,000
365930094480001	10/19/1976	1610	180	M	9,000	<1	2,500	<1	360,000
365930094480001	12/07/1976	1220	160	M	1,500	--	200	--	4,400
365930094480001	12/07/1976	1225	170	--	--	--	--	--	--
365930094480001	12/07/1976	1235	180	M	10,000	--	2,900	--	390,000
365930094480001	02/18/1977	0845	145	--	--	--	--	--	--
365930094480001	02/18/1977	0905	160	300	5,000	--	3,100	--	340,000
365930094480001	02/18/1977	0920	170	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft3/s, cubic feet per second; mm of Hg, millimeters of mercury; ˚C, degrees Celsius; mS/cm, microSiemens per centimeter; mg/L, milligrams per liter; (µg/L), micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Lead, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium, dissolved (µg/L)	Zinc, dissolved (µg/L)
365930094480001	02/18/1977	0935	180	300	7,000	--	3,200	--	380,000
365930094480001	04/21/1977	1415	155	M	300	--	M	--	8,300
365930094480001	04/21/1977	1425	167	--	--	--	--	--	--
365930094480001	04/21/1977	1455	170	200	4,400	--	2,900	--	270,000
365930094480001	04/21/1977	1515	180	200	14,000	--	3,000	--	370,000
365930094480001	06/08/1977	1200	155	M	190	<1	M	<1	6,700
365930094480001	06/08/1977	1220	162	--	--	--	--	--	--
365930094480001	06/08/1977	1240	166	--	--	--	--	--	--
365930094480001	06/08/1977	1300	170	M	5,200	<1	3,500	<1	340,000
365930094480001	06/08/1977	1325	175	--	--	--	--	--	--
365930094480001	06/08/1977	1345	180	M	13,000	<1	3,000	<1	400,000
				Kansas 1					
--	04/27/1976	--	200	6	40	0	10	0	640
--	04/27/1976	--	205	--	--	--	--	--	--
--	04/27/1976	--	211	--	--	--	--	--	--
--	04/27/1976	--	222	7	5,100	0	370	0	2,900
--	04/27/1976	--	230	2	2,300	1	240	0	8,100
--	04/27/1976	--	259	--	--	--	--	--	--
--	04/27/1976	--	287	--	--	--	--	--	--
--	04/27/1976	--	298	4	2,400	1	240	0	8,300
--	10/21/1976	--	200	3	10	0	4	0	670
--	10/21/1976	--	220	4	2,000	1	200	0	7,000
--	10/21/1976	--	260	--	--	--	--	--	--
--	10/21/1976	--	298	--	--	--	--	--	--
--	06/09/1977	--	180	--	--	--	--	--	--

Appendix 1. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 1976-1977 —Continued

[data from Playton and others, 1980[1], ft3/s, cubic feet per second; mm of Hg, millimeters of mercury; ˚C, degrees Celsius; mS/cm, microSiemens per centimeter; mg/L, milligrams per liter; (µg/L), micrograms per liter; <, less than; M, presence of material verified, but not quantified; U, material specifically analyzed for, but not detected]

Station number	Date	Time	Sampling depth (feet)	Lead, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium, dissolved (µg/L)	Zinc, dissolved (µg/L)
--	06/09/1977	--	200	6	10	0	6	0	2,300
--	06/09/1977	--	210	--	--	--	--	--	--
--	06/09/1977	--	220	4	1,900	2	250	0	6,600
--	06/09/1977	--	240	--	--	--	--	--	--
--	06/09/1977	--	260	--	--	--	--	--	--
--	06/09/1977	--	280	--	--	--	--	--	--
--	06/09/1977	--	298	--	--	--	--	--	--

[1]Data retrieved from USGS National Water Information System data base on March 12, 2003. Differences between this data and Playton and other (1980) may be due to rounding.

Appendix 2. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 2002

[mm of Hg, millimeters of mercury; ˚C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated value; --, no data]

Station number	Date	Time	Sampling depth (feet)	Barometric pressure (mm of Hg)	Specific conductance at 25˚C, (µS/cm)		pH (standard unit)		Temperature, water (˚C)	Oxygen, dissolved (mg/L)	Alkalinity, dissolved, field (mg/L as $CaCO_3$)	Alkalinity, dissolved, lab (mg/L as $CaCO_3$)
					field	lab	field	lab				
Admiralty #3												
365737094502201	07/17/2002	0825	47.0	760	710	682	7.5	7.6	15.4	8.7	--	167
365737094502201	07/17/2002	0900	97.0	760	705	678	7.5	7.5	15.3	8.6	166	166
365737094502201	07/17/2002	0930	167	760	882	631	7.3	7.7	15.3	7.8	--	167
365737094502201	07/17/2002	1000	177	760	884	805	7.2	7.3	15.3	7.5	158	160
365737094502201	07/17/2002	1040	187	760	1,740	829	6.1	7.4	15.4	1.9	--	157
365737094502201	07/17/2002	1115	197	760	2,750	2,270	5.9	5.6	15.4	0.3	--	59
Admiralty #4												
365753094504601	07/19/2002	0920	40.0	760	2,630	2,400	6.1	5.9	15.3	0.9	--	80
365753094504601	07/19/2002	1005	100	760	2,630	2,400	6.1	5.9	15.3	0.5	--	78
365753094504601	07/19/2002	1030	170	760	2,640	2,410	6.1	5.8	15.3	0.3	--	63
365753094504601	07/19/2002	1100	190	760	2,670	2,400	6.1	5.8	15.3	0.3	--	63
365753094504601	07/19/2002	1135	200	760	2,690	2,440	6.1	5.8	15.3	0.3	--	71
365753094504601	07/19/2002	1200	205	760	2,780	2,430	6.1	5.8	15.4	0.2	--	70
Federal #5												
365803094494101	07/17/2002	1720	40.0	760	1,060	921	6.5	6.6	16.3	2.4	--	74
365803094494101	07/17/2002	1745	120	760	1,010	880	6.7	6.8	15.8	1.6	--	86
365803094494101	07/17/2002	1805	195	760	1,470	923	6.2	6.7	16.1	0.4	--	87
365803094494101	07/17/2002	1830	200	760	2,640	899	6.0	6.9	16.1	0.1	--	86
365803094494101	07/17/2002	1850	210	760	2,800	898	6.1	6.7	16.1	0.1	--	88
365803094494101	07/17/2002	1920	190	760	1,050	892	6.6	6.8	15.8	1.4	--	88
Baby Jim												
365818094505201	07/18/2002	1440	30.0	760	588	543	6.5	6.8	16.8	0.7	--	82
365818094505201	07/18/2002	1510	70.0	760	625	595	6.7	7.0	15.8	0.4	--	107
365818094505201	07/18/2002	1545	120	760	923	627	6.8	7.1	15.7	0.3	113	116
365818094505201	07/18/2002	1620	150	760	2,270	2,010	6.2	6.5	15.9	0.2	--	123
365818094505201	07/18/2002	1650	160	760	2,330	2,080	6.2	6.2	15.9	0.2	--	133
365818094505201	07/18/2002	1730	170	760	2,520	2,150	6.1	6.1	15.9	0.2	--	138

Appendix 2. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 2002—Continued.

[mm of Hg, millimeters of mercury; ˚C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated value; --, no data]

Station number	Date	Time	Sampling depth (feet)	Barometric pressure (mm of Hg)	Specific conductance at 25˚C, (µS/cm)		pH (standard unit)		Temperature, water (˚C)	Oxygen, dissolved (mg/L)	Alkalinity, dissolved, field (mg/L as $CaCO_3$)	Alkalinity, dissolved, lab (mg/L as $CaCO_3$)
					field	lab	field	lab				
Royal												
365832094490301	08/07/2002	1230	50.0	762	1,130	1,090	5.7	6.7	18.9	0.5	--	124
365832094490301	08/07/2002	1335	90.0	762	1,030	1,030	5.9	6.7	17.8	1.4	--	127
365832094490301	08/07/2002	1410	130	762	930	913	6.1	6.7	17.1	1.8	--	132
365832094490301	08/07/2002	1450	180	762	850	826	6.3	6.8	16.4	1.4	--	127
365832094490301	08/07/2002	1525	200	762	1,180	966	6.3	6.7	15.8	0.8	--	133
365832094490301	08/07/2002	1605	220	762	1,210	922	6.4	6.7	15.7	0.6	--	131
Consolidated #2												
365927094485901	07/16/2002	0900	40.0	759	548	526	7.0	7.5	20.2	8.5	--	60
365927094485901	07/16/2002	1010	130	759	547	525	7.3	7.5	15.6	7.2	65	67
365927094485901	07/16/2002	1455	220	759	607	533	7.3	7.4	15.4	7.7	--	67
365927094485901	07/16/2002	1550	227	759	2,640	684	6.2	6.9	15.7	1.1	--	68
365927094485901	07/16/2002	1610	230	759	2,780	915	6.1	6.5	15.8	0.3	--	70
365927094485901	07/16/2002	1650	224	759	607	535	7.0	7.1	15.4	7.3	--	68
Kansas 2												
370036094513901	07/18/2002	0955	18.0	760	1,340	1,220	6.6	6.9	22.5	6.1	--	99
370036094513901	07/18/2002	1030	33.0	760	1,270	1,180	6.5	6.8	19.5	5.5	--	102
370036094513901	07/18/2002	1100	48.0	760	1,240	1,130	6.5	6.8	16.9	5.0	--	96

Appendix 2. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 2002—Continued

[mm of Hg, millimeters of mercury; ˚C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated value; --, no data]

Station number	Date	Time	Sampling depth (feet)	Solids, residue at 180˚C, dissolved (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicarbonate, dissolved, field (mg/L)	Carbonate, dissolved, field (mg/L)	Sulfate, dissolved (mg/L)
Admiralty #3											
365737094502201	07/17/2002	0825	47.0	484	135	11.6	2.71	0.62	--	--	200
365737094502201	07/17/2002	0900	97.0	480	134	11.5	2.67	0.57	202	0.0	201
365737094502201	07/17/2002	0930	167	493	134	11.6	2.80	0.61	--	--	207
365737094502201	07/17/2002	1000	177	654	165	14.6	4.20	0.65	192	0.0	297
365737094502201	07/17/2002	1040	187	652	166	14.9	4.39	0.68	--	--	307
365737094502201	07/17/2002	1115	197	2,330	479	52.2	23.9	2.54	--	--	1,400
Admiralty #4											
365753094504601	07/19/2002	0920	40.0	2,580	563	59.7	27.7	3.28	--	--	1,550
365753094504601	07/19/2002	1005	100	2,580	569	60.2	27.9	3.39	--	--	1,550
365753094504601	07/19/2002	1030	170	2,590	551	58.0	26.6	3.38	--	--	1,550
365753094504601	07/19/2002	1100	190	2,560	556	58.9	27.1	3.37	--	--	1,470
365753094504601	07/19/2002	1135	200	2,660	556	62.1	29.2	3.31	--	--	1,590
365753094504601	07/19/2002	1200	205	2,630	557	63.6	30.2	3.22	--	--	1,590
Federal #5											
365803094494101	07/17/2002	1720	40.0	795	143	36.4	20.0	2.17	--	--	456
365803094494101	07/17/2002	1745	120	761	147	32.4	17.1	2.10	--	--	413
365803094494101	07/17/2002	1805	195	774	152	31.8	16.9	2.20	--	--	412
365803094494101	07/17/2002	1830	200	751	149	32.1	16.7	2.08	--	--	415
365803094494101	07/17/2002	1850	210	713	141	33.3	17.6	2.22	--	--	400
365803094494101	07/17/2002	1920	190	737	152	32.0	16.7	2.17	--	--	423
Baby Jim											
365818094505201	07/18/2002	1440	30.0	393	88.7	12.1	11.0	1.97	--	--	201
365818094505201	07/18/2002	1510	70.0	451	95.9	13.0	12.8	1.95	--	--	213
365818094505201	07/18/2002	1545	120	469	103	13.5	13.2	1.96	138	0.0	212
365818094505201	07/18/2002	1620	150	1,930	368	56.2	27.6	3.18	--	--	1,100
365818094505201	07/18/2002	1650	160	1,960	374	56.6	27.4	3.15	--	--	1,140
365818094505201	07/18/2002	1730	170	2,050	382	56.3	27.8	3.13	--	--	1,170

Appendix 2. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 2002—Continued

[mm of Hg, millimeters of mercury; ˚C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated value; --, no data]

Station number	Date	Time	Sampling depth (feet)	Solids, residue at 180˚C, dissolved (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicarbonate, dissolved, field (mg/L)	Carbonate, dissolved, field (mg/L)	Sulfate, dissolved (mg/L)
Royal											
365832094490301	08/07/2002	1230	50.0	955	178	37.2	18.4	4.65	--	--	537
365832094490301	08/07/2002	1335	90.0	894	167	33.5	17.1	4.33	--	--	487
365832094490301	08/07/2002	1410	130	756	150	26.3	13.6	3.72	--	--	397
365832094490301	08/07/2002	1450	180	661	136	21.3	11.2	3.30	--	--	340
365832094490301	08/07/2002	1525	200	776	152	27.6	14.3	3.97	--	--	414
365832094490301	08/07/2002	1605	220	733	147	24.0	12.4	3.46	--	--	374
Consolidated #2											
365927094485901	07/16/2002	0900	40.0	384	101	10.0	3.22	0.67	--	--	211
365927094485901	07/16/2002	1010	130	409	93.3	8.81	3.00	0.71	--	--	211
365927094485901	07/16/2002	1455	220	408	104	9.69	3.27	0.75	--	--	211
365927094485901	07/16/2002	1550	227	551	136	12.4	4.78	0.93	--	--	298
365927094485901	07/16/2002	1610	230	782	190	18.2	7.65	1.24	--	--	453
365927094485901	07/16/2002	1650	224	402	103	9.58	3.24	0.76	--	--	212
Kansas 2											
370036094513901	07/18/2002	0955	18.0	1,100	247	28.0	30.2	2.03	--	--	620
370036094513901	07/18/2002	1030	33.0	1,110	231	25.7	27.3	2.14	--	--	622
370036094513901	07/18/2002	1100	48.0	1,050	225	23.4	23.9	2.11	--	--	566

Appendix 2. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 2002—Continued

[mm of Hg, millimeters of mercury; ˚C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated value; --, no data]

Station number	Date	Time	Sampling depth (feet)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Silica, dissolved (mg/L)
			Admiralty #3				
365737094502201	07/17/2002	0825	47.0	2.23	0.17	0.04	9.85
365737094502201	07/17/2002	0900	97.0	1.96	0.18	0.04	9.77
365737094502201	07/17/2002	0930	167	1.90	0.21	0.03	10.0
365737094502201	07/17/2002	1000	177	2.39	0.46	0.05	9.29
365737094502201	07/17/2002	1040	187	2.50	0.47	0.05	9.23
365737094502201	07/17/2002	1115	197	9.88	2.24	0.06	17.6
			Admiralty #4				
365753094504601	07/19/2002	0920	40.0	9.72	2.59	0.06	12.1
365753094504601	07/19/2002	1005	100	9.97	2.67	0.06	12.3
365753094504601	07/19/2002	1030	170	9.54	2.67	0.05	11.7
365753094504601	07/19/2002	1100	190	9.52	2.84	0.06	11.8
365753094504601	07/19/2002	1135	200	10.2	2.73	0.08	12.3
365753094504601	07/19/2002	1200	205	10.7	2.53	0.06	12.4
			Federal #5				
365803094494101	07/17/2002	1720	40.0	4.18	0.24	E0.02	20.4
365803094494101	07/17/2002	1745	120	2.37	0.24	E0.02	19.1
365803094494101	07/17/2002	1805	195	2.87	0.32	E0.03	18.1
365803094494101	07/17/2002	1830	200	2.19	0.26	E0.02	19.1
365803094494101	07/17/2002	1850	210	2.28	0.25	E0.02	19.1
365803094494101	07/17/2002	1920	190	2.35	0.29	E0.03	18.6
			Baby Jim				
365818094505201	07/18/2002	1440	30.0	2.22	0.28	E0.02	12.3
365818094505201	07/18/2002	1510	70.0	2.55	0.23	E0.02	12.0
365818094505201	07/18/2002	1545	120	2.12	0.23	E0.02	12.0
365818094505201	07/18/2002	1620	150	10.5	1.77	0.05	10.3
365818094505201	07/18/2002	1650	160	11.6	1.94	0.06	10.6
365818094505201	07/18/2002	1730	170	10.9	2.17	0.06	10.9

Appendix 2. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 2002—Continued

[mm of Hg, millimeters of mercury; ˚C, degrees Celsius; µS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated value; --, no data]

Station number	Date	Time	Sampling depth (feet)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Bromide, dissolved (mg/L)	Silica, dissolved (mg/L)
			Royal				
365832094490301	08/07/2002	1230	50.0	2.50	0.30	0.04	20.3
365832094490301	08/07/2002	1335	90.0	2.25	0.30	0.03	18.5
365832094490301	08/07/2002	1410	130	2.14	0.27	E0.02	15.3
365832094490301	08/07/2002	1450	180	2.03	0.28	<0.03	13.0
365832094490301	08/07/2002	1525	200	2.15	0.27	E0.02	16.0
365832094490301	08/07/2002	1605	220	2.13	0.30	E0.02	14.0
			Consolidated #2				
365927094485901	07/16/2002	0900	40.0	1.14	0.27	<0.03	12.7
365927094485901	07/16/2002	1010	130	1.22	0.24	E0.01	15.9
365927094485901	07/16/2002	1455	220	1.08	0.25	<0.03	11.2
365927094485901	07/16/2002	1550	227	1.34	0.35	0.03	12.0
365927094485901	07/16/2002	1610	230	1.61	0.53	E.03	11.2
365927094485901	07/16/2002	1650	224	1.24	0.26	E.01	11.2
			Kansas 2				
370036094513901	07/18/2002	0955	18.0	1.94	0.4	0.03	18.2
370036094513901	07/18/2002	1030	33.0	1.89	0.42	0.03	16.6
370036094513901	07/18/2002	1100	48.0	1.99	0.39	0.03	15.3

Appendix 2. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 2002—Continued

[mm of Hg, millimeters of mercury; ˚C, degrees Celsius; mS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated value; --, no data]

Station number	Date	Time	Sampling depth (feet)	Aluminum, dissolved (µg/L)	Antimony, dissolved (µg/L)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)	Beryllium, dissolved (µg/L)	Cadmium dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)
Admiralty #3												
365737094502201	07/17/2002	0825	47.0	<1	0.21	<2	15	<0.06	9.12	<0.8	0.34	16.5
365737094502201	07/17/2002	0900	97.0	<1	0.18	<2	15	<0.06	8.94	<0.8	0.29	8.5
365737094502201	07/17/2002	0930	167	<1	0.19	<2	14	<0.06	8.26	<0.8	0.36	3.9
365737094502201	07/17/2002	1000	177	1	0.21	<2	13	<0.06	12.6	<0.8	0.59	4.5
365737094502201	07/17/2002	1040	187	2	0.21	<2	13	<0.06	12.8	<0.8	0.57	3.9
365737094502201	07/17/2002	1115	197	241	0.07	26	6	0.29	2.56	<0.8	35.8	6.9
Admiralty #4												
365753094504601	07/19/2002	0920	40.0	93	<0.05	14	8	0.21	0.10	1.6	35.4	32.0
365753094504601	07/19/2002	1005	100	96	<0.05	14	8	0.21	0.14	<0.8	35.6	75.7
365753094504601	07/19/2002	1030	170	136	<0.05	19	7	0.28	0.60	<0.8	38.9	52.4
365753094504601	07/19/2002	1100	190	130	<0.05	19	7	0.24	0.47	<0.8	37.9	11.6
365753094504601	07/19/2002	1135	200	121	<0.05	21	7	0.22	0.20	<0.8	35.6	12.1
365753094504601	07/19/2002	1200	205	149	0.05	21	6	0.16	0.22	<0.8	39.4	19.0
Federal #5												
365803094494101	07/17/2002	1720	40.0	<1	0.06	<2	7	<0.06	11.9	<0.8	0.90	40.9
365803094494101	07/17/2002	1745	120	<1	0.10	<2	8	<0.06	11.6	<0.8	0.58	36.2
365803094494101	07/17/2002	1805	195	<1	0.08	<2	9	<0.06	10.6	<0.8	1.69	17.2
365803094494101	07/17/2002	1830	200	<1	0.14	<2	8	<0.06	11.2	<0.8	0.74	21.5
365803094494101	07/17/2002	1850	210	<1	0.07	<2	8	<0.06	11.1	1.7	0.60	6.2
365803094494101	07/17/2002	1920	190	<1	0.08	<2	9	<0.06	11.0	<0.8	1.29	9.2
Baby Jim												
365818094505201	07/18/2002	1440	30.0	<1	0.23	<2	25	E0.04	5.43	<0.8	2.09	17.6
365818094505201	07/18/2002	1510	70.0	<1	0.20	<2	23	<0.06	5.20	<0.8	1.92	15.5
365818094505201	07/18/2002	1545	120	<1	0.20	<2	24	<0.06	3.90	<0.8	1.64	15.5
365818094505201	07/18/2002	1620	150	31	0.05	14	14	0.17	0.78	<0.8	29.9	18.2
365818094505201	07/18/2002	1650	160	36	0.06	15	13	0.14	0.98	<0.8	30.7	8.6
365818094505201	07/18/2002	1730	170	33	0.09	15	13	0.14	0.98	<0.8	29.0	4.8

Appendix 2. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 2002—Continued

[mm of Hg, millimeters of mercury; ˚C, degrees Celsius; mS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated value; --, no data]

Station number	Date	Time	Sampling depth (feet)	Aluminum, dissolved (µg/L)	Antimony, dissolved (µg/L)	Arsenic, dissolved (µg/L)	Barium, dissolved (µg/L)	Beryllium, dissolved (µg/L)	Cadmium dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)
Royal												
365832094490301	08/07/2002	1230	50.0	3	0.11	E1	19	E0.05	0.65	<0.8	15.3	5.0
365832094490301	08/07/2002	1335	90.0	2	0.12	<2	18	E0.03	1.46	<0.8	8.96	6.7
365832094490301	08/07/2002	1410	130	<1	0.14	3	15	<0.06	3.27	<0.8	3.10	5.0
365832094490301	08/07/2002	1450	180	<1	0.16	<2	13	<0.06	5.25	<0.8	1.78	3.5
365832094490301	08/07/2002	1525	200	<1	0.14	<2	15	E0.03	2.85	<0.8	3.41	3.0
365832094490301	08/07/2002	1605	220	1	0.15	<2	14	<0.06	2.09	<0.8	3.74	2.2
Consolidated #2												
365927094485901	07/16/2002	0900	40.0	2	0.16	<2	19	<0.06	111	<0.8	0.80	2.0
365927094485901	07/16/2002	1010	130	<1	0.19	<2	16	<0.06	86.1	<0.8	0.30	1.4
365927094485901	07/16/2002	1455	220	<1	0.21	<2	17	<0.06	87.6	<0.8	0.35	1.5
365927094485901	07/16/2002	1550	227	3	0.20	<2	16	<0.06	82.6	<0.8	1.79	1.7
365927094485901	07/16/2002	1610	230	9	0.19	2	16	<0.06	74.5	<0.8	4.24	2.2
365927094485901	07/16/2002	1650	224	<1	0.22	<2	17	<0.06	86.5	<0.8	0.33	1.4
Kansas 2												
370036094513901	07/18/2002	0955	18.0	<1	0.12	<2	21	<0.06	41.4	<0.8	2.18	50.2
370036094513901	07/18/2002	1030	33.0	<1	0.11	<2	21	<0.06	52.9	<0.8	1.40	10.6
370036094513901	07/18/2002	1100	48.0	<1	0.10	<2	21	<0.06	67.5	<0.8	0.92	26.2

Appendix 2. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 2002—Continued

[mm of Hg, millimeters of mercury; ˚C, degrees Celsius; mS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated value; --, no data]

Station number	Date	Time	Sampling depth (feet)	Iron, dissolved (µg/L)	Lead, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium dissolved (µg/L)	Silver, dissolved (µg/L)	Zinc, dissolved (µg/L)	Uranium, dissolved (µg/L)
Admiralty #3												
365737094502201	07/17/2002	0825	47.0	<10	10.2	0.5	E0.2	9.46	<2	<1	1,940	0.79
365737094502201	07/17/2002	0900	97.0	<10	10.8	0.4	E0.1	7.88	<2	<1	1,840	0.82
365737094502201	07/17/2002	0930	167	<10	8.84	0.3	E0.2	9.12	<2	<1	1,960	0.76
365737094502201	07/17/2002	1000	177	<10	6.46	1.1	0.4	18.6	E1	<1	3,290	1.38
365737094502201	07/17/2002	1040	187	<10	6.49	1.3	0.4	18.3	E2	<1	3,920	1.41
365737094502201	07/17/2002	1115	197	56,200	2.08	1020	4.4	265	4	<1	9,250	3.16
Admiralty #4												
365753094504601	07/19/2002	0920	40.0	49,200	<0.08	1,440	3.7	324	3	<1	9,680	2.77
365753094504601	07/19/2002	1005	100	50,000	E0.05	1,420	3.6	324	3	<1	9,630	2.77
365753094504601	07/19/2002	1030	170	49,900	0.54	1,230	4.0	358	4	<1	10,300	3.07
365753094504601	07/19/2002	1100	190	50,400	0.36	1,190	4.0	362	4	<1	10,300	3.03
365753094504601	07/19/2002	1135	200	54,800	0.96	1,130	4.1	345	5	<1	9,890	3.48
365753094504601	07/19/2002	1200	205	56,300	0.55	1,300	4.2	344	5	<1	11,100	3.13
Federal #5												
365803094494101	07/17/2002	1720	40.0	<10	0.25	134	<0.2	24.8	<2	<1	1,980	0.18
365803094494101	07/17/2002	1745	120	<10	0.16	46.0	<0.2	25.6	<2	<1	2,170	0.29
365803094494101	07/17/2002	1805	195	326	0.09	115	<0.2	29.2	<2	<1	2,140	0.33
365803094494101	07/17/2002	1830	200	22	0.13	54.1	<0.2	28.0	E1	<1	2,180	0.29
365803094494101	07/17/2002	1850	210	<30	0.13	57.9	<0.2	24.2	E1	<1	2,050	0.27
365803094494101	07/17/2002	1920	190	199	0.09	92.4	<0.2	28.1	<2	<1	2,140	0.32
Baby Jim												
365818094505201	07/18/2002	1440	30.0	53	32.7	466	0.5	10.3	<2	<1	1,070	0.10
365818094505201	07/18/2002	1510	70.0	46	6.17	470	0.4	12.4	<2	<1	1,080	0.12
365818094505201	07/18/2002	1545	120	74	3.01	453	0.4	11.0	<2	<1	1,040	0.14
365818094505201	07/18/2002	1620	150	44,200	1.05	935	1.2	234	3	<1	9,050	2.81
365818094505201	07/18/2002	1650	160	45,100	1.13	940	1.3	240	3	<1	8,550	3.42
365818094505201	07/18/2002	1730	170	45,400	2.01	893	1.4	235	3	<1	7,970	3.91

Appendix 2. Water-quality concentrations from water samples collected in mineshafts in the Picher mining district in 2002—Continued

[mm of Hg, millimeters of mercury; ˚C, degrees Celsius; mS/cm, microSiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated value; --, no data]

Station number	Date	Time	Sampling depth (feet)	Iron, dissolved (µg/L)	Lead, dissolved (µg/L)	Mangan-ese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium dissolved (µg/L)	Silver, dissolved (µg/L)	Zinc, dissolved (µg/L)	Uranium, dissolved (µg/L)
Royal												
365832094490301	08/07/2002	1230	50.0	16	1.73	1,550	0.3	48.4	<2	<1	1,240	0.56
365832094490301	08/07/2002	1335	90.0	E5	1.20	946	0.2	41.0	<2	<1	1,540	0.58
365832094490301	08/07/2002	1410	130	<10	1.11	375	0.3	26.8	<2	<1	1,830	0.62
365832094490301	08/07/2002	1450	180	E6	0.65	205	0.3	23.0	<2	<1	1,920	0.65
365832094490301	08/07/2002	1525	200	<10	2.11	400	0.5	27.7	<2	<1	1,720	0.59
365832094490301	08/07/2002	1605	220	77	3.84	447	0.3	26.6	<2	<1	1,850	0.67
Consolidated #2												
365927094485901	07/16/2002	0900	40.0	<10	0.37	105	0.3	9.44	<2	<1	1,620	0.10
365927094485901	07/16/2002	1010	130	<10	0.10	11.2	0.3	8.89	E2	<1	1,610	0.14
365927094485901	07/16/2002	1455	220	18	0.10	11.6	0.3	9.88	E1	<1	1,670	0.18
365927094485901	07/16/2002	1550	227	3,820	E0.07	105	0.3	20.3	E1	<1	1,900	0.84
365927094485901	07/16/2002	1610	230	10,600	0.12	253	0.5	37.7	E1	<1	2,270	1.94
365927094485901	07/16/2002	1650	224	15	E0.07	9.4	0.3	9.52	E1	<1	1,680	0.18
Kansas 2												
370036094513901	07/18/2002	0955	18.0	11	4.85	1,320	0.5	13.1	E1	<1	4,160	0.72
370036094513901	07/18/2002	1030	33.0	<10	5.27	568	0.3	16.3	<2	<1	4,770	0.87
370036094513901	07/18/2002	1100	48.0	<10	4.49	209	0.2	17.7	<2	<1	6,630	0.81