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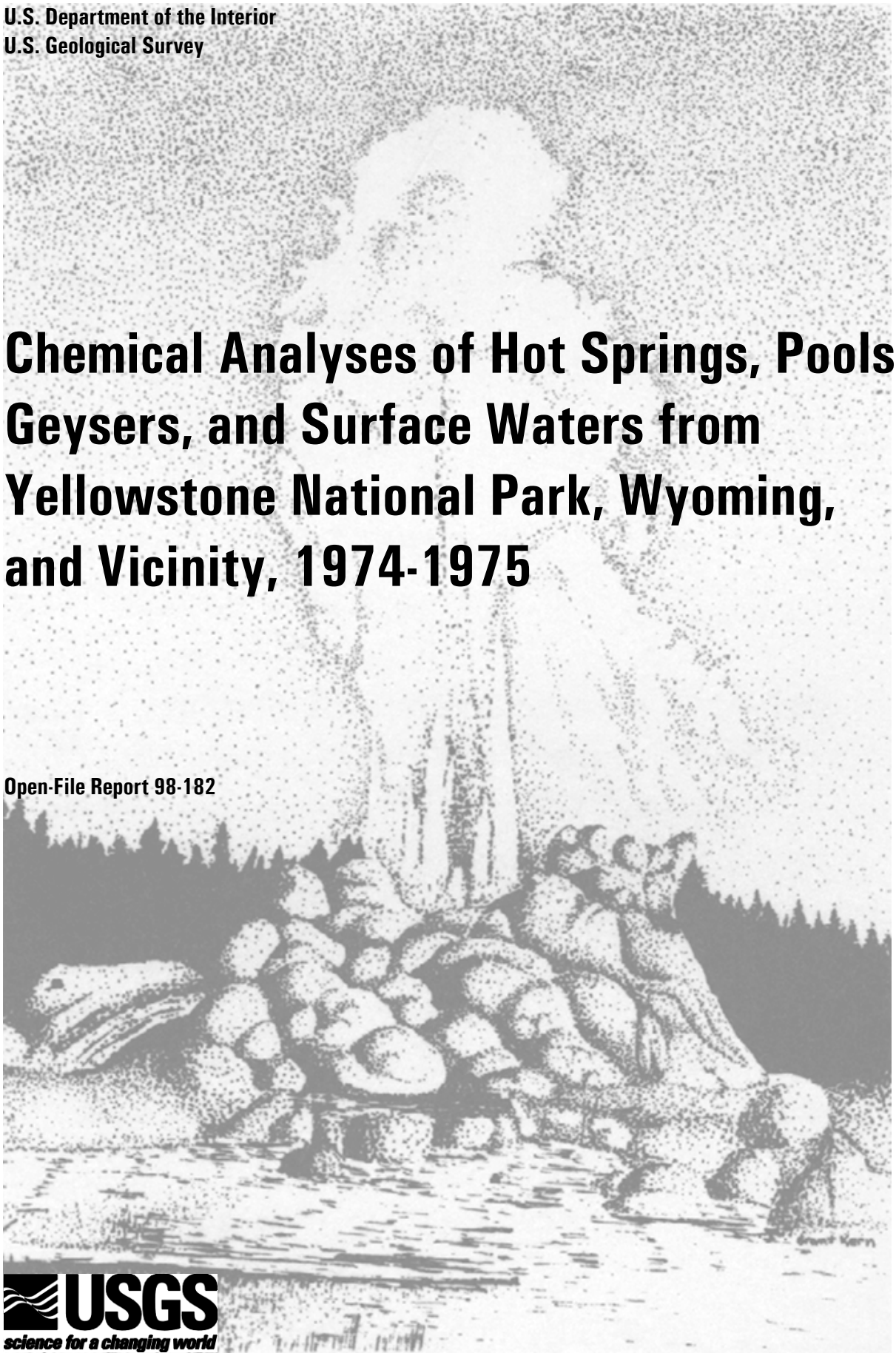
Chemical Analyses of Hot Springs, Pools, Geysers, and Surface Waters from Yellowstone National Park, Wyoming, and Vicinity, 1974-1975

Open-File Report 98-182



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Chemical Analyses of Hot Springs, Pools, Geysers, and Surface Waters from Yellowstone National Park, Wyoming, and Vicinity, 1974-1975

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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
L (liter)	0.2642	gallon
mg (milligram)	3.520×10^{-5}	ounce
：m (micrometer)	3.937×10^{-5}	inch

Temperature in degrees Fahrenheit (ºF) can be converted to degrees Celsius (ºC) as follows:

$$ºF = 1.8 \times ºC + 32$$

Explanation of abbreviations:

ºC (degrees Celsius)
：S/cm (microsiemens per centimeter at 25ºC)
mg/L (milligrams per liter)

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ABSTRACT

This report presents all analytical determinations for samples collected from Yellowstone National Park and vicinity during 1974 and 1975. Water temperature, pH, Eh, and dissolved O_2 were determined on-site. Total alkalinity and F were determined on the day of sample collection. Flame atomic-absorption spectrometry was used to determine concentrations of Li, Na, K, Ca, and Mg. Ultraviolet/visible spectrophotometry was used to determine concentrations of Fe(II), Fe(III), As(III), and As(V). Direct-current plasma-optical-emission spectrometry was used to determine the concentrations of B, Ba, Cd, Cs, Cu, Mn, Ni, Pb, Rb, Sr, and Zn. Two samples collected from Yellowstone Park in June 1974 were used as reference samples for testing the plasma analytical method. Results of these tests demonstrate acceptable precision for all detectable elements. Charge imbalance calculations revealed a small number of samples that may have been subject to measurement errors in pH or alkalinity. These data represent some of the most complete analyses of Yellowstone waters available.

INTRODUCTION

A survey of the waters of Yellowstone National Park and vicinity was conducted by the U.S. Geological Survey during the summers of 1974 and 1975 to measure on-site parameters and to collect water samples for determination of major and trace element concentrations. Major element concentrations were determined so that geochemical modeling calculations could be made with the data. Such calculations can be helpful in describing the source, fate, and processes governing the composition of natural waters (Nordstrom and Jenne, 1977).

Concentrations for many of the dissolved constituents in samples collected during 1974 were reported and discussed by Stauffer and others (1980). The purpose of this report is to present all analytical determinations for samples collected during both 1974 and 1975. These data are some of the most complete analyses of Yellowstone waters that are available.

The authors gratefully acknowledge the assistance of the U.S. National Park Service and the many helpful employees of Yellowstone National Park who made our sampling trips into the Yellowstone back country possible. We especially recognize the late Rick Hutchinson, whose contributions to the geoscience community's knowledge of the Park's thermal features are incalculable.

SAMPLE SOURCES

Locations of samples collected in 1974 (figs. 1 and 2) are described by Stauffer and others (1980). Thirty-three springs and drainages in the Gibbon Geyser Basin were sampled in 1975. Four

discrete areas of this basin are: (1) Artists Paintpots, near the boardwalk at the south end of Gibbon Meadows east of Grand Loop road, 5 samples; (2) the Gibbon Hill Geyser group, along the base of Gibbon Hill from the northeast to the southeast of Artists Paintpots, 9 samples; (3) the Geyser Springs group, to the east-southeast of Artists Paintpots, 10 samples; and (4) Sylvan Springs, west of the Grand Loop road and the Gibbon River, 9 samples. The former three areas are identified on figure 3, and the northern, central, and southern localities of the Sylvan Springs area are identified on figure 4. Table 1 contains detailed descriptions of all sample locations.

SAMPLE COLLECTION AND PRESERVATION

Samples were collected and preserved in accordance with procedures described by Ball and others (1976). Briefly, the samples were pumped from their source with a Masterflex portable peristaltic pump equipped with silicone tubing. Filtered samples were obtained by attaching the pump's outlet tube to a filtration assembly consisting of a 0.1-∶m membrane sandwiched between two acrylic plastic plates and sealed with a viton or silicone o-ring. The design and operation of this filtration device is described in detail by Kennedy and others (1976). This arrangement allowed sample collection from sources of all temperatures with minimal contact with ambient air and with a maximum temperature variation of ±2°C between source water and filtered sample water. Samples for major cation and Fe and As valence species determinations were acidified with 1 mL concentrated HCl per 250 mL of sample. Samples for trace metal determinations were acidified with 5 mL concentrated HNO_3 per L of sample. Samples for total dissolved sulfide species [S(-II)] determination were preserved by sequentially adding 1 mL 1M $Zn(CH_3COO)_2$ and 1 mL 1M NaOH per 250 mL. Samples for NO_3 and soluble reactive P determination were preserved by freezing with dry ice.

ANALYTICAL METHODS

Field Measurements

Water temperature, pH, specific conductance, Eh, and dissolved O_2 were determined on-site. Hot spring temperatures were determined using a calibrated Hg thermometer immersed in samples withdrawn in an insulated bottle clamped to the end of an aluminum pole. Temperatures of cooler waters were measured by direct immersion of the thermometer in the source. The Eh and pH were measured by placing the electrodes in a flow-through cell (Ball and others, 1976) through which sample water was pumped with a portable peristaltic pump. Dissolved O_2 was determined using the azide modification of the Winkler procedure (American Public Health Association, 1971).

Total alkalinity and F were determined on the day of sample collection. Alkalinity was determined by titration to pH 4.5 with standardized sulfuric acid. Fluoride was determined using an Orion fluoride ion-selective electrode after mixing the sample (10:1) with total ionic strength adjustment buffer.

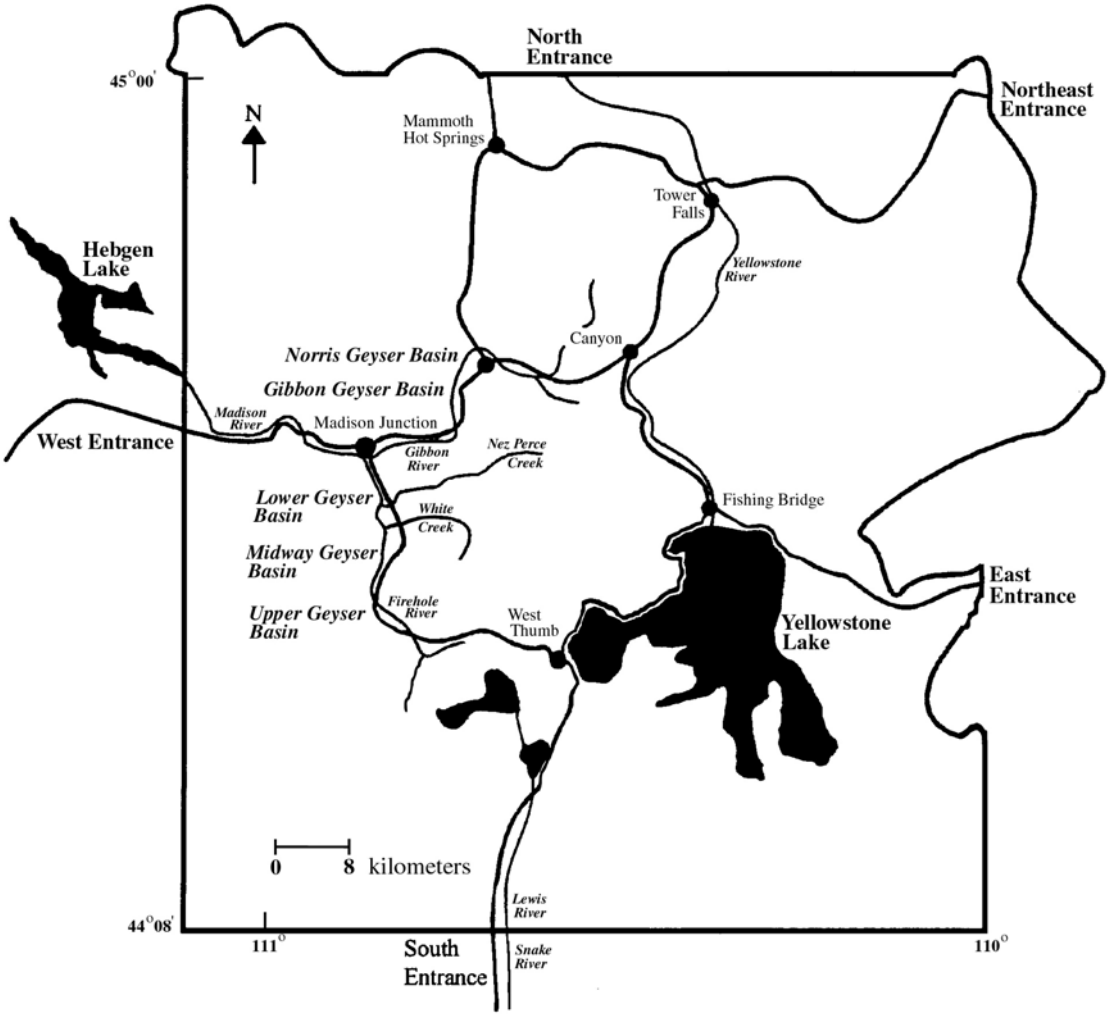

Figure 1. Location of major geyser basins in Yellowstone National Park, Wyo.

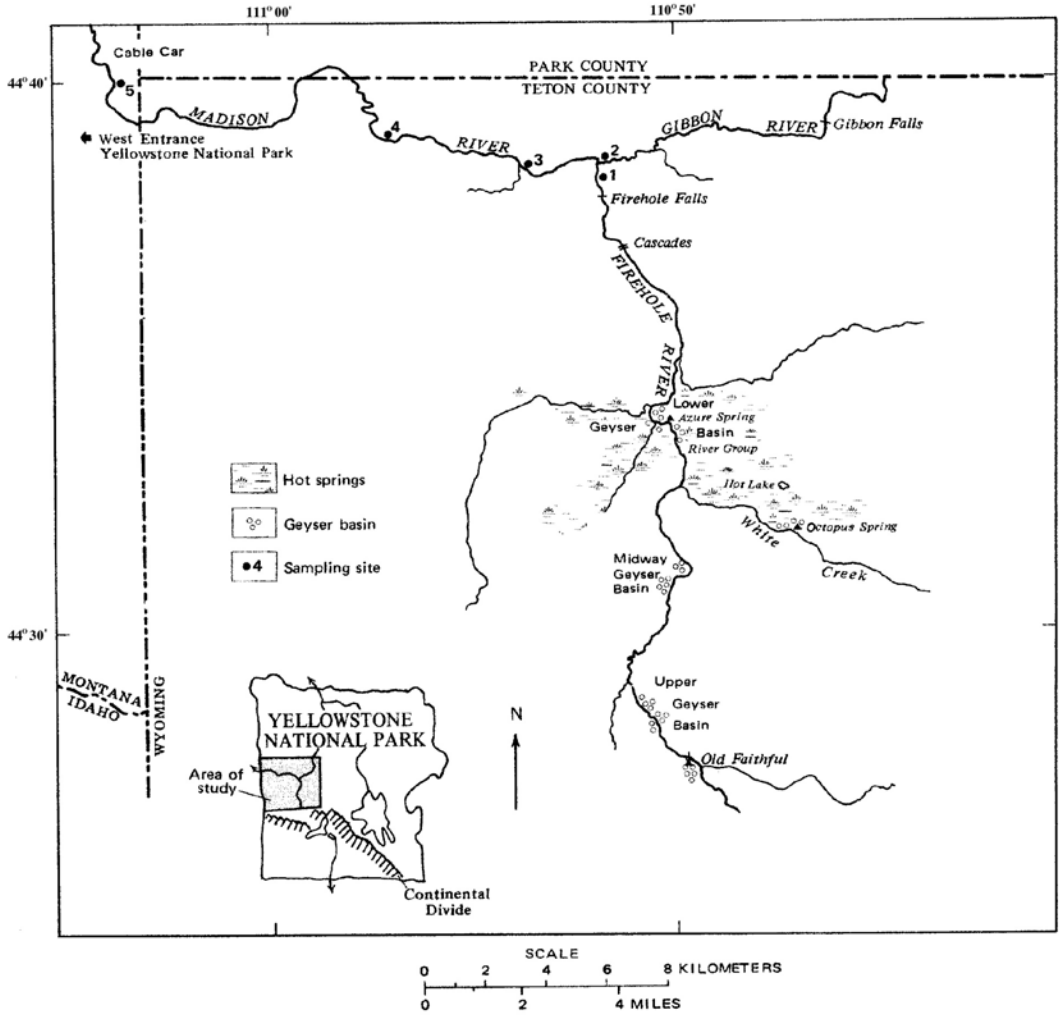

Figure 2. Rivers and major hydrothermal areas sampled in Yellowstone National Park, Wyo. (from Stauffer and others, 1980).

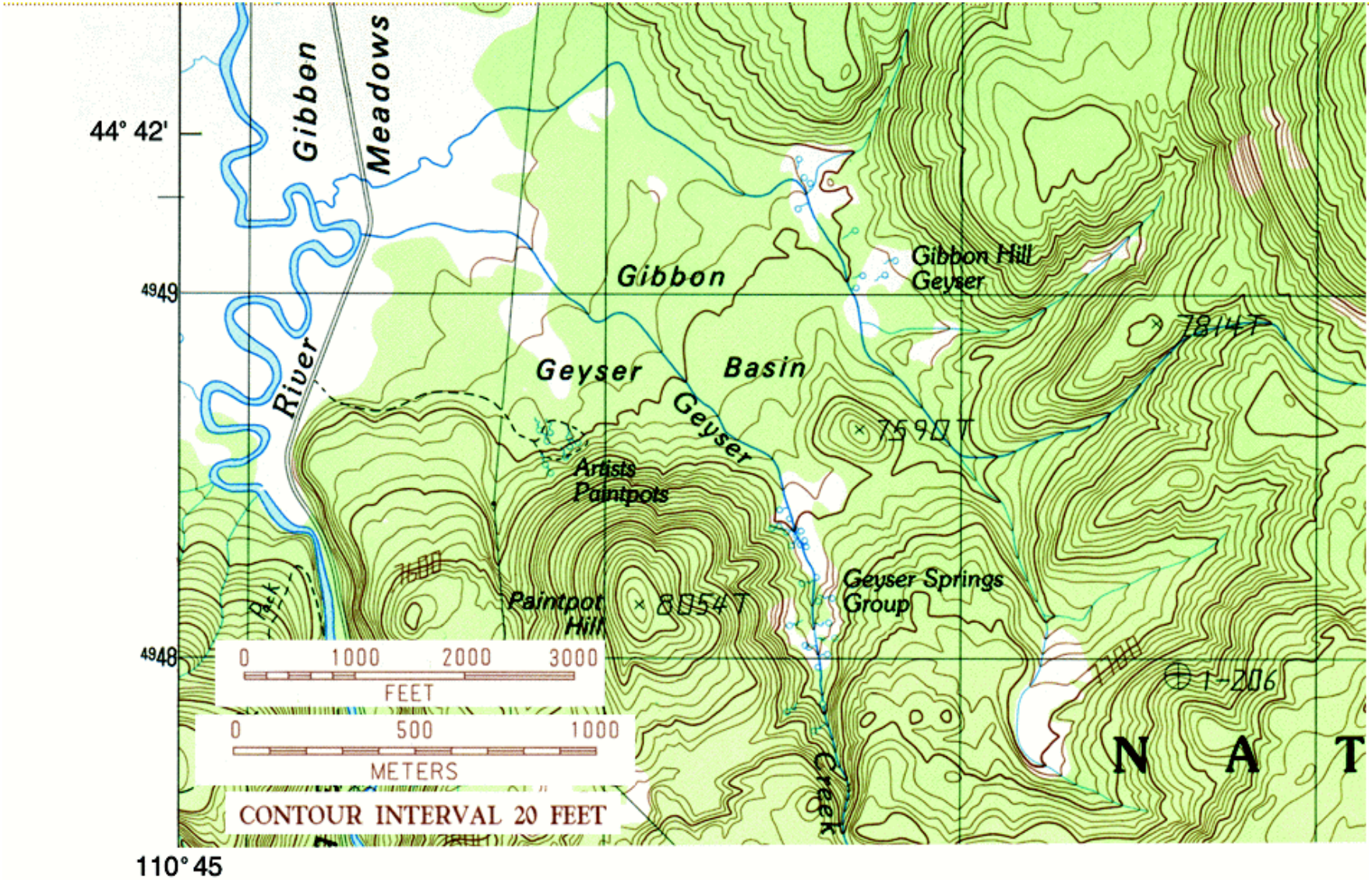

Figure 3. Sampling locations in the Artists Paintpots, Geyser Springs Group, and Gibbon Hill Geyser areas of the Gibbon Geyser Basin, Yellowstone National Park, Wyo.

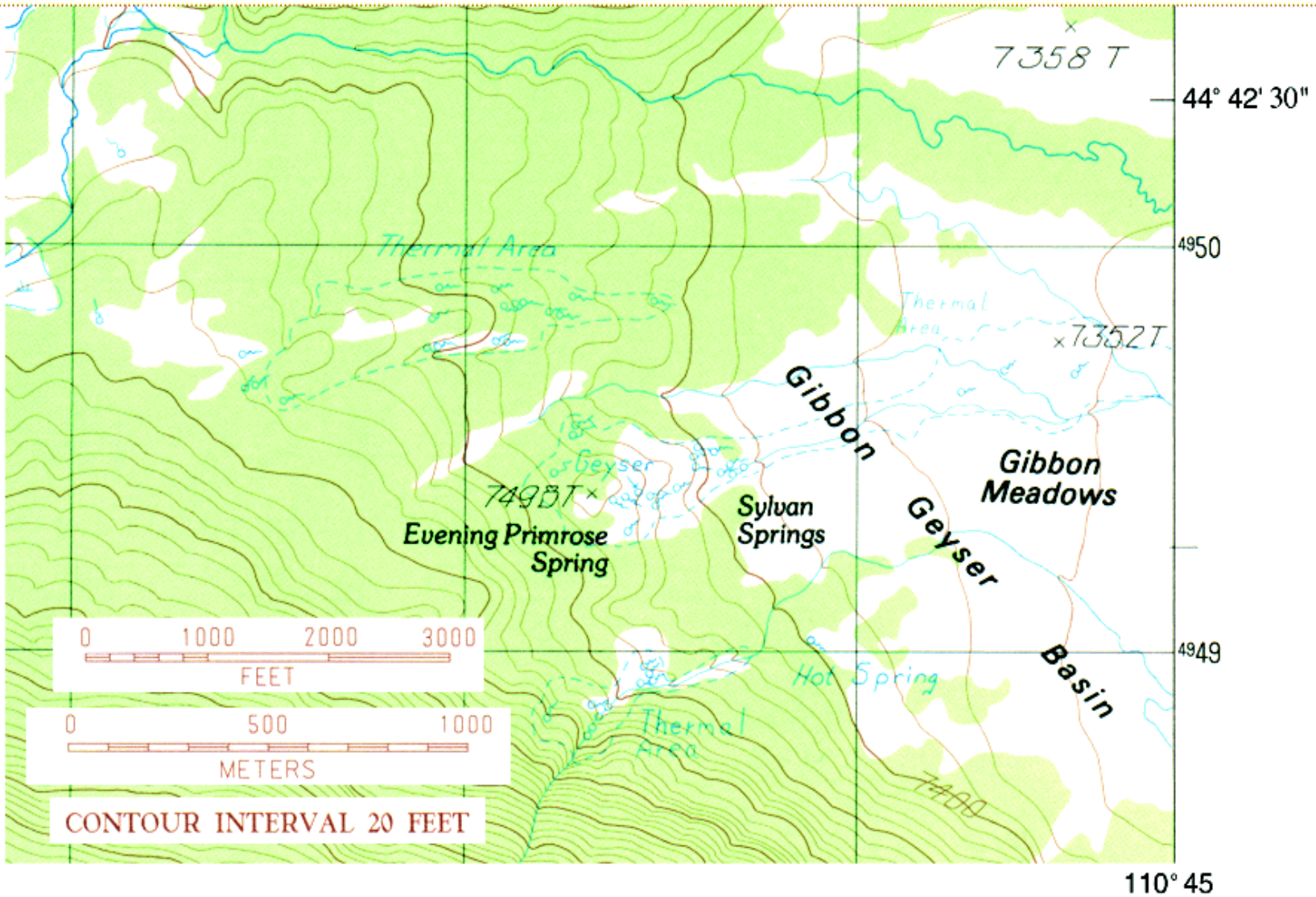

Figure 4. Sampling locations in the Sylvan Springs area of the Gibbon Geyser Basin, Yellowstone National Park, Wyo.

Table 1. Detailed sample site descriptions

Sample code number	Site description
74WA107	Firehole River, 1.1 kilometers below Firehole Falls, first turnout in Firehole Canyon Drive, sampled from gravel bar on right bank facing downstream; canyon walls almost reach stream bank, stream turbulent across entire width
74WA108	Gibbon River, 80 meters upstream from highway bridge south of Madison Junction, in grassy meadow below double bend in river
74WA109	Madison River, 1.8 kilometers by road west of Madison Junction, in broad grassy meadow 60 meters downstream of roadside plaque
74WA110	Madison River, 6.0 kilometers by road west of Madison Junction, 80 meters upstream of turnout, above point where river widens and begins to meander, right bank
74WA111	Madison River at cable crossing below West Yellowstone gaging station
74WA112	Octopus Spring, Lower Geyser Basin, 81-85ºC
74WA113	Octopus Spring drainage, Lower Geyser Basin, 1 meter above confluence with White Creek, 23-26ºC
74WA114	Octopus Spring drainage, Lower Geyser Basin, 63-75ºC
74WA115	Octopus Spring drainage, Lower Geyser Basin, 53-61ºC
74WA116	Octopus Spring drainage, Lower Geyser Basin, 50ºC
74WA117	Octopus Spring drainage, Lower Geyser Basin, 40ºC
74WA118	Octopus Spring drainage, Lower Geyser Basin, 30ºC
74WA119	White Creek above culvert, Lower Geyser Basin
74WA120	Madison River, Hebgen Lake at Hebgen Dam spillway entrance
74WA121	Madison River at Highway 87 (Montana-Idaho) crossing
74WA122	Drainage from dormant geyser on west slope of Old Faithful sinter mound, Upper Geyser Basin
74WA123	Tortoise Shell, Upper Geyser Basin, at west edge of Castle Geyser
74WA124	Unnamed spring, largest of 3 small features between Tardy and Sawmill Geysers, upslope from boardwalk, Upper Geyser Basin
74WA125	Witches Cauldron, Upper Geyser Basin
74WA126	Unnamed spring, across Firehole River from Old Faithful, highest and western-most vent, with bubbling and overflow to West, Upper Geyser Basin
74WA127	Spouter Geyser, Black Sand Basin
74WA128	Unnamed spring, south of Old Faithful Interchange, discrete drainage continues for 175 meters
74WA129	Unnamed spring (“Bow Tie”), Black Sand Basin, vigorously boiling
74WA130	Unnamed spring (“S.W.G.L.-1.3”), north of 74WA128, 0.3 m orifice, 0.6 X 1.5 m surface, gas bubbling, no overflow
74WA132	Azure Spring, Lower Geyser Basin, 86ºC
74WA133	Azure Spring drainage, Lower Geyser Basin, 45-63ºC

Table 1. Detailed sample site descriptions--Continued

Sample code number	Site description
74WA134	Azure Spring drainage, Lower Geyser Basin, 33-41ºC
74WA135	Azure Spring drainage, Lower Geyser Basin, 64-70ºC
74WA136	Azure Spring, Lower Geyser Basin, black surface deposits, satellite spring 1 m S of main pool
74WA137	Azure Spring drainage, Lower Geyser Basin, 49-50ºC
74WA138	Mixed cold spring (74WA143) and unnamed ("Sulfide") spring (74WA141) at marsh entrance, upper edge of river terrace gravels, near base of steep hill
74WA139	Mixed cold spring (74WA143) and unnamed ("Sulfide") spring (74WA141), midway between confluence and marsh entrance on 30 degree slope, turbulent stream 12 to 24 centimeters wide, marked by log crossing stream
74WA140	Mixed cold spring (74WA143) and unnamed ("Sulfide") spring (74WA141), about 1.5 meters below confluence
74WA141	Unnamed ("Sulfide") spring drainage 0.3 meters above confluence with 74WA143
74WA142	Unnamed ("Sulfide") spring, near Calcite Spring, sampled at mouth, under fallen tree
74WA143	Unnamed cold spring, near Calcite Spring, fed by small thermal spring and non-point-source ground-water seepage
74WA144	Calcite Spring, near Tower Falls
74WA146	New Highland Spring, Mammoth Hot Springs
74WA147	Unnamed blue-colored spring, adjacent to New Highland Spring
75WA139	Beryl Spring, Gibbon Geyser Basin
75WA140	Unnamed 2.4-meter-diameter spring, north end Geyser Springs Group, Gibbon Geyser Basin
75WA141	Unnamed spring ("Bullseye"), Geyser Springs Group, Gibbon Geyser Basin, 90 meters North of "Oblique Geyser"
75WA142	Unnamed 3.7 X 6.4-meter superheated spring ("Bat Pool"), south end (4th level) of Geyser Springs Group, Gibbon Geyser Basin
75WA143	Unnamed spring, "North" Sylvan Springs Group, Gibbon Geyser Basin, 6 meters upslope of ephemeral stream, yellow coatings at pool edges
75WA144	Unnamed small churning spring under welded Yellowstone tuff, "North" Sylvan Springs Group, Gibbon Geyser Basin
75WA145	Unnamed spring issuing from hillside, "South" Sylvan Springs Group, Gibbon Geyser Basin
75WA146	Unnamed upwelling spring 250 meters east of 75WA145, "South" Sylvan Springs Group, Gibbon Geyser Basin
75WA147	Unnamed spring ("Iron Fortress"), Gibbon Hill Group, Gibbon Geyser Basin, highest-elevation spring in its group
75WA148	Drainage from "Iron Fortress", Gibbon Hill Group, Gibbon Geyser Basin
75WA149	Drainage from "Iron Fortress", Gibbon Hill Group, Gibbon Geyser Basin
75WA150	Drainage from "Iron Fortress", Gibbon Hill Group, Gibbon Geyser Basin

Table 1. Detailed sample site descriptions--Continued

Sample code number	Site description
75WA151	Unnamed spring 400 meters North of 75WA147, Gibbon Hill Group, Gibbon Geyser Basin
75WA152	Unnamed 0.6 meter-diameter spouter, Artists Paintpots, Gibbon Meadows
75WA153	Unnamed 3.7 X 4.6-meter spring, Artists Paintpots, Gibbon Meadows, adjacent to warning sign, “Dangerous Thermal Area”
75WA154	Unnamed spring behind small grove of trees, 90 meters west of 75WA153, opposite group of opalescent blue low-pH pools, Artists Paintpots, Gibbon Meadows
75WA155	Octopus Spring, Lower Geyser Basin, Diel Site 1, Time = 12:30
75WA156	Octopus Spring, Lower Geyser Basin, Diel Site 1, Time = 15:30
75WA157	Octopus Spring, Lower Geyser Basin, Diel Site 1, Time = 18:30
75WA158	Octopus Spring, Lower Geyser Basin, Diel Site 1, Time = 22:00
75WA159	Octopus Spring, Lower Geyser Basin, Diel Site 1, Time = 01:00
75WA160	Octopus Spring, Lower Geyser Basin, Diel Site 1, Time = 04:00
75WA161	Octopus Spring, Lower Geyser Basin, Diel Site 1, Time = 07:00
75WA162	Octopus Spring, Lower Geyser Basin, Diel Site 1, Time = 10:00
75WA163	Octopus Spring, Lower Geyser Basin, Diel Site 1, Time = 13:00
75WA164	Octopus Spring, Lower Geyser Basin, Diel Site 2, Time = 12:30
75WA165	Octopus Spring, Lower Geyser Basin, Diel Site 2, Time = 15:50
75WA166	Octopus Spring, Lower Geyser Basin, Diel Site 2, Time = 19:00
75WA167	Octopus Spring, Lower Geyser Basin, Diel Site 2, Time = 22:00
75WA168	Octopus Spring, Lower Geyser Basin, Diel Site 2, Time = 01:00
75WA169	Octopus Spring, Lower Geyser Basin, Diel Site 2, Time = 04:00
75WA170	Octopus Spring, Lower Geyser Basin, Diel Site 2, Time = 07:40
75WA171	Octopus Spring, Lower Geyser Basin, Diel Site 2, Time = 10:30
75WA172	Octopus Spring, Lower Geyser Basin, Diel Site 2, Time = 13:00
75WA173	Unnamed 1.5 meter-diameter clear blue circular spring with coliform silica sinter mound, north end of Gibbon Hill Group, Gibbon Geyser Basin
75WA174	Unnamed violently-boiling turbid spring, south of marsh adjacent to stream, Gibbon Hill Group, Gibbon Geyser Basin
75WA175	Unnamed spring, less than 1 meter in diameter, red algae, Gibbon Hill Group, Gibbon Geyser Basin
75WA176	Unnamed 3 X 5-meter spring with thin sinter crust, Gibbon Hill Group, Gibbon Geyser Basin
75WA177	Oblique Geyser drainage about 3.7 meters from geyser, Geyser Springs Group, Gibbon Geyser Basin
75WA178	Oblique Geyser drainage about 12.8 meters from geyser, Geyser Springs Group, Gibbon Geyser Basin

Table 1. Detailed sample site descriptions--Continued

Sample code number	Site description
75WA179	Oblique Geyser drainage about 30 meters from geyser, Geyser Springs Group, Gibbon Geyser Basin
75WA180	Oblique Geyser drainage about 70 meters from geyser, Geyser Springs Group, Gibbon Geyser Basin
75WA181	Mixed drainage about 7 meters below confluence of several hot spring drainages, Gibbon Geyser Basin
75WA182	Unnamed spring, Sylvan Springs, Gibbon Geyser Basin
75WA183	Unnamed spring, next to Evening Primrose Spring, yellow-white turbidity and sinter deposits, violent bubbling, Sylvan Springs, Gibbon Geyser Basin
75WA184	Evening Primrose Spring, Sylvan Springs, Gibbon Geyser Basin, 6 meters in diameter, water level about 2 meters below land surface
75WA189	Yellowstone River, 18 kilometers below Gardner River confluence, at Yankee Jim Canyon
75WA190	Yellowstone River, 5 kilometers below Gardner River confluence, above sewage treatment plant, near airport, sampled from North bank
75WA191	Yellowstone River at Gardiner, about 140 meters below Gardner River confluence
75WA192	Unnamed hot spring, about 1 kilometer along trail, east side of Snake River at cable car crossing
75WA193	Snake River, east bank at cable car crossing
75WA194	Unnamed spring, Geyser Springs Group, Gibbon Geyser Basin, at south end of 4th level near superheated sapphire pool
75WA195	Unnamed spring with black coatings, 3rd level, Geyser Springs Group, Gibbon Geyser Basin
75WA196	Unnamed yellow-fringed opalescent green hot spring, base of Paint Pot Hill, Gibbon Geyser Basin
75WA197	Unnamed spring, larger of 2 in small sandy basin North of curved portion of boardwalk, Artists' Paintpots, Gibbon Geyser Basin
75WA198	Unnamed 20 X 40 meter-diameter spring (“Sylvan Spring”) southwest and upslope of top of main area, Sylvan Springs, Gibbon Geyser Basin
75WA199	Unnamed large surging hot spring on central drainage channel near top of area, Sylvan Springs, Gibbon Geyser Basin
75WA200	Mushroom Spring, Lower Geyser Basin, 800 meters east of White Dome Geyser
75WA201	Hot Lake drainage, Lower Geyser Basin, 700 meters by road from White Dome Geyser, 15 meters downstream of confluence of 2 major flows, 25 meters upstream of small pink-coned spouter on opposite side of road
75WA202	Hot Lake drainage, lower road crossing, Lower Geyser Basin, near White Dome Geyser
75WA203	Hot Lake drainage, upper road crossing, Lower Geyser Basin, 100 meters by road from White Dome Geyser

Laboratory Measurements

Taylor (1981) has summarized the application of plasma-optical emission spectrometry to the analysis of natural waters. Direct-current plasma-optical emission spectrometry (DCP-OES) can be used to determine major and trace concentrations of many metals simultaneously over a wide concentration range in aqueous solution. The technique is sensitive, precise, accurate, and rapid, with little or no sample pretreatment required other than occasional dilution of concentrated samples. In addition, automated analysis and data reduction systems are readily available from the instrument manufacturers. This technique has been compared with inductively coupled plasma-optical emission spectrometry (ICP-OES) by Ball and Nordstrom (1994), and the two techniques were found generally to be comparable in most respects.

Flame atomic-absorption spectrometry (flame AAS) and ultraviolet/visible (UV/VIS) spectrometry were used to determine concentrations of several constituents. These techniques are characterized by high sensitivity, accuracy, and precision, and, like the plasma method, usually are suitable for the analysis of complex matrices. These two techniques have slower analytical speed than the simultaneous plasma technique because of their inherently single-element nature and, except for analyses in uncomplicated matrices using the flame AAS technique, because of added requirements for sample pretreatment during analysis, prior to the measurement step. For up to six elements, flame AAS and plasma spectrometers, operated in their respective sequential multi-element modes, are capable of equivalent analytical speed.

Chloride and SO_4 were determined by cation exchange using a modification (Stauffer, 1980a) of the method of Mackereth (1963). Arsenic and soluble reactive P were determined using a modification (Stauffer, 1980b) of the molybdenum-blue UV/VIS spectrometric method of Johnson and Pilson (1972).

For the 1974 samples, Fe, Mn, Al, and Cu were complexed with 8-quinolinol at pH$8 and extracted into methyl isobutyl ketone, followed by determination using flame AAS. Total dissolved S(-II) was determined on the $Zn(CH_3COO)_2$-fixed samples using a Ag/S ion-selective electrode (Baumann, 1974; Vivit and others, 1984). Iron(II) and Fe(total) were determined by UV/VIS spectrometry using a modification (D. K. Nordstrom, USGS, written commun., 1989) of the FerroZine method of Stookey (1970).

Lithium, Na, K, Mg, and Ca were determined by flame AAS using a Perkin-Elmer Model 303 or 306 spectrophotometer and following procedures specified by the manufacturer. Silicon was determined by DCP-OES using a DCP spectrometer operated in the single-element mode. In 1980 and 1981, the following additional metals were determined by simultaneous direct-reading multi-element DCP-OES: B, Sr, Ba, Rb, Mn, Zn, Pb, Ni, Cu, Cd, and Cs. Head spaces in the sample bottles stored for 6 years before determination of metal concentrations typically were 30 percent or less of bottle volume. Errors caused by evaporation would result in positive bias in metal concentrations, and thus would tend to yield positive calculated charge imbalances.

The DCP spectrometer used was a SpectraSpan IIIB (SpectraMetrics, Inc., Andover, MA) simultaneous direct-reading unit, equipped with two cassettes containing apertures designed to direct pre-selected monochromatic wavelengths of 20 elements into a bank of 20 photomultiplier tube detectors, one per respective element, by means of an echelle grating spectrometer. To increase

thermal contact between the plasma and the measuring zone located directly below the plasma (Johnson and others, 1979), a Li solution was mixed at approximately a 1:11 ratio with the sample just prior to nebulization such that a total concentration of 2,270 mg/L of Li was generated in the sample (Ball and others, 1978). Instrument output was collected, then processed offline, using a Tektronix 4052 desktop microcomputer with a serial printer and a data-reduction software package developed by J. W. Ball (unpub. data, 1989). This output-collection method is explained in more detail by Ball and Nordstrom (1985; 1989). External calibration was accomplished by fitting emission intensities for standards analyzed as unknowns to a straight line using a first-order least-squares method. The resulting fit parameters were then combined with emission intensities for unknowns to yield concentration values. All DCP determinations were done without off-peak dynamic background correction.

The specific wavelengths for the DCP simultaneous multi-element modes were selected by the instrument manufacturer at the time of construction of the optical cassettes. These wavelengths, concentrations of calibrating solutions, operational detection limits, and literature detection limits are shown in table 2. The operational detection limits, which were defined and determined by Ball and Nordstrom (1994), are strongly influenced by many factors, one of which is the choice of wavelength. If the wavelength at which a literature detection limit was measured is different from that used for making the measurements of this report, its value is given as a footnote to table 2. The reader is referred to Ball and others (1978) for instrument settings for the SpectraSpan IIIB DCP spectrometer.

Minor- and trace-element concentrations were corrected for inter-element spectral effects that result from the presence of concomitant major elements (Ball and Nordstrom, 1989). This correction required the prior collection of concentration data for a representative concentration range of the potential interferent in the absence of the analyte. The resulting apparent analyte concentration values were fitted to various types of linear and non-linear simple regression equations, and the selected fit parameters were determined. After assembling apparent concentration data for the unknowns, the concentrations of the concomitant elements were sequentially combined with the selected fit parameters to yield concentration values for their interference effects. The resulting concentration values were subtracted from the apparent analyte concentration. This inter-element correction technique was used to correct for the effects of Ca, Mg, Si, K, Na, and Fe, on the apparent concentrations of Al, As, B, Cd, Cu, Fe, Pb, Mn, Ni, and Zn. No effects of Ca, Mg, Si, K, Na, or Fe at their upper concentration limits (232, 29, 263, 59, 520, and 4.1 mg/L, respectively) were observed on the apparent concentrations of Si, Mg, Ca, Fe, Sr, Ba, K, or Na. The effect of Ca is the most serious for the analysis of geothermal effluent by DCP spectrometry.

Many of these samples contained Na, Cl, and SiO_2 at concentrations exceeding 250 mg/L and had total alkalinities that also were in the several-hundred-mg/L range. These constituents do not usually contribute spectral interferences to the determination of concentrations of minor and trace metals, although SiO_2 at elevated concentrations may necessitate more flushing of the nebulizer with water to prevent solid deposits from forming in it.

Table 2. Wavelengths and analytical ranges for the direct-current plasma (DCP) spectrometer [nm, nanometers; mg/L, milligrams per liter]

Element	Wavelength (nm)	Maximum standard concentration (mg/L)	Operational detection limit (mg/L)	Literature detection limit (mg/L)
Al[1]	396.15	0.5	0.01	[2]0.01
As	193.80	20.0	0.4	(3)
Ba	455.40	1.0	0.005	[2,4]0.02
B	249.77	1.0	0.02	[2,5]0.005
Cd	214.44	1.0	0.01	[2]0.01
Ca	393.37	5.0	0.2	[2,4,6]0.2
Cu[1]	324.75	0.5, [7]0.2	0.01, [7]0.003	[2]0.005
Fe[1]	371.99	2.0, [7]1.0	0.015, [7]0.02	(3)
Pb	405.78	4.0	0.02	[2]0.01
Mg	279.55	2.0	0.02	[2,4]0.13
Mn[1]	257.61	0.5	0.01	[2]0.01
Ni	341.48	0.5	0.004	[2]0.01
K	766.49	20.0	0.3	[2,4,8]0.04
Si	251.61	10.0	0.2	[2]0.01
Na	589.59	20.0	0.2	[2,4]0.4
Sr	421.55	1.0	0.001	[2,9]0.1
Zn	213.86	0.5, [7]0.5	0.02, [7]0.006	(3)

[1]Element concentrations were determined by solvent extraction and flame atomic absorption spectrometry for 1974 samples. Detection limits are: Al, 0.002 mg/L; Cu, 0.0003 mg/L; Fe, 0.0004 mg/L; Mn, 0.0002 mg/L.
[2]Johnson and others(1979).
[3]No literature detection limit found for this element.
[4]Attempts to achieve maximum sensitivity were not made since these elements normally are present at higher concentrations in natural and effluent waters.
[5]Wavelength = 249.68 nm.
[6]Wavelength = 396.85 nm.
[7]Two values refer to DCP cassettes 1 and 2, respectively. Wavelengths are the same.
[8]Wavelength = 769.90 nm.
[9]Wavelength = 460.73 nm.

Reagents

All reagents were American Chemical Society (ACS) Reagent Grade or better. Reagents and solutions other than ACS Reagent Grade were as follows:

1. Double distilled water, better than 1 megohm purity for rinsing and on-site dilutions.
2. Baker Ultrex HNO_3 and HCl for acidifying samples.

For the plasma emission determinations, multi-element working standard solutions composed of alkali and alkaline earth salts of purity 99.99 percent or better and other metal and alkaline earth salts, acids, and commercially prepared solutions of purity 99.999 percent or better were used. The set of standard solutions consisted of a top standard and three additional standards containing 0.5, 0.25, and 0.1 fractions of the concentration of the top standard for each element, diluted to volume with 1.0*N* HNO_3. A 0.1*N* HNO_3 solution was used as a blank. Two different sets of standards were prepared for the DCP determinations, one for each of the two multi-element cassettes.

DATA RELIABILITY

Accuracy of Plasma Analyses

Accuracy of DCP-OES analysis is variable among elements and generally depends on analyte concentration compared with instrument sensitivity, presence of background and inter-element spectral interferences, and precision with which the spectrometer can measure the emitted energy from the DCP source at the wavelength of interest. Instrument sensitivity depends on which wavelength is selected for inclusion in the multi-element array. This choice sometimes depends on space constraints within the exit slit cassette or the detector module. Sensitivity also depends on operating conditions for the DCP source and nebulizer, and positioning of the DCP source image on the spectrometer entrance slit. Severity of background and inter-element effects depends on the proximity of analyte wavelengths to interferent wavelengths and on the interferent-to-analyte concentration ratio. The closer the wavelengths are to each other and the larger the magnitude of the interferent-to-analyte ratio, the more severe will be the interference and the less precise and accurate will be its correction. The reader is referred to the reports of Ball and Nordstrom (1989; 1994) for more detailed discussions of factors affecting accuracy and precision of DCP-OES analysis. DCP-OES precision issues for the determinations reported here are addressed in the following paragraphs.

Two samples collected from Yellowstone Park in June 1974 were used as reference samples for testing of methods. Reference sample 1 was collected from Steady Geyser near Firehole Loop Road, Midway Geyser Basin. Reference sample 2 was collected from Emerald Spring in Norris Geyser Basin. There were 35 cassette-1 and 14 cassette-2 analytical runs. Data were not corrected for inter-element interferences. For reference sample 1, diluted by a factor of 10 for cassette 1 analysis, usable data were obtained for Ca, Na, K, Si, B, and Mn. For reference sample 2, diluted by a factor of 20 for cassette 1 analysis, usable data were obtained for Na, K, Si, and B. Undiluted samples were analyzed for As using cassette 2. Results are presented in tables 3 and 4.

Table 3. Raw analytical results for reference sample 1 (Steady Geyser, Firehole Loop Road). [All concentrations in milligrams per liter; stdev, standard deviation; RSD, relative standard deviation, in percent]

Lab number	Analysis date	Dilution	Ca	Na	K	Si	B	Mn
911001	6/21/79	1/10	12.8	97.7	16.1	88.8	0.42	[1]***0.48***
911101	6/21/79	1/10	13.6	90.3	16.1	89.4	0.49	0.11
911201	6/22/79	1/10	13.4	92.3	16.1	91.0	0.48	***0.29***
911301	6/22/79	1/10	12.9	87.3	15.3	89.0	0.46	0.15
003601	1/16/80	1/10	14.3	93.0	17.1	93.0	0.41	0.12
003701	1/16/80	1/10	13.0	90.5	15.2	88.3	0.43	0.14
003801	1/17/80	1/10	14.0	95.2	16.3	91.7	0.38	0.13
003901	1/16/80	1/10	***15.7***	***106.2***	16.3	***107.6***	0.36	
004001	1/17/80	1/10	13.4	85.0	14.5	88.8	0.39	0.13
004101	1/17/80	1/10	14.1	92.5	15.4	92.5	0.41	0.12
004201	1/18/80	1/10	14.3	93.3	15.5	93.7	0.40	0.13
004301	1/18/80	1/10	***15.0***	***102.1***	***17.8***	***97.9***	0.41	0.13
004401	1/18/80	1/10	12.3	81.7	14.2	86.4	0.42	0.13
004501	1/21/80	1/10	***16.1***	***115***	***19.9***	***97.9***	0.29	0.10
004601	1/21/80	1/10	12.7	87.0	14.9	87.7	0.34	0.10
004701	1/21/80	1/10	***15.0***	***103***	***18.3***	***101***	0.44	0.15
004801	1/21/80	1/10	12.8	89.1	15.6	91.0	0.36	0.14
004901	1/22/80	1/10	13.6	94.2	16.1	93.3	0.40	0.11
005001	1/22/80	1/10	12.5	85.3	14.0	88.5	0.40	0.11
005101	1/22/80	1/10	12.6	94.2	15.7	89.9	0.35	0.12
005201	1/22/80	1/10	12.8	87.5	14.9	89.2	0.46	0.14
005301	1/22/80	1/10	12.5	96.0	16.0	86.9	0.42	0.12
007201	4/1/80	1/10	13.7	92.1	15.8	92.2	0.47	0.15
007301	4/3/80	1/10	13.0	88.7	14.6	86.1	0.45	0.13
008201	6/16/80	1/10	13.0	91.0	14.4	87.9	0.44	
008801	6/18/80	1/10	13.3	85.3	14.1	88.3	0.40	0.12
008901	6/18/80	1/10	13.3	84.8	14.2	89.4	0.52	0.13
009001	6/18/80	1/10	13.7	88.3	14.2	92.5	0.53	0.17
009101	6/18/80	1/10	12.9	84.6	13.4	87.4	0.45	0.14
009201	6/20/80	1/10	13.7	88.1	15.1	88.6	0.36	0.16
009301	6/20/80	1/10	13.7	89.8	13.7	90.2	0.49	0.13
009401	6/20/80	1/10	13.4	87.4	15.2	90.1	0.49	0.14
009701	6/24/80	1/10	13.5	89.1	15.0	88.4	0.54	0.16
009801	6/24/80	1/10	13.2	89.7	14.8	89.2	0.43	0.12
009901	6/24/80	1/10	***12.0***	85.3	13.3	88.3	0.20	0.12
Sample mean			13.5	91.5	15.4	90.9	0.42	0.145
Sample stdev (statistics for all samples)			0.9	6.8	1.4	4.4	0.07	0.068
RSD			6.8	7.4	9.0	4.8	16.1	46.8
Sample mean			13.3	89.6	15.1	89.6		0.130
Sample stdev (statistics for selected samples)			0.5	3.8	0.9	2.1		0.016
RSD			4.1	4.3	6.2	2.3		12.5

[1]***Bold italic*** denotes analytical determinations that are suspected outliers.

Table 4. Raw analytical results for reference sample 2 (Emerald Spring, Norris Geyser Basin). [All concentrations in milligrams per liter; stdev, standard deviation; RSD, relative standard deviation, in percent]

Lab number	Analysis date	Dilution	Na	K	Si	B
911002	6/21/79	1/10		50.3	233	8.48
911102	6/21/79	1/10		51.1	234	8.43
911202	6/22/79	1/10		52.3		8.66
911302	6/22/79	1/10		49.9		8.70
003602	1/16/80	1/20	348	55.3	234	8.56
003702	1/16/80	1/20	367	51.5	227	8.26
003802	1/17/80	1/20	369	53.1	233	8.19
003902	1/16/80	1/20	365	56.9	[1]***262***	9.21
004002	1/17/80	1/20	336	49.0	223	8.51
004102	1/17/80	1/20	358	51.1	232	8.33
004202	1/18/80	1/20	356	51.3	236	8.85
004302	1/18/80	1/20	380	***59.0***	***249***	8.24
004402	1/18/80	1/20	342	48.6	221	8.24
004502	1/21/80	1/20	396	***68.5***	***245***	8.35
004602	1/21/80	1/20	357	49.3	226	8.21
004702	1/21/80	1/20	363	***59.9***	***251***	8.99
004802	1/21/80	1/20	341	52.8	235	8.36
004902	1/22/80	1/20	362	53.7	239	8.72
005002	1/22/80	1/20	363	47.1	233	8.56
005102	1/22/80	1/20	362	51.6	231	8.39
005202	1/22/80	1/20	385	51.4	234	8.35
005302	1/22/80	1/20	374	53.4	225	8.14
007202	4/1/80	1/20	387	55.0	236	8.99
007302	4/3/80	1/20	402	51.9	226	8.95
008202	6/16/80	1/20	345	47.7	207	8.69
008802	6/18/80	1/20	333	46.6	214	8.46
008902	6/18/80	1/20	345	47.6	222	8.87
009002	6/18/80	1/20	367	46.9	223	8.70
009102	6/18/80	1/20	358	45.2	221	8.46
009202	6/20/80	1/20	346	48.8	214	8.15
009302	6/20/80	1/20	355	46.2	219	8.66
009402	6/20/80	1/20	332	51.4	218	8.59
009702	6/24/80	1/20	348	49.1	212	8.45
009802	6/24/80	1/20	352	48.4	209	8.48
009902	6/24/80	1/20	355	44.9	217	8.00
Sample mean			359.7	51.3	228.5	8.519
Sample std dev (statistics for all analyses)			17.4	4.7	12.3	0.280
RSD			4.8	9.1	5.4	3.3
Sample mean				50.3	225.2	
Sample std dev (statistics for selected analyses)				3.0	8.9	
RSD				5.9	4.0	

[1]***Bold italic*** denotes analytical determinations that are suspected outliers.

For Ca, reference sample 1 was analyzed at a concentration 6 to 7 times the operational detection limit of the DCP spectrometer. The between-run relative standard deviation of 6.8 percent for all analyses is reasonable for this concentration. If the four $15 mg/L values and the 12 mg/L value are assumed to be outliers and ignored, the relative standard deviation for the remaining analyses is 4.1 percent.

For Na, reference sample 1 was analyzed at a concentration about 40 times the operational detection limit, and yielded a relative standard deviation of 7.4 percent for all samples. If the four values >100 mg/L are ignored, the relative standard deviation for the remaining samples is 4.3 percent. Reference sample 2 was analyzed at a concentration near the upper limit of the instrument calibration, and yielded a relative standard deviation for all samples of 4.8 percent.

For K, reference samples 1 and 2 were analyzed at concentrations about 5 and 10 times the operational detection limit, respectively, and yielded relative standard deviations of about 9 percent for all samples. If three reference sample 1 values $17.8 mg/L and three reference sample 2 values $59 mg/L are ignored, the relative standard deviations for the remaining analyses are 6.2 and 5.9 percent, respectively. Ball and Nordstrom (1994) observed consistently poor DCP-OES precision for Na and K.

For Si, reference samples 1 and 2 were analyzed at concentrations near the upper limit of the instrument calibration, and yielded relative standard deviations of 4.8 and 5.4 percent, respectively, for all samples. If the four reference sample 1 values $97.9 mg/L and the four reference sample 2 values $245 mg/L are ignored, the relative standard deviations for the remaining samples are 2.3 and 4.0 percent, respectively.

Reference sample 1 contained B at only about 2.5 times the detection limit when diluted by a factor of 10. The relative standard deviation of 16.1 percent for these 35 B determinations was nevertheless acceptable for this concentration. For reference sample 2, the relative standard deviation of 3.3 percent at 40 times the operational detection limit for 34 B determinations was well within acceptable limits.

Reference sample 1, when diluted 1/10, contained Mn at a concentration of about 0.015 mg/L. The relative standard deviation of 46.8 percent for these 33 Mn determinations improves to an acceptable 12.5 percent if two obvious outliers at 0.48 and 0.29 mg/L are rejected.

Reference sample 2 contained As (data not shown) at a concentration of about 2 mg/L, which is only about 7 times the operational detection limit. The relative standard deviation for 12 separate determinations was about 9 percent, and is deemed acceptable for this As concentration.

Charge Balance Calculations

Data for all samples with complete analyses were checked using program WATEQ4F (Ball and Nordstrom, 1991) for charge imbalance (C.I.), using the following calculation:

$$\text{C.I. (percent)} = \frac{100 \times (\text{meq cations} - \text{meq anions})}{(\text{meq cations} + \text{meq anions}) \div 2}. \quad \textbf{(1)}$$

Note that the result of this calculation is twice the value that would be reported by an analytical laboratory, because equation (1) relates the cation-anion difference to the salts rather than to the sum of the ions comprising them. Speciated charge imbalances for hot, alkaline, high-SiO_2 waters are subject to errors resulting from inaccurate corrections for non-carbonate alkalinity. The aqueous $H_3SiO_4^-$ species consumes acid during alkalinity titration and thus can be a significant source of non-carbonate alkalinity for which the speciation model's corrections were found to be less accurate than experimentally determined corrections. Four water samples with complete analyses yielded calculated charge imbalances with absolute values exceeding 20 percent. These samples (75WA143, 75WA150, 75WA184 and 75WA197) likely were subject to errors in the measurement of either alkalinity or pH. Explanations appear as footnotes on the appropriate pages of table 5. The remaining samples with complete analyses have charge imbalances less than 11 percent.

PHYSICAL MEASUREMENTS AND CHEMICAL ANALYSES

Physical measurements and concentration values for dissolved constituents are presented in table 5. The data are arranged in order of water sample code number, with earlier samples preceding later ones at a given site. Each page is divided into three parts: The top block contains the sample code number, sample collection date, and on-site parameters. Specific conductance values are corrected to 25ºC. The second block contains chemical concentrations in mg/L. The third block contains the results of the charge imbalance calculations discussed above.

Table 5. Results of water analyses
[: S/cm, microsiemens per centimeter; mg/L, milligrams per liter; ---, sample not analyzed for this constituent; <, less-than; meq/L, milliequivalents per liter]

Sample code number	74WA107	74WA108	74WA109	74WA110
Date collected	9/18/74	9/18/74	9/18/74	9/18/74
Temperature (°C)	15	14	18.5	18.5
pH (field)	8.40	7.04	7.50	7.68
Specific conductance (µS/cm)	415	348	403	397
Eh (volts)	0.452	0.402	0.358	0.394
Dissolved oxygen (mg/L)	7.6	9.1	8.4	8.15
Constituent (mg/L)				
Ca	5.24	8.29	6.37	6.04
Mg	0.483	1.23	0.704	0.691
Na	73.6	55.4	68.1	67.5
K	6.75	8.4	7.25	7.15
SO_4	10	18	13	12
H_2S	---	---	---	---
Total alkalinity (as HCO_3)	106	115	115	108
F	7.2	4.1	6.4	6.4
Cl	54	33	47	45
SiO_2	100	75	92	86
Al (filtered & field extracted)	0.057	0.235	0.067	0.056
Al (filtered & lab extracted)	0.052	0.235	0.111	0.097
Al (unfiltered & lab extracted)	---	---	---	---
Fe(tot) (filtered & lab extracted)	0.014	0.030	0.016	0.013
Fe(tot) (unfiltered & lab extracted)	---	---	---	---
Fe(II)	---	---	---	---
B	0.59	0.48	0.54	0.51
P[1]	0.006	0.004	0.006	0.008
Li	0.528	0.323	0.477	0.457
Sr	0.008	0.027	0.015	0.013
Ba	<0.005	0.01	<0.005	<0.005
Rb	<0.03	<0.03	<0.03	<0.03
Cs	---	---	---	---
Mn (filtered & lab extracted)	0.0026	0.024	0.0076	0.0058
Mn (unfiltered & lab extracted)	---	---	---	---
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu (lab extracted)	0.0004	0.0004	<0.0003	<0.0003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	0.252	0.083	0.212	0.200
As(III)	0.007	---	---	0.015
As(V)	0.245	0.092	---	0.185
Sb	---	---	---	---
Sum Cations (meq/L)	3.74	3.17	3.58	3.53
Sum Anions (meq/L)	3.84	3.37	3.8	3.62
Charge Imbalance (percent)	-2.7	-6	-6.1	-2.4

[1]Soluble reactive phosphorus as P

Table 5. Results of water analyses--Continued

Sample code number	74WA111	74WA112	74WA113	[1]74WA114
Date collected	9/19/74	9/20/74	9/20/74	9/20/74
Temperature (°C)	16.5	82-85	23-26	63-75
pH (field/lab)	8.25	7.78	8.65	---
Specific conductance (µS/cm)	392	---	---	---
Eh (volts)	0.448	0.018	0.332	0.242
Dissolved oxygen (mg/L)	8.20	0.92	6.78	2.68
Constituent (mg/L)				
Ca	6.12	0.54	0.73	1.27
Mg	0.762	0.009	0.010	0.018
Na	66.4	307	332	317
K	7.15	15.2	16.4	15.4
SO_4	12	21	23	---
H_2S	---	<0.016	<0.016	---
Total alkalinity (as HCO_3)	109	340	367	---
F	6.3	22.0	25.0	---
Cl	44	262	284	269
SiO_2	87	270	219	256
Al (filtered & field extracted)	0.062	0.047	0.016	---
Al (filtered & lab extracted)	0.090	0.041	0.047	--
Al (unfiltered & lab extracted)	---	0.051	0.047	0.054
Fe(tot) (filtered & lab extracted)	0.014	0.0028	0.003	---
Fe(tot) (unfiltered & lab extracted)	---	0.0014	---	---
Fe(II)	---	---	---	---
B	0.51	2.5	2.6	2.5
P[2]	0.002	0.002	0.0009	---
Li	0.450	3.42	3.72	3.53
Sr	0.009	<0.001	<0.001	<0.001
Ba	<0.005	<0.005	<0.005	<0.005
Rb	<0.03	0.07	0.15	0.12
Cs	---	---	---	---
Mn (filtered & lab extracted)	0.0016	0.0030	0.0007	---
Mn (unfiltered & lab extracted)	---	0.0034	0.0008	0.0037
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu (lab extracted)	<0.0003	<0.0003	<0.0003	0.0006
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	0.204	1.455	1.620	1.525
As(III)	---	0.075	0.010	---
As(V)	---	1.380	1.610	---
Sb	---	0.058	---	---
Sum Cations (meq/L)	3.49	14.2	15.4	14.8
Sum Anions (meq/L)	3.60	14.5	15.8	7.66
Charge Imbalance (percent)	-3.1	-2.3	-2.7	N.D.[3]

[1]Unfiltered sample
[2]Soluble reactive phosphorus as P
[3]Lack of concentration data for major dissolved constituents precluded meaningful charge balance calculation

Table 5. Results of water analyses--Continued

Sample code number	[1]74WA115	[1]74WA116	[1]74WA117	[1]74WA118
Date collected	9/20/74	9/20/74	9/20/74	9/20/74
Temperature (°C)	53-61	50	40	30
pH (field/lab)	8.3	8.6	8.8	9.00
Specific conductance (µS/cm)	---	---	---	---
Eh (volts)	0.288	0.305	0.289	---
Dissolved oxygen (mg/L)	3.93	5.38	5.90	6.65
Constituent (mg/L)				
Ca	0.64	0.64	0.79	0.59
Mg	0.007	0.008	0.01	0.009
Na	322	326	336	335
K	15.5	16.1	16.5	16.4
SO_4	---	---	---	---
H_2S	---	---	---	---
Total alkalinity (as HCO_3)	---	---	---	---
F	---	---	---	---
Cl	269	262	275	286
SiO_2	257	258	261	216
Al (filtered & field extracted)	---	---	---	---
Al (filtered & lab extracted)	---	---	---	---
Al (unfiltered & lab extracted)	0.064	0.026	0.009	0.033
Fe(tot) (filtered & lab extracted)	---	---	---	---
Fe(tot) (unfiltered & lab extracted)	---	---	---	---
Fe(II)	---	---	---	---
B	2.5	2.6	2.9	2.8
P[2]	---	---	---	---
Li	3.57	3.64	3.72	3.75
Sr	<0.001	<0.001	<0.001	<0.001
Ba	<0.005	<0.005	<0.005	<0.005
Rb	0.08	0.13	0.05	0.08
Cs	---	---	---	---
Mn (filtered & lab extracted)	---	---	---	---
Mn (unfiltered & lab extracted)	0.0034	0.0031	0.0050	0.0011
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu (lab extracted)	<0.0003	<0.0003	<0.0003	<0.0003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	1.510	1.545	1.575	1.630
As(III)	---	---	---	---
As(V)	---	---	---	---
Sb	---	---	---	---
Sum Cations (meq/L)	15.0	15.2	15.6	15.6
Sum Anions (meq/L)	8.02	8.05	8.54	8.79
Charge Imbalance (percent)	N.D.[3]	N.D.[3]	N.D.[3]	N.D.[3]

[1]Unfiltered sample
[2]Soluble reactive phosphorus as P
[3]Lack of concentration data for major dissolved constituents precluded meaningful charge balance calculation

Table 5. Results of water analyses--Continued

Sample code number	74WA119	74WA120	[1]74WA122
Date collected	9/20/74	9/21/74	9/23/74
Temperature (°C)	51	14	89.5
pH (field/lab)	8.00	---	8.20
Specific conductance (µS/cm)	---	---	1700
Eh (volts)	0.274	---	-0.170
Dissolved oxygen (mg/L)	---	---	0.0
Constituent (mg/L)			
Ca	13	11.9	1.1
Mg	0.28	1.83	0.023
Na	95	---	310
K	17	4.30	17
SO_4	---	---	---
H_2S	---	---	0.67
Total alkalinity (as HCO_3)	---	---	---
F	10.1	---	24.0
Cl	---	20	365
SiO_2	165	1	434
Al (filtered & field extracted)	---	---	---
Al (filtered & lab extracted)	---	0.015	---
Al (unfiltered & lab extracted)	---	---	0.045
Fe(tot) (filtered & lab extracted)	---	0.024	---
Fe(tot) (unfiltered & lab extracted)	---	---	0.024
Fe(II)	---	---	---
B	0.7	0.22	4.0
P[2]	---	0.007	---
Li	1.0	0.186	6.5
Sr	0.01	0.032	<0.001
Ba	<0.005	0.008	<0.005
Rb	0.08	<0.01	0.16
Cs	---	---	---
Mn (filtered & lab extracted)	---	0.024	---
Mn (unfiltered & lab extracted)	---	---	0.0013
Zn	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004
Cu (lab extracted)	<0.0003	<0.0007	<0.0003
Cd	<0.01	<0.01	<0.01
As(III+V)	0.345	0.088	1.280
As(III)	0.03	0.030	1.245
As(V)	0.315	---	#0.035
Sb	---	---	---
Sum Cations (meq/L)	5.39	0.886	15.0
Sum Anions (meq/L)	0.12	0.564	11.3
Charge Imbalance (percent)	N.D.[3]	N.D.[3]	N.D.[3]

[1]Unfiltered sample
[2]Soluble reactive phosphorus as P
[3]Lack of concentration data for major dissolved constituents precluded meaningful charge balance calculation

Table 5. Results of water analyses--Continued

Sample code number	[1]74WA123	[1]74WA124	[1]74WA125	[1]74WA126
Date collected	9/23/74	9/23/74	9/23/74	9/23/74
Temperature (°C)	93.5	89.5	91.0	87
pH (field/lab)	8.44	---	7.86	7.10
Specific conductance (µS/cm)	2100	2050	1940	1402
Eh (volts)	-0.156	-0.037	-0.108	---
Dissolved oxygen (mg/L)	0.0	0.22	00	0.0
Constituent (mg/L)				
Ca	0.50	0.47	0.46	0.48
Mg	<0.02	<0.02	<0.02	<0.02
Na	430	400	420	280
K	19	18	18	37
SO_4	---	---	---	---
H_2S	0.58	<0.016	0.16	0.41
Total alkalinity (as HCO_3)	---	---	---	---
F	30.0	30.0	30.8	25.0
Cl	389	382	377	272
SiO_2	451	439	304	513
Al (filtered & field extracted)	---	---	---	---
Al (filtered & lab extracted)	---	---	---	---
Al (unfiltered & lab extracted)	0.026	0.056	0.027	<0.006
Fe(tot) (filtered & lab extracted)	---	---	---	---
Fe(tot) (unfiltered & lab extracted)	0.0024	0.0067	0.0016	0.0052
Fe(II)	---	---	---	---
B	4.0	3.7	3.7	3.1
P[2]	---	---	---	---
Li	7.4	6.9	7.0	3.3
Sr	<0.001	<0.001	0.02	0.006
Ba	<0.005	<0.005	<0.005	<0.005
Rb	0.12	0.10	0.12	0.13
Cs	---	---	---	---
Mn (filtered & lab extracted)	---	---	---	---
Mn (unfiltered & lab extracted)	0.0005	0.0005	0.0012	0.0015
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu (lab extracted)	<0.0003	<0.0003	<0.0003	<0.0003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	1.620	1.590	1.500	0.850
As(III)	1.590	0.330	1.460	0.830
As(V)	#0.030	1.260	#0.040	#0.020
Sb	---	---	---	---
Sum Cations (meq/L)	20.3	19.0	19.8	13.6
Sum Anions (meq/L)	12.7	10.9	10.7	7.78
Charge Imbalance (percent)	N.D.[3]	N.D.[3]	N.D.[3]	N.D.[3]

[1]Unfiltered sample
[2]Soluble reactive phosphorus as P
[3]Lack of concentration data for major dissolved constituents precluded meaningful charge balance calculation

Table 5. Results of water analyses--Continued

Sample code number	[1]74WA127	[1]74WA128	[1]74WA129	[1]74WA130
Date collected	9/24/74	9/24/74	9/24/74	9/24/74
Temperature (°C)	92	73.5	88.5	82
pH (field/lab)	8.20	7.35	8.3	7.15
Specific conductance (µS/cm)	2080	1285	2000	2040
Eh (volts)	-0.116	0.185	-0.109	---
Dissolved oxygen (mg/L)	0.0	0.60	0.0	0.0
Constituent (mg/L)				
Ca	0.48	1.0	0.92	0.43
Mg	---	0.06	---	---
Na	470	280	440	450
K	18	26	19	16
SO_4	---	---	---	---
H_2S	0.20	<0.016	0.096	0.14
Total alkalinity (as HCO_3)	---	---	---	---
F	29.0	16.8	27.6	30.0
Cl	317	242	314	353
SiO_2	295	267	306	267
Al (filtered & field extracted)	---	---	---	---
Al (filtered & lab extracted)	---	---	---	---
Al (unfiltered & lab extracted)	0.029	0.016	0.023	0.036
Fe(tot) (filtered & lab extracted)	---	---	---	---
Fe(tot) (unfiltered & lab extracted)	0.0035	0.154	0.064	0.020
Fe(II)	---	---	---	---
B	3.3	2.7	3.3	3.5
P[2]	---	---	---	---
Li	5.9	3.8	4.3	5.8
Sr	---	---	---	0.005
Ba	---	0.007	---	---
Rb	0.12	0.18	0.17	0.22
Cs	---	---	---	---
Mn (filtered & lab extracted)	---	---	---	---
Mn (unfiltered & lab extracted)	0.0007	0.0143	0.0074	0.0014
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu (lab extracted)	<0.0003	0.010	0.007	<0.0007
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	1.495	0.895	1.455	1.255
As(III)	1.425	0.035	>1.175	>1.055
As(V)	#0.070	0.860	#0.280	#0.200
Sb	---	---	---	---
Sum Cations (meq/L)	21.8	13.5	20.3	20.9
Sum Anions (meq/L)	9.59	6.92	9.71	10.0
Charge Imbalance (percent)	N.D.[3]	N.D.[3]	N.D.[3]	N.D.[3]

[1]Unfiltered sample
[2]Soluble reactive phosphorus as P
[3]Lack of concentration data for major dissolved constituents precluded meaningful charge balance calculation

Table 5. Results of water analyses--Continued

Sample code number	74WA132	74WA133	74WA134
Date collected	9/25/74	9/25/74	9/25/74
Temperature (°C)	86	45-63	33-41
pH (field/lab)	8.62	9.25	9.42
Specific conductance (µS/cm)	1590	1750	1780
Eh (volts)	-0.185	0.075	0.342
Dissolved oxygen (mg/L)	0.0	1.78	4.78
Constituent (mg/L)			
Ca	1.20	1.21	1.25
Mg	0.028	0.018	0.075
Na	322	332	353
K	13.8	15	14.6
SO_4	52	49	55
H_2S	1.6	0.064	0.021
Total alkalinity (as HCO_3)	198	204	209
F	29.8	31.0	32.5
Cl	316	342	352
SiO_2	240	226	210
Al (filtered & field extracted)	0.090	0.029	---
Al (filtered & lab extracted)	0.465	0.036	0.036
Al (unfiltered & lab extracted)	0.595	0.039	0.039
Fe(tot) (filtered & lab extracted)	0.0063	0.0129	0.0084
Fe(tot) (unfiltered & lab extracted)	0.060	---	---
Fe(II)	---	---	---
B	4.0	4.4	3.9
P[1]	0.003	---	0.003
Li	3.23	3.16	3.30
Sr	0.007	0.01	0.008
Ba	<0.005	0.01	0.006
Rb	0.14	0.15	0.13
Cs	---	---	---
Mn (filtered & lab extracted)	0.00061	0.00201	0.00202
Mn (unfiltered & lab extracted)	0.0043	0.0026	0.0026
Zn	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004
Cu (lab extracted)	<0.0003	<0.0003	0.0007
Cd	0.05	0.04	0.02
As(III+V)	1.480	1.520	1.615
As(III)	1.450	1.493	0.805
As(V)(µg/L)	0.030	0.027	0.810
Sb	0.081	---	---
Sum Cations (meq/L)	14.7	15.2	16.2
Sum Anions (meq/L)	14.7	15.5	16.1
Charge Imbalance (percent)	0.0	-2.1	0.2

[1]Soluble reactive phosphorus as P

Table 5. Results of water analyses--Continued

Sample code number	[1]74WA135	74WA136	[1]74WA137	74WA138
Date collected	9/25/74	9/25/74	9/24/74	9/26/74
Temperature (°C)	64-70	89	49-50	14.5
pH (field/lab)	9.18	7.49	9.20	8.35
Specific conductance (µS/cm)	---	---	---	---
Eh (volts)	-0.036	-0.076	0.351	0.139
Dissolved oxygen (mg/L)	0.38	0.0	2.62	5.80
Constituent (mg/L)				
Ca	1.14	2.10	1.49	123
Mg	0.054	0.079	0.027	20.3
Na	328	311	337	64.8
K	14.5	13.4	14.6	29.5
SO_4	---	50	---	171
H_2S	---	---	---	<0.016
Total alkalinity (as HCO_3)	---	---	---	---
F	---	28.6	---	2.0
Cl	---	310	321	63
SiO_2	320	148	230	66
Al (filtered & field extracted)	---	---	---	<0.004
Al (filtered & lab extracted)	---	0.069	0.052	0.012
Al (unfiltered & lab extracted)	0.045	---	---	---
Fe(tot) (filtered & lab extracted)	---	0.017	---	0.006
Fe(tot) (unfiltered & lab extracted)	---	---	---	---
Fe(II)	---	---	---	---
B	4.2	4.0	4.3	7.8
P[2]	0.005	0.002	---	0.060
Li	3.10	2.93	3.16	0.56
Sr	0.01	0.01	0.01	0.75
Ba	<0.005	0.006	<0.005	0.06
Rb	0.16	0.16	0.19	<0.03
Cs	---	---	---	---
Mn (filtered & lab extracted)	---	0.0077	---	0.037
Mn (unfiltered & lab extracted)	0.0027	---	0.0025	---
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu (lab extracted)	<0.0003	<0.0003	<0.0003	<0.0003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	1.505	1.420	1.540	0.270
As(III)	---	1.390	---	---
As(V)	---	0.030	---	---
Sb	---	0.073	---	---
Sum Cations (meq/L)	15.2	14.4	15.9	10.7
Sum Anions (meq/L)	2.83	11.3	10.8	4.80
Charge Imbalance (percent)	N.D.[3]	N.D.[3]	N.D.[3]	N.D.[3]

[1]Unfiltered sample
[2]Soluble reactive phosphorus as P
[3]Lack of concentration data for major dissolved constituents precluded meaningful charge balance calculation

Table 5. Results of water analyses--Continued

Sample code number	74WA139	74WA140	74WA141	74WA142
Date collected	9/26/74	9/26/74	9/26/74	9/26/74
Temperature (°C)	19	23-26	40	46
pH (field/lab)	8.05	7.22	6.90	5.98
Specific conductance (µS/cm)	---	---	---	---
Eh (volts)	0.185	-0.030	-0.066	-0.094
Dissolved oxygen (mg/L)	5.10	0.80	0.0	0.0
Constituent (mg/L)				
Ca	120	141	232	227
Mg	19.4	21.4	29.1	28.5
Na	63.0	75.3	116	---
K	29.9	34.8	56.4	---
SO_4	159	187	279	251
H_2S	<0.016	2.4	5.1	3.4
Total alkalinity (as HCO_3)	399	---	[1]~600	798
F	2.0	2.0	2.5	2.2
Cl	64	78	127	112
SiO_2	69	68	78	72
Al (filtered & field extracted)	---	0.069	0.415	0.328
Al (filtered & lab extracted)	0.094	0.128	0.243	0.239
Al (unfiltered & lab extracted)	---	---	---	---
Fe(tot) (filtered & lab extracted)	0.108	0.113	0.215	0.190
Fe(tot) (unfiltered & lab extracted)	---	---	---	---
Fe(II)	---	---	---	---
B	7.9	9.1	15	14
P[2]	0.056	0.053	0.057	0.061
Li	0.54	0.65	1.09	1.3
Sr	0.77	0.89	1.5	1.4
Ba	0.07	0.07	0.1	0.1
Rb	---	0.03	0.1	0.1
Cs	---	---	---	---
Mn (filtered & lab extracted)	0.088	0.088	0.098	0.283
Mn (unfiltered & lab extracted)	---	---	---	---
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu (lab extracted)	<0.0003	<0.0003	<0.0003	<0.0003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	0.280	0.395	0.710	0.742
As(III)	---	---	---	---
As(V)	---	---	---	---
Sb	---	---	---	---
Sum Cations (meq/L)	10.2	12.1	18.5	11.7
Sum Anions (meq/L)	10.8	5.31	17.1	19.4
Charge Imbalance (percent)	-5.5	N.D.[3]	7.3	N.D.[3]

[1]Best estimate, sample poorly mixed
[2]Soluble reactive phosphorus as P
[3]Lack of concentration data for major dissolved constituents precluded meaningful charge balance calculation

Table 5. Results of water analyses--Continued

Sample code number	74WA143	[1]74WA144	[1]74WA146	[1]74WA147
Date collected	9/26/74	9/26/74	9/26/74	9/26/74
Temperature (°C)	14	90	---	---
pH (field/lab)	7.45	7.72	---	---
Specific conductance (µS/cm)	---	---	---	---
Eh (volts)	0.014	-0.166	---	---
Dissolved oxygen (mg/L)	4.60	0.0	---	---
Constituent (mg/L)				
Ca	62.0	28.2	---	---
Mg	16.4	12.6	---	---
Na	36.6	196	---	---
K	14.1	95.8	---	---
SO_4	86	203	---	---
H_2S	0.058	3.0	---	---
Total alkalinity (as HCO_3)	207	261	---	---
F	1.6	4.3	---	---
Cl	25	242	171	166
SiO_2	68	169	---	---
Al (filtered & field extracted)	0.011	0.113	---	---
Al (filtered & lab extracted)	<0.004	---	---	---
Al (unfiltered & lab extracted)	---	---	0.018	0.053
Fe(tot) (filtered & lab extracted)	0.035	0.0035	---	---
Fe(tot) (unfiltered & lab extracted)	---	---	0.0071	0.0143
Fe(II)	---	---	---	---
B	3.0	30	---	---
P[2]	0.057	0.002	---	---
Li	0.22	2.24	---	---
Sr	0.3	1.3	---	---
Ba	0.05	0.2	<0.005	<0.005
Rb	<0.03	0.3	<0.03	<0.03
Cs	---	---	---	---
Mn (filtered & lab extracted)	0.089	0.0074	---	---
Mn (unfiltered & lab extracted)	---	---	0.0158	0.127
Zn	<0.02	0.09	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu (lab extracted)	<0.0003	<0.0003	<0.0003	<0.0003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	0.150	1.450	0.690	0.680
As(III)	---	---	$0.675	$0.610
As(V)	---	---	#0.015	#0.070
Sb	---	0.054	---	---
Sum Cations (meq/L)	6.11	13.0	0.001	0.048
Sum Anions (meq/L)	5.65	14.8	4.83	4.69
Charge Imbalance (percent)	7.9	[3]-13.5	N.D.[4]	N.D.[4]

Table 5. Results of water analyses--Continued

[1]Unfiltered sample
[2]Soluble reactive phosphorus as P
[3]NH_4^+ missing from analysis probably accounts for cation deficiency
[4]Lack of concentration data for major dissolved constituents precluded meaningful charge balance calculation

Sample code number	75WA139	75WA140	75WA141	75WA142a/b
Date collected	8/12/75	8/12/75	8/12/75	8/12/75
Temperature (°C)	94.2	93.3	94.0	95.5
pH	6.7	6.8	7.7	8.1
Specific conductance (µS/cm)	2050	2265	2400	2380
Eh (volts)	-0.083	-0.113	-0.105	-0.166
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	5.5	7.99	7.97	0.414
Mg	<0.02	<0.02	<0.02	<0.02
Na	409	434	451	519
K	22.4	40.0	39.8	26.8
SO_4	70.0	133	77.0	113
H_2S	---	0.005	0.007	0.007
Carbonate/total alkalinity (as HCO_3)	189	92.0	89.0	[1]362/449
F	18.0	13.0	14.7	23.9
Cl	524	568	649	448
SiO_2	227	245	232	180
Al	0.220	0.243	0.111	0.204
Fe(tot)	0.016	0.013	0.011	0.012
Fe(II)	0.004	0.008	0.004	0.005
B	6.48	7.21	8.37	5.90
PO_4	0.003	<0.001	<0.001	0.020
Li	6.73	6.22	8.76	3.27
Sr	<0.001	<0.001	<0.001	<0.001
Ba	<0.005	<0.005	<0.005	<0.005
Rb	0.398	0.765	0.761	0.490
Mn	0.016	<0.01	<0.01	<0.01
Cs	0.440	0.510	0.540	0.460
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	0.043	<0.02	<0.02
Ni	<0.004	0.005	<0.004	<0.004
Cu	<0.003	<0.003	<0.003	<0.003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	2.45	2.52	3.08	2.53
As(III)	2.45	2.51	3.05	2.53
As(V)	0.005	0.006	0.031	---
Sb	---	---	---	---
Sum Cations (meq/L)	19.5	21.1	22.2	23.4/23.3
Sum Anions (meq/L)	20.2	20.9	22.1	21.8/23.2
Charge Imbalance (percent)	-3.4	1.1	0.7	6.9/0.6

[1]First alkalinity value is carbonate species only (HCO_3^-, CO_3^{2-}); second alkalinity value is total alkalinity (uncorrected for noncarbonate species). Single values are total alkalinity.

Table 5. Results of water analyses--Continued

Sample code number	75WA143	75WA144	75WA145a/b	75WA146
Date collected	8/13/75	8/13/75	8/13/75	8/13/75
Temperature (°C)	79.0	92.5	88.0	68.0
pH	4.5	4.3	6.4	6.0
Specific conductance (µS/cm)	343	254	1250	348
Eh (volts)	0.010	0.108	-0.103	0.136
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	1.25	4.64	8.77	13.0
Mg	0.112	0.732	0.164	2.87
Na	29.2	21.8	250	61.5
K	15.6	10.2	14.1	13.9
SO_4	93.8	88.8	129	3.6
H_2S	---	---	0.009	0.007
Carbonate/total alkalinity (as HCO_3)	---	---	[1]139/175	210
F	1.46	0.380	16.2	7.00
Cl	17.0	0.400	221	1.4
SiO_2	215	98.8	238	153
Al	<0.01	0.923	0.187	0.052
Fe(tot)	0.040	2.01	0.013	0.010
Fe(II)	0.004	0.970	0.005	0.003
B	<0.02	<0.02	3.42	0.036
PO_4	---	0.006	0.003	0.015
Li	<0.005	<0.005	0.871	0.102
Sr	0.007	0.023	0.019	0.018
Ba	0.108	0.071	0.040	0.011
Rb	<0.03	<0.03	0.079	0.055
Mn	0.062	1.06	0.189	0.033
Cs	---	---	---	---
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu	<0.003	<0.003	<0.003	0.004
Cd	<0.01	0.008	<0.01	<0.01
As(III+V)	<0.001	<0.001	0.910	0.010
As(III)	<0.001	<0.001	0.900	<0.001
As(V)	0.005	0.004	0.009	0.011
Sb	---	---	---	---
Sum Cations (meq/L)	1.76	1.61	11.7/11.7	3.9
Sum Anions (meq/L)	2.47	1.76	11.9/12.5	3.9
Charge Imbalance (percent)	[2]-33.7	-8.9	-1.9/-6.8	0.40

[1]First alkalinity value is carbonate species only (HCO_3^-, CO_3^{2-}); second alkalinity value is total alkalinity (uncorrected for noncarbonate species). Single values are total alkalinity.
[2]Poor charge balance most likely caused by a combination of pH measurement and analytical errors.

Table 5. Results of water analyses--Continued

Sample code number	75WA147	75WA148	75WA149a/b	75WA150
Date collected	8/14/75	8/14/75	8/14/75	8/14/75
Temperature (°C)	88.0	78.0	67.5	57.5
pH	7.0	7.6	8.2	8.5
Specific conductance (µS/cm)	1560	1570	1630	---
Eh (volts)	0.032	0.124	0.212	0.262
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	4.32	4.32	4.62	4.50
Mg	0.031	0.035	0.031	0.037
Na	369	375	381	390
K	20.1	19.6	22.7	21.1
SO_4	23.8	24.6	25.7	25.7
H_2S	---	---	---	---
Carbonate/total alkalinity (as HCO_3)	619	639	[1]421/635	448
F	21.8	22.8	22.5	22.5
Cl	193	188	193	200.
SiO_2	236	248	241	233
Al	0.029	0.030	0.029	0.027
Fe(tot)	0.042	0.045	0.050	0.041
Fe(II)	0.001	0.001	0.002	0.002
B	2.82	3.03	2.97	2.93
PO_4	0.006	0.006	0.003	<0.001
Li	1.62	2.05	1.46	1.95
Sr	<0.001	<0.001	<0.001	<0.001
Ba	0.009	0.008	0.008	0.008
Rb	0.313	0.282	0.376	0.337
Cs	<0.05	0.050	0.050	0.050
Mn	0.295	0.284	0.288	0.271
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	0.004	<0.004
Cu	<0.003	<0.003	<0.003	<0.003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	0.740	0.770	0.810	0.870
As(III)	0.340	0.160	<0.001	<0.001
As(V)	0.400	0.610	0.830	0.870
Sb	---	---	---	---
Sum Cations (meq/L)	16.9	17.2	17.4/17.6	17.8
Sum Anions (meq/L)	17.1	17.3	13.9/17.6	14.5
Charge Imbalance (percent)	-1.2	-1.0	22.6/0.1	[2]20.5

[1]First alkalinity value is carbonate species only (HCO_3^-, CO_3^{2-}); second alkalinity value is total alkalinity (uncorrected for noncarbonate species). Single values are total alkalinity.
[2]Alkalinity determination may be in error. Chemistry of samples 75WA147 to 75WA151 should be similar.

Table 5. Results of water analyses--Continued

Sample code number	75WA151	75WA152a/b	75WA153a/b	75WA154
Date collected	8/14/75	8/15/75	8/15/75	8/15/75
Temperature (°C)	86.5	89.5	93.0	89.5
pH	7.1	8.6	8.3	8.6
Specific conductance (µS/cm)	1385	1995	1880	2170
Eh (volts)	-0.152	-0.241	-0.180	-0.191
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	7.39	3.43	4.06	3.24
Mg	0.109	<0.02	<0.02	<0.02
Na	325	390	365	432
K	21.7	20.0	17.3	20.0
SO_4	17.6	119	138	144
H_2S	---	0.032	0.012	0.012
Carbonate/total alkalinity (as HCO_3)	679	[1]46/125	[1]73/114	88
F	12.2	15.5	12.6	16.5
Cl	113	458	434	533
SiO_2	235	217	177	240
Al	0.067	0.074	0.111	0.136
Fe(tot)	0.057	0.036	0.012	0.020
Fe(II)	0.006	0.006	0.001	0.009
B	1.68	5.92	5.56	7.18
PO_4	<0.001	0.007	<0.001	0.003
Li	1.04	6.69	5.48	11.4
Sr	<0.001	<0.001	<0.001	<0.001
Ba	<0.005	<0.005	<0.005	<0.005
Rb	0.270	0.402	0.295	0.370
Cs	<0.05	0.370	0.440	0.450
Mn	0.319	<0.01	<0.01	<0.01
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu	<0.003	<0.003	<0.003	0.010
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	0.100	1.55	1.42	2.18
As(III)	0.100	1.23	0.820	0.980
As(V)	0.005	0.032	0.600	1.20
Sb	---	---	---	---
Sum Cations (meq/L)	15.1	18.5/18.5	17.2/17.2	21.0
Sum Anions (meq/L)	15.2	17.4/18.1	16.9/14.7	20.3
Charge Imbalance (percent)	-0.6	6.5/1.9	1.9/16.0	3.5

[1]First alkalinity value is carbonate species only (HCO_3^-, CO_3^{2-}); second alkalinity value is total alkalinity (uncorrected for noncarbonate species). Single values are total alkalinity.

Table 5. Results of water analyses--Continued

Sample code number	75WA155	75WA156a/b	75WA157a/b	75WA158
Date collected	9/10/75	9/10/75	9/10/75	9/10/75
Time collected	12:30	15:30	18:30	22:00
Temperature (°C)	62.0	61.0	59.5	58.0
pH	8.4	8.5	8.4	8.3
Specific conductance (µS/cm)	1550	1600	1550	1520
Eh (volts)	0.107	0.068	0.085	0.057
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	0.638	0.675	0.666	0.649
Mg	<0.02	<0.02	<0.02	<0.02
Na	319	318	315	315
K	15.4	16.6	16.2	16.0
SO_4	19.5	19.5	19.5	19.4
H_2S	---	---	---	---
Carbonate/total alkalinity (as HCO_3)	347	[1]290/363	[1]312/356	353
F	24.0	23.0	23.0	23.0
Cl	267	275	271	271
SiO_2	224	225	256	256
Al	0.228	0.244	0.235	0.233
Fe(tot)	0.004	0.006	0.004	0.006
Fe(II)	<0.001	<0.001	<0.001	0.002
B	2.59	2.56	2.55	2.52
PO_4	0.009	---	<0.001	0.003
Li	5.71	5.36	5.20	6.18
Sr	<0.001	<0.001	<0.001	<0.001
Ba	<0.005	<0.005	<0.005	<0.005
Rb	0.062	0.111	0.135	0.078
Cs	---	---	---	---
Mn	0.031	<0.01	<0.01	<0.01
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	0.007	<0.004
Cu	<0.003	<0.003	<0.003	<0.003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	1.57	1.46	1.49	1.48
As(III)	0.080	0.020	0.050	0.080
As(V)	1.49	1.44	1.44	1.40
Sb	---	---	---	---
Sum Cations (meq/L)	16.0	14.9/14.9	14.8/14.8	14.9
Sum Anions (meq/L)	14.8	15.2/14.0	15.0/14.3	15.0
Charge Imbalance (percent)	1.3	-2.0/6.2	-1.6/3.4	-0.3

[1]First alkalinity value is carbonate species only (HCO_3^-, CO_3^{2-}); second alkalinity value is total alkalinity (uncorrected for noncarbonate species). Single values are total alkalinity.

Table 5. Results of water analyses--Continued

Sample code number	75WA159	75WA160	75WA161	75WA162
Date collected	9/11/75	9/11/75	9/11/75	9/11/75
Time collected	01:00	04:00	07:00	10:00
Temperature (°C)	58.0	56.0	55.5	58.5
pH	8.3	8.2	8.3	8.4
Specific conductance (µS/cm)	1480	1520	1580	1520
Eh (volts)	0.122	0.173	0.241	0.188
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	0.657	0.666	0.689	0.655
Mg	<0.02	<0.02	<0.02	<0.02
Na	318	319	318	314
K	16.3	16.1	15.8	15.9
SO_4	19.3	19.3	19.5	19.7
H_2S	---	---	---	---
Total alkalinity (as HCO_3)	358	356	360	362
F	23.0	23.5	23.5	23.5
Cl	274	275	272	271
SiO_2	285	227	223	227
Al	0.231	0.236	0.235	0.235
Fe(tot)	0.003	0.005	0.005	0.007
Fe(II)	<0.001	<0.001	<0.001	<0.001
B	2.54	2.56	2.57	2.54
PO_4	<0.001	<0.001	0.006	0.006
Li	4.85	5.25	5.74	5.37
Sr	<0.001	<0.001	<0.001	<0.001
Ba	<0.005	<0.005	<0.005	<0.005
Rb	0.112	0.142	0.123	0.075
Cs	---	---	---	---
Mn	<0.01	<0.01	<0.01	<0.01
Zn	<0.02	<0.02	<0.02	<0.02
Pb	0.043	<0.02	<0.02	<0.02
Ni	0.013	0.005	<0.004	<0.004
Cu	<0.003	<0.003	<0.003	<0.003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	1.50	1.53	1.45	1.44
As(III)	0.130	0.130	0.020	<0.001
As(V)	1.37	1.40	1.43	1.48
Sb	---	---	---	---
Sum Cations (meq/L)	14.9	15.0	15.0	14.7
Sum Anions (meq/L)	13.5	15.2	13.8	15.1
Charge Imbalance (percent)	9.7	-1.2	8.6	-2.6

Table 5. Results of water analyses--Continued

Sample code number	75WA163a/b	75WA164	75WA165	75WA166
Date collected	9/11/75	9/10/75	9/10/75	9/10/75
Time collected	13:00	12:30	15:50	19:00
Temperature (°C)	62.0	35.0	28.5	27.0
pH	8.4	9.2	9.1	8.9
Specific conductance (µS/cm)	1550	1610	1620	1590
Eh (volts)	0.100	0.248	0.259	0.254
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	0.668	0.604	0.638	0.630
Mg	<0.02	<0.02	<0.02	<0.02
Na	320	345	351	353
K	16.3	17.1	16.5	16.8
SO_4	19.7	21.1	21.1	20.6
H_2S	---	---	---	---
Carbonate/total alkalinity (as HCO_3)	[1]310/360	310	333	342
F	24.0	25.3	24.3	24.3
Cl	279	283	290	286
SiO_2	238	313	269	314
Al	0.237	0.170	0.187	0.180
Fe(tot)	0.004	0.004	0.005	0.005
Fe(II)	<0.001	<0.001	<0.001	<0.001
B	2.54	2.75	2.73	2.74
PO_4	0.004	---	0.020	0.004
Li	5.70	6.92	4.92	4.46
Sr	<0.001	<0.001	<0.001	<0.001
Ba	<0.005	<0.005	<0.005	<0.005
Rb	0.098	1.41	0.085	0.097
Cs	---	---	---	---
Mn	<0.01	<0.01	<0.01	<0.01
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	0.077	0.263
Ni	<0.004	<0.004	0.009	0.035
Cu	<0.003	<0.003	<0.003	<0.003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	1.59	1.61	1.60	1.63
As(III)	0.090	<0.001	<0.001	<0.001
As(V)	1.50	1.64	1.65	1.63
Sb	---	---	---	---
Sum Cations (meq/L)	15.1/15.1	16.4	16.3	16.4
Sum Anions (meq/L)	15.3/14.5	14.8	15.3	15.3
Charge Imbalance (percent)	-1.9/3.6	10.4	6.5	6.6

[1]First alkalinity value is carbonate species only (HCO_3^-, CO_3^{2-}); second alkalinity value is total alkalinity (uncorrected for noncarbonate species). Single values are total alkalinity.

Table 5. Results of water analyses--Continued

Sample code number	75WA167	75WA168	75WA169	75WA170
Date collected	9/10/75	9/11/75	9/11/75	9/11/75
Time collected	22:00	01:00	04:00	07:40
Temperature (°C)	25.5	24.5	24.0	22.5
pH	8.7	8.8	8.7	8.8
Specific conductance (µS/cm)	1510	1700	1555	1790
Eh (volts)	0.235	0.301	0.300	0.302
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	0.667	0.667	0.680	0.664
Mg	<0.02	<0.02	<0.02	<0.02
Na	346	346	346	349
K	16.7	16.9	17.1	16.6
SO_4	20.2	19.7	19.3	19.6
H_2S	---	---	---	---
Total alkalinity (as HCO_3)	354	338	376	378
F	24.5	24.0	24.0	24.8
Cl	296	278	275	279
SiO_2	302	317	314	304
Al	0.180	0.184	0.190	0.187
Fe(tot)	0.003	0.005	0.005	0.003
Fe(II)	<0.001	<0.001	<0.001	<0.001
B	2.63	2.62	2.64	2.65
PO_4	0.008	<0.001	<0.001	0.003
Li	4.54	6.75	5.07	4.86
Sr	<0.001	<0.001	<0.001	<0.001
Ba	<0.005	<0.005	<0.005	<0.005
Rb	0.119	0.142	0.115	0.094
Cs	---	---	---	---
Mn	<0.01	<0.01	<0.01	<0.01
Zn	<0.02	<0.02	<0.02	<0.02
Pb	0.259	<0.02	0.065	<0.02
Ni	0.033	<0.004	0.012	<0.004
Cu	<0.003	<0.003	<0.003	<0.003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	1.63	1.52	1.60	1.55
As(III)	<0.001	<0.001	<0.001	<0.001
As(V)	1.63	1.55	1.61	1.57
Sb	---	---	---	---
Sum Cations (meq/L)	16.1	16.4	16.2	16.3
Sum Anions (meq/L)	15.8	15.0	15.6	15.8
Charge Imbalance (percent)	1.7	8.9	4.0	3.3

Table 5. Results of water analyses--Continued

Sample code number	75WA171	75WA172	75WA173	75WA174
Date collected	9/11/75	9/13/75	9/13/75	9/13/75
Time collected	10:30	13:00	---	---
Temperature (°C)	26.0	34.0	90.0	92.0
pH	9.0	9.1	6.5	5.0
Specific conductance (µS/cm)	1640	1410	1825	570
Eh (volts)	0.255	0.249	-0.139	-0.025
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	0.659	0.628	4.25	3.26
Mg	<0.02	<0.02	<0.02	0.195
Na	349	349	331	86
K	16.5	16.8	38.9	13.2
SO_4	19.9	19.9	62.9	156
H_2S	---	---	---	---
Total alkalinity (as HCO_3)	363	367	132	1.00
F	24.8	24.3	10.8	4.55
Cl	280	289	419	52.9
SiO_2	312	317	302	219
Al	0.186	0.167	0.103	1.82
Fe(tot)	0.004	0.007	0.012	0.380
Fe(II)	0.001	0.001	0.008	0.011
B	2.69	2.80	6.35	7.01
PO_4	<0.001	<0.001	<0.001	0.007
Li	4.95	5.74	3.48	0.823
Sr	<0.001	<0.001	0.017	0.006
Ba	<0.005	<0.005	0.006	0.050
Rb	0.119	0.139	0.401	0.127
Cs	---	---	0.300	<0.05
Mn	<0.01	<0.01	0.013	0.047
Zn	<0.02	<0.02	<0.02	<0.02
Pb	0.062	<0.02	<0.02	<0.02
Ni	0.010	<0.004	<0.004	<0.004
Cu	<0.003	<0.003	<0.003	<0.003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	1.58	1.62	2.0	0.250
As(III)	<0.001	<0.001	2.0	<0.001
As(V)	1.60	1.64	0.006	0.250
Sb	---	---	---	---
Sum Cations (meq/L)	16.3	16.3	16.1	4.4
Sum Anions (meq/L)	15.5	15.8	15.8	4.8
Charge Imbalance (percent)	4.7	3.5	1.6	-8.7

Table 5. Results of water analyses--Continued

Sample code number	75WA175a/b	75WA176	75WA177	75WA178a/b
Date collected	9/13/75	9/13/75	9/13/75	9/13/75
Temperature (°C)	78.5	90.0	81.0	68.5
pH	7.4	6.7	7.2	8.2
Specific conductance (µS/cm)	1058	2240	1400	1420
Eh (volts)	-0.162	-0.160	-0.144	0.060
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	8.45	4.04	6.77	6.86
Mg	0.354	<0.02	0.070	0.071
Na	210	432	324	334
K	29.2	12.8	21.0	22.8
SO_4	27.9	58.2	16.4	15.7
H_2S	---	---	---	---
Carbonate/total alkalinity (as HCO_3)	[1]321/356	176	678	[1]528/697
F	10.2	13.0	12.6	12.6
Cl	140.	567	110.	118
SiO_2	145	266	230	241
Al	0.037	1.95	0.063	0.063
Fe(tot)	0.006	0.004	0.050	0.063
Fe(II)	0.001	0.001	0.007	0.006
B	1.68	0.873	1.66	1.67
PO_4	<0.001	<0.001	<0.001	---
Li	1.55	4.35	0.958	0.909
Sr	0.042	0.015	<0.001	<0.001
Ba	<0.005	<0.005	<0.005	<0.005
Rb	0.212	0.578	0.215	0.251
Cs	0.150	0.440	---	---
Mn	0.175	0.013	0.307	0.303
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu	<0.003	<0.003	<0.003	<0.003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	0.430	2.55	0.110	0.140
As(III)	0.420	2.54	0.100	0.140
As(V)	0.014	0.007	0.006	<0.001
Sb	---	---	---	---
Sum Cations (meq/L)	10.5/10.5	19.9	15.0	15.3/15.3
Sum Anions (meq/L)	10.2/10.8	20.7	15.1	12.7/15.4
Charge Imbalance (percent)	2.3/-3.2	-4.0	-0.6	18.8/-0.9

[1]First alkalinity value is carbonate species only (HCO_3^-, CO_3^{2-}); second alkalinity value is total alkalinity (uncorrected for noncarbonate species). Single values are total alkalinity.

Table 5. Results of water analyses--Continued

Sample code number	75WA179a/b	75WA180a/b	75WA181a/b	75WA182
Date collected	9/13/75	9/13/75	9/13/75	9/15/75
Temperature (°C)	44.0	26.0	23.5	83.5
pH	8.7	8.0	8.6	6.1
Specific conductance (µS/cm)	1495	1500	1490	1850
Eh (volts)	0.171	0.200	0.252	-0.116
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	6.43	7.76	3.66	3.56
Mg	0.067	0.086	0.062	<0.02
Na	342	346	346	397
K	23.1	26.1	25.8	17.1
SO_4	17.8	17.0	21.7	288
H_2S	---	---	---	---
Carbonate/total alkalinity (as HCO_3)	[1]580/610	[1]561/693	[1]537/692	238
F	13.8	16.0	14.6	15.0
Cl	120.	132	118	298
SiO_2	249	150.	167	259
Al	0.051	<0.01	<0.01	0.127
Fe(tot)	0.042	0.033	---	0.014
Fe(II)	0.003	0.005	---	0.009
B	1.77	20.9	1.81	5.11
PO_4	<0.001	<0.001	<0.001	<0.001
Li	0.938	1.01	1.08	---
Sr	<0.001	<0.001	<0.001	---
Ba	<0.005	<0.005	<0.005	---
Rb	0.226	0.329	0.282	---
Cs	---	---	---	---
Mn	0.241	0.217	0.016	0.015
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu	<0.003	<0.003	<0.003	<0.003
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	0.110	0.190	0.130	1.40
As(III)	0.100	<0.001	<0.001	1.39
As(V)	0.010	0.210	0.140	0.006
Sb	---	---	---	---
Sum Cations (meq/L)	15.7/15.6	16.2/16.2	15.9/15.9	17.7
Sum Anions (meq/L)	13.7/14.2	14.0/16.2	13.2/15.8	18.8
Charge Imbalance (percent)	13.3/9.8	14.3/-0.1	18.6/1.0	-6.5

[1]First alkalinity value is carbonate species only (HCO_3^-, CO_3^{2-}); second alkalinity value is total alkalinity (uncorrected for noncarbonate species). Single values are total alkalinity.

Table 5. Results of water analyses--Continued

Sample code number	75WA183	75WA184	75WA189	75WA190
Date collected	9/15/75	9/15/75	9/16/75	9/16/75
Temperature (°C)	83.0	45.0	10.0	11.0
pH	2.4	1.1	8.3	7.9
Specific conductance (µS/cm)	2740	12000	188	122
Eh (volts)	0.202	0.452	0.196	0.265
Dissolved oxygen (mg/L)	---[1]	---	---	---
Constituent (mg/L)				
Ca	5.49	5.74	13.5	12.4
Mg	0.370	1.11	4.84	4.47
Na	287	54.0	16.4	15.0
K	28.5	24.8	3.60	3.65
SO_4	566	6300	21.7	20.9
H_2S	---	---	0.005	0.003
Total alkalinity (as HCO_3)	---	---	65.0	58.0
F	8.50	0.520	0.800	0.750
Cl	327	38.2	---	---
SiO_2	274	274	27.2	27.2
Al	8.17	<0.01	0.018	0.037
Fe(tot)	2.65	4.08	0.006	0.005
Fe(II)	2.48	3.04	0.002	0.002
B	5.65	0.544	0.269	0.265
PO_4	0.008	0.011	0.014	0.010
Li	3.46	0.677	<0.005	<0.005
Sr	0.032	0.039	0.107	0.084
Ba	0.121	0.094	0.021	0.019
Rb	0.237	0.284	<0.03	<0.03
Cs	---	0.210	---	---
Mn	0.348	0.097	<0.01	<0.01
Zn	<0.02	0.179	<0.02	<0.02
Pb	<0.02	0.062	<0.02	<0.02
Ni	<0.004	0.009	<0.004	<0.004
Cu	0.003	<0.003	<0.003	<0.003
Cd	<0.01	<0.01	---	0.004
As(III+V)	1.06	0.190	0.020	0.040
As(III)	1.05	0.100	<0.001	0.020
As(V)	0.015	0.087	0.020	0.022
Sb	---	---	---	---
Sum Cations (meq/L)	18.9	100.	1.84	1.71
Sum Anions (meq/L)	17.8	76.7	1.52	1.40
Charge Imbalance (percent)	6.2	[1]26.5	[2]19.0	[2]20.0

[1]Poor charge balance most likely caused by pH measurement error
[2]No chloride analysis for this sample

Table 5. Results of water analyses--Continued

Sample code number	75WA191	75WA192	75WA193	75WA194
Date collected	9/16/75	9/16/75	9/16/75	9/17/75
Temperature (°C)	12.0	69.5	12.0	67.0
pH	8.28	6.50	7.90	6.60
Specific conductance (µS/cm)	238	1180	315	1900
Eh (volts)	323.1	289	353.1	266.7
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	25.3	84.3	26.0	0.676
Mg	7.58	15.0	4.87	0.042
Na	18.1	135	29.3	368
K	5.64	24.7	4.91	20.5
SO_4	43.3	121	43.1	188
H_2S	0.008	---	0.004	0.005
Total alkalinity (as HCO_3)	97.0	272	95.0	325
F	0.92	5.15	1.74	16.4
Cl	---	143	---	301
SiO_2	29.4	63.4	35.4	---
Al	0.014	0.115	<0.01	0.363
Fe(tot)	0.008	0.004	0.005	0.047
Fe(II)	<0.001	0.001	0.001	0.002
B	0.326	1.61	0.257	3.95
PO_4	0.017	0.003	0.008	<0.001
Li	<0.005	1.14	<0.005	2.87
Sr	0.153	0.646	0.208	<0.001
Ba	0.025	0.149	0.032	<0.005
Rb	<0.03	0.111	<0.03	0.33
Cs	---	---	---	0.220
Mn	<0.01	<0.01	0.087	<0.01
Zn	<0.02	<0.02	<0.02	<0.02
Pb	<0.02	<0.02	<0.02	<0.02
Ni	<0.004	<0.004	<0.004	<0.004
Cu	<0.003	<0.003	<0.003	0.004
Cd	<0.01	<0.01	<0.01	<0.01
As(III+V)	0.04	0.37	0.30	2.15
As(III)	<0.001	<0.001	<0.001	<0.001
As(V)	0.034	0.41	0.033	2.29
Sb	---	---	---	---
Sum Cations (meq/L)	2.72	11.4	3.02	16.8
Sum Anions (meq/L)	2.44	10.6	2.46	18.5
Charge Imbalance (percent)	[1]10.9	7.7	[1]20.4	-9.2

[1]No chloride analysis for this sample

Table 5. Results of water analyses--Continued

Sample code number	75WA195	75WA196	75WA197	75WA198
Date collected	9/17/75	9/17/75	9/17/75	9/18/75
Temperature (°C)	83.0	74.0	63.5	86.8
pH	5.8	2.5	2.9	5.2
Specific conductance (µS/cm)	1560	2650	816	2420
Eh (volts)	-0.083	0.661	0.595	-0.058
Dissolved oxygen (mg/L)	---	---	---	---
Constituent (mg/L)				
Ca	5.22	2.98	1.32	5.14
Mg	0.138	0.078	0.211	0.017
Na	295	158	15.8	431
K	20.8	15.7	19.7	53.4
SO_4	87.6	426	200	173
H_2S	0.011	0.409	0.487	---
Total alkalinity (as HCO_3)	140	---	---	41.4
F	14.0	3.45	0.350	19.5
Cl	324	143	0.800	550
SiO_2	198	216	200	581
Al	0.102	5.27	0.936	---
Fe(tot)	0.016	0.505	0.480	---
Fe(II)	0.006	0.120	0.023	0.042
B	3.92	1.72	<0.02	9.20
PO_4	<0.001	0.013	<0.001	<0.001
Li	3.47	2.30	<0.005	5.40
Sr	<0.001	<0.001	<0.001	0.054
Ba	0.360	<0.005	0.011	<0.005
Rb	0.367	0.185	0.182	0.460
Cs	---	0.130	---	0.280
Mn	0.116	0.023	0.054	---
Zn	<0.02	0.006	0.023	---
Pb	<0.02	<0.02	<0.02	---
Ni	<0.004	<0.004	<0.004	---
Cu	0.004	0.004	0.006	---
Cd	<0.01	<0.01	<0.01	---
As(III+V)	1.18	0.610	0.010	2.83
As(III)	1.18	0.020	<0.001	2.83
As(V)	0.003	0.590	0.011	0.005
Sb	---	---	---	---
Sum Cations (meq/L)	14.1	11.5	2.67	21.0
Sum Anions (meq/L)	13.9	10.9	3.71	20.6
Charge Imbalance (percent)	1.2	5.7	[1]-32.6	1.8

[1] Poor charge balance most likely caused by pH measurement error; pH = 2.75 yields charge imbalance = -10.4 percent

Table 5. Results of water analyses--Continued

Sample code number	75WA199	75WA200a/b	75WA201	75WA202a/b	75WA203a/b
Date collected	9/18/75	9/19/75	9/19/75	9/19/75	9/19/75
Temperature (°C)	88.5	67.0	34.0	26.5	37.0
pH	4.3	7.9	8.2	8.6	8.6
Specific conductance (µS/cm)	2210	1370	550	560	535
Eh (volts)	0.031	0.232	0.233	0.340	0.308
Dissolved oxygen (mg/L)	---	---	---	---	---
Constituent (mg/L)					
Ca	8.17	0.280	14.7	14.7	14.3
Mg	0.052	0.038	0.100	0.095	0.088
Na	376	288	99.0	95.0	94.0
K	58.5	18.7	16.0	15.8	15.5
SO_4	293	20.4	28.2	28.6	29.4
H_2S	---	0.003	0.005	0.009	0.011
Carbonate/total alkalinity (as HCO_3)	---	[1]232/289	178	[1]69.5/181	[1]153/180
F	13.8	16.6	10.5	10.7	10.7
Cl	440	245	51.2	49.6	50.5
SiO_2	563	247	202	203	212
Al	---	0.120	<0.01	<0.01	0.003
Fe(tot)	0.538	0.003	0.005	0.009	0.011
Fe(II)	0.495	0.001	0.001	0.001	<0.001
B	7.30	2.51	0.546	0.537	0.502
PO_4	0.036	0.073	<0.001	<0.001	<0.001
Li	4.98	2.55	0.663	0.555	0.553
Sr	0.046	<0.001	0.012	0.012	0.013
Ba	0.080	<0.005	<0.005	<0.005	<0.005
Rb	0.480	0.086	0.108	0.111	0.111
Cs	0.220	---	---	---	---
Mn	---	<0.01	0.093	0.058	0.146
Zn	---	<0.02	<0.02	<0.02	<0.02
Pb	---	<0.02	<0.02	<0.02	<0.02
Ni	---	<0.004	<0.004	<0.004	<0.004
Cu	---	0.007	0.012	<0.003	<0.003
Cd	---	<0.01	<0.01	<0.01	<0.01
As(III+V)	2.45	1.77	0.010	0.020	0.010
As(III)	2.44	<0.001	<0.001	<0.001	<0.001
As(V)	0.013	1.86	0.016	0.021	0.018
Sb	---	---	---	---	---
Sum Cations (meq/L)	18.8	13.3/13.3	5.49	5.31/5.28	5.20/5.19
Sum Anions (meq/L)	18.8	12.0/12.9	5.43	3.87/5.44	5.02/5.45
Charge Imbalance (percent)	0.0	10.5/3.0	1.0	31.3/-3.0	3.6/-4.8

[1]First alkalinity value is carbonate species only (HCO_3^-, CO_3^{2-}); second alkalinity value is total alkalinity (uncorrected for noncarbonate species). Single values are total alkalinity.

REFERENCES CITED

American Public Health Association, 1971, Standard Methods for the Examination of Water and Wastewater: Washington, D.C., 874 p.

Ball, J. W., Jenne, E. A., and Burchard, J. M., 1976, Sampling and preservation techniques for waters in geysers and hot springs, *with a section on gas collection by A. H. Truesdell*: Workshop on Sampling Geothermal Effluents, 1st, Proceedings, Environmental Protection Agency 600/9-76-011, p. 218-234.

Ball, J. W., Thompson, J. M., and Jenne, E. A., 1978, Determination of dissolved boron in fresh, estuarine, and geothermal waters by D.C. argon-plasma emission spectrometry: Analytica Chimica Acta, v. 98, p. 67-75.

Ball, J. W., and Nordstrom, D. K., 1985, Major and trace-element analyses of waters in the Leviathan/Bryant Creek drainage basin, California/Nevada, October, 1981 to October, 1982: U.S. Geological Survey Water-Resources Investigations Report 85-4169, 46 p.

Ball, J. W., and Nordstrom, D. K., 1989, Final revised major and trace-element analyses of waters from the Leviathan/Bryant Creek drainage basin, California and Nevada, October, 1981 to October, 1982: U.S. Geological Survey Water-Resources Investigations Report 89-4138, 46 p.

Ball, J. W., and Nordstrom, D. K., 1991, User's Manual for WATEQ4F, with Revised Thermodynamic Data Base and Test Cases for Calculating Speciation of Major, Trace, and Redox Elements in Natural Waters: U.S. Geological Survey Open-File Report 91-183, 189 p.

Ball, J. W., and Nordstrom, D. K., 1994, A Comparison of Simultaneous Plasma, Atomic Absorption, and Iron Colorimetric Determinations of Major and Trace Constituents in Acid Mine Waters: U.S. Geological Survey Water-Resources Investigations Report 93-4122, 151 p.

Baumann, E. W., 1974, Determination of parts per billion sulfide in water with the sulfide-selective electrode: Analytical Chemistry, v. 46, p. 1345-1347.

Johnson, D. L., and Pilson, M. E. Q., 1972, Spectrophotometric determination of arsenite, arsenate, and phosphate in natural waters: Analytica Chimica Acta, v. 58, p. 289-299.

Johnson, G. W., Taylor, H. E., and Skogerboe, R. K., 1979, Evaluation of spectral interferences associated with a direct current plasma - multielement atomic emission spectrometer (DCP-MAES) system: Applied Spectroscopy, v. 33, p. 451.

Kennedy, V. C., Jenne, E. A., and Burchard, J. M., 1976, Backflushing filters for field processing of water samples prior to trace-element analyses: U.S. Geological Survey Open-File Report 76-126, 12 p.

Mackereth, F. J. H., 1963, Some methods of water analysis for limnologists: Freshwater Biology Association Scientific Publication, v. 21, 71 p.

Nordstrom, D. K. and Jenne, E. A., 1977, Fluorite solubility equilibria in selected geothermal waters: Geochimica et Cosmochimica Acta: 41, p. 175-188.

Stauffer, R. E., 1980a, Bias evaluation of the cation-exchange method for sulfate and chloride: Canadian Journal of Fisheries and Aquatic Sciences, v. 37, p. 1266-1275.

Stauffer, R. E., 1980b, Molybdenum-blue applied to arsenic and phosphorus determinations in silica and fluoride rich geothermal waters: Environmental Science and Technology, v. 14, p. 1475-1481.

Stauffer, R. E., Jenne, E. A., and Ball, J. W., 1980, Chemical Studies of Selected Trace Elements in Hot-Spring Drainages of Yellowstone National Park: U.S. Geological Survey Professional Paper 1044-F, 20 p.

Stookey, L. L., 1970, FerroZine - a new spectrophotometric reagent for iron: Analytical Chemistry, v. 42, p. 779-781.

Taylor, H. E., 1981, Current status of plasma emission spectroscopy in water analysis, in Barnes, R. M., ed., Developments in Atomic Spectrochemical Analysis: Heyden, p. 303.

Vivit, D. V., Ball, J. W., and Jenne, E. A., 1984, Specific-ion electrode determinations of sulfide preconcentrated from San Francisco Bay waters: Environmental Geology and Water Science, v. 6, p. 79-90.