

Prepared in cooperation with the National Park Service

Water Quality and Quantity of Selected Springs and Seeps Along the Colorado River Corridor, Utah and Arizona: Arches National Park, Canyonlands National Park, Glen Canyon National Recreation Area, and Grand Canyon National Park, 1997-98

By Howard E. Taylor[1], John R. Spence[2], Ronald C. Antweiler[1], Kevin Berghoff[2], Terry I. Plowman[1], Dale B. Peart[1], and David A. Roth[1]

[1]U.S. Geological Survey
[2]National Park Service

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U.S. Department of the Interior
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Conversion Factors, Datums, Acronyms, Abbreviations, and Chemical Notation

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic yard (yd^3)	0.7646	cubic meter (m_3)
foot (ft)	0.3048	meter (m)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
inch (in.)	2.54	centimeter (cm)
mile (mi)	1.609	kilometer (km)
pound (lb)	0.4536	kilogram (kg)

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

$$°F = (1.8 \times °C) + 32$$

Spatial Datums

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83). Elevation, as used in this report, refers to distance above the National Geodetic Vertical Datum of 1929 (NGVD of 1929).

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 in either milligrams per liter (mg/L), micrograms per liter (µg/L), or nanograms per liter (ng/L).

Acronyms, Abbreviations, and Chemical Notation

Acronyms

CVAFS, cold vapor atomic fluorescence spectrometry
DI, deionized (water)
D.O., dissolved oxygen
DOC, dissolved organic carbon
EPA, U.S. Environmental Protection Agency
IC, ion chromatography
ICP–AES, Inductively coupled plasma–atomic emission spectrometry
ICP–MS, Inductively coupled plasma–mass spectrometry
MDL, method detection limit
NRCC, National Research Council Canada
NRP, National Research Program
QA, quality assurance
QC, quality control
SC, specific conductance
SRM, standard reference material
SRWS, standard reference water sample
USEPA, United States Environmental Protection Agency
USGS, United States Geological Survey

Abbreviations

cm, centimeter
g, gram
kg, kilogram
L, liter
µg, microgram
mg, milligram
mL, milliliter
µm, micrometer
MΩ-cm, megaohm-centimeter
ng, nanogram
ng/L, nanogram per liter
ppb, parts per billion
ppm, parts per million
wt, weight
s, second
>, greater than
<, less than

Chemical Notation

Al, aluminum
As, arsenic
B, boron
Ba, barium
Be, beryllium
Bi, bismuth
B, boron
Ca, calcium
Cd, cadmium
Ce, cerium
Cl, chloride
Co, cobalt
Cr, chromium
Cs, cesium
Cu, copper
Dy, dysprosium
Er, erbium
Eu, europium
Fe, iron
Gd, gadolinium
HCl, hydrochloric acid
HF, hydrofluoric acid
Hg, mercury
HNO_3, nitric acid
Ho, holmium
In, indium
Ir, iridium
K, potassium
La, lanthanum
Li, lithium
Lu, lutetium
Mg, magnesium
Mn, manganese

N, Nitrogen
Na, sodium
Nd, neodymium
NH_3, ammonia
Ni, nickel
NO_3, nitrate
P, phosphorous
PO_4, orthophosphate
Pb, lead
Pr, praseodymium
Rb, rubidium
Re, rhenium
Rh, rhodium
Sb, antimony
Se, selenium
Si, silica
SiO_2, silicon oxide
Sm, samarium
Sn, tin
Sr, strontium
$SnCl_2$, stannous chloride
Tb, terbium
Te, tellurium
Th, thorium
Tl, thallium
Tm, thulium
U, uranium
V, vanadium
Y, yttrium
Yb, ytterbium
Zn, zinc
Zr, zirconium

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By Howard E. Taylor, John R. Spence, Ronald C. Antweiler, Kevin Berghoff, Terry I. Plowman, Dale B. Peart, and David A. Roth

Abstract

The U.S. Geological Survey, in cooperation with the National Park Service conducted an intensive assessment of selected springs along the Colorado River Corridor in Arches National Park, Canyonlands National Park, Glen Canyon National Recreation Area, and Grand Canyon National Park in 1997 and 1998, for the purpose of measuring and evaluating the water quality and quantity of the resource. This study was conducted to establish baseline data for the future evaluation of possible effects from recreational use and climate change. Selected springs and seeps were visited over a study period from 1997 to 1998, during which, discharge and on-site chemical measurements were made at selected springs and seeps, and samples were collected for subsequent chemical laboratory analysis. This interdisciplinary study also includes simultaneous studies of flora and fauna, measured and sampled coincidently at the same sites. Samples collected during this study were transported to U.S. Geological Survey laboratories in Boulder, Colorado, where analyses were performed using state-of-the-art laboratory technology. The location of the selected springs and seeps, elevation, geology, aspect, and onsite measurements including temperature, discharge, dissolved oxygen, pH, and specific conductance, were recorded. Laboratory analyses include determinations for alkalinity, aluminum, ammonium (nitrogen), antimony, arsenic, barium, beryllium, bismuth, boron, bromide, cadmium, calcium, cerium, cesium, chloride, chromium, cobalt, copper, dissolved inorganic carbon, dissolved organic carbon, dysprosium, erbium, europium, fluoride, gadolinium, holmium, iodine, iron, lanthanum, lead, lithium, lutetium, magnesium, manganese, mercury, molybdenum, neodymium, nickel, nitrate (nitrogen), nitrite (nitrogen), phosphate, phosphorus, potassium, praseodymium, rhenium, rubidium, samarium, selenium, silica, silver, sodium, strontium, sulfate, tellurium, terbium, thallium, thorium, thulium, tin, titanium, tungsten, uranium, vanadium, yttrium, ytterbium, zinc, and zirconium in these springs and seeps. Biological observations include physical setting, vegetation, invertebrate habitats, and invertebrate microhabitats.

Introduction

A significant portion of the Colorado River drainage is on the Colorado Plateau. Four National Parks administer most of this river corridor (along with about 60 river km of a combination of private, Bureau of Land Management, and Utah state owned land located between Arches and Canyonlands National Parks). These parks include: Arches National Park, Canyonlands National Park, Glen Canyon National Recreation Area and Grand Canyon National Park. Numerous springs and seeps occur

along this reach of the Colorado River corridor. Most of these springs and seeps exist as isolated sites in arid or semi-arid climates, surrounded by arid adapted communities.

Recreational use and grazing in the arid regions of southern Utah and northern Arizona have a significant effect on both the ecology of the area and the water quality of springs. Springs and seeps, together with associated wetlands, are important and sensitive riparian and aquatic habitat. Traditionally, much of the land encompassed by and bordered by the recreation area has been used for livestock grazing. Springs are essential for commercial grazing. Livestock watering and recent increases in recreational use of the backcountry, if not managed properly, may result in detrimental effects on the water quality of the resource and, therefore, produce ecological effects on the spring and seep habitats. Finally, the increase in recreational use of the backcountry may adversely effect water quality and, therefore, produce ecological effects on these springs and seeps. Recreational activities, such as trampling and swimming at springs can damage vegetation, increase erosion, allow exotic species to invade, interfere with animal life cycles, and threaten the health of aquatic life in these sensitive environments.

Baseline data are needed for the future evaluation of effects on the resource. To address this need, the U.S. Geological Survey (USGS) in cooperation with the National Park Service (NPS), visited selected springs and seeps in the specified National Parks in 1997 and 1998. The purpose of these visits was to make observations, field measurements and to collect samples for the evaluation of water quality. This study was conducted to develop baseline information on the quantity and quality of these water resources.

Purpose and scope

This report presents water quality and quantity data collected along the Colorado River corridor in 1997-98. The study area involves the reach of the Colorado River ranging from Arches National Park to Lake Mead, a distance of about 920 river kilometers (km) (Fig. 1). The water quality of springs and seeps along the Colorado River corridor and in the boundaries of Glen Canyon National Recreation Area have been studied by several scientists including, Taylor and others (1997), Blanchard (1986) and Williamson, written communication (1985). Davis and others. (1963) and Kister and Hatchett (1963) also provide water quality data on a few of the springs in this area. Some limited water-quality data on springs and seeps is reported by Lively-Schall and Foust (1988). Cooley (1965) provides descriptions and discharge data of many of the springs in the Glen Canyon region. Potter and Drake (1989) in their monograph on Lake Powell make a passing reference to water quality of springs and seeps, but provide no data. None of these studies provide a comprehensive chemical profile on the trace elements at indigenous concentration levels.

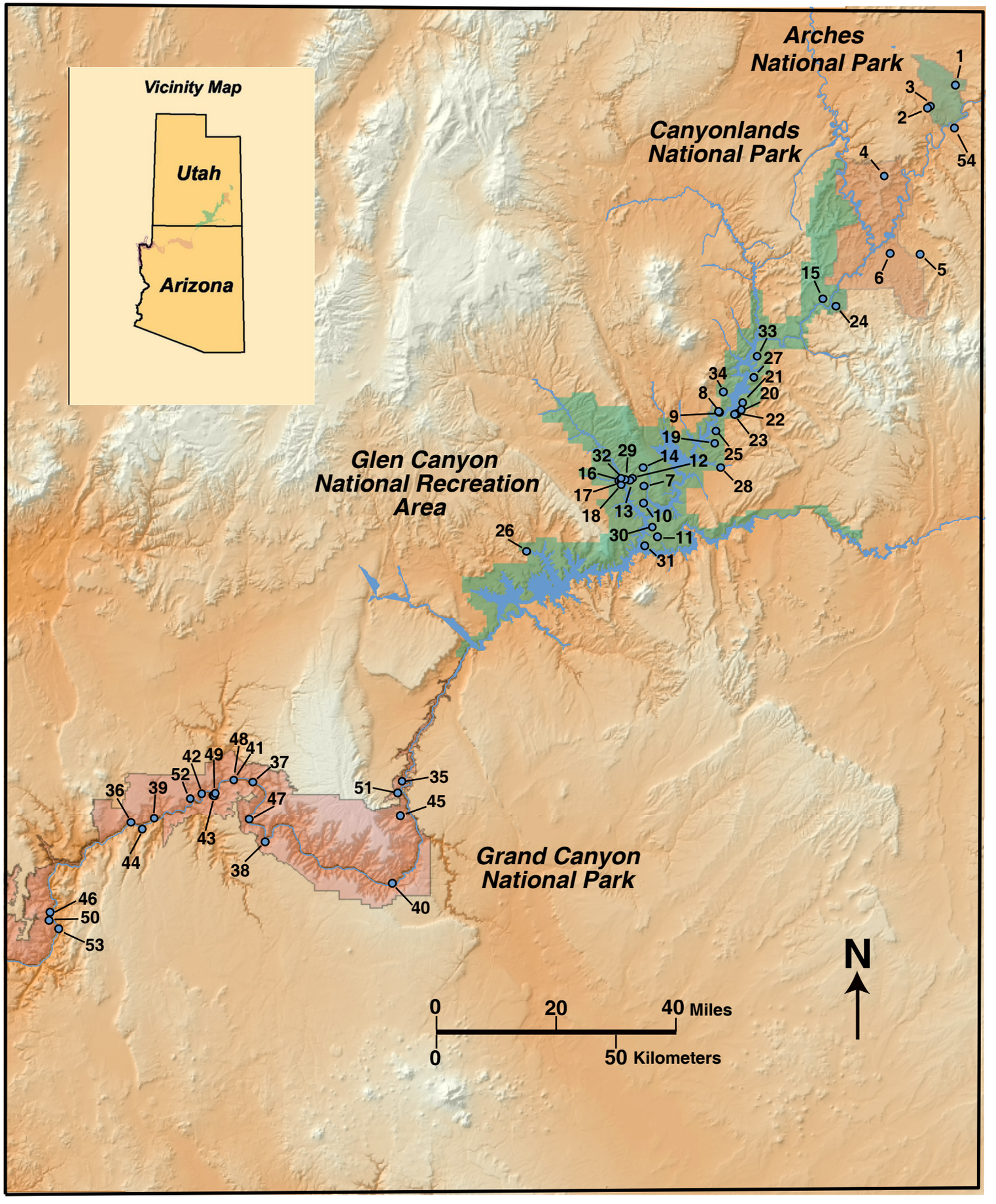
Brown and Moran (1979) identified the principal water sources in Grand Canyon National Park, identifying 36 spring sites. Information on south rim springs in the Grand Canyon, was published by Metzger (1961). Theses by Goings (1985) and Zukosky (1995) describe water flow and some water chemistry data from selected springs and wells located on the south rim of the Grand Canyon. A preliminary National Park Service (NPS) Fact Sheet (Rihs, 2001) previews information in a final report that is in preparation from on-going collaborative studies between the USGS and the NPS on seeps and springs on the south rim of the Grand Canyon from the Little Colorado River to above Havasu Creek.

Study area description

The springs and seeps selected for this study are located within the boundaries of Arches National Park, Canyonlands National Park, Glen Canyon National Recreation Area, and Grand Canyon National Park (fig. 1). Most of these springs and seeps emerge in tributaries (within a few km) to the Colorado River. These springs and seeps often emanate from geological contacts between rock formations. Discharge from rock formations generally is in the form of small springs and seeps (with discharges of less than 0.6 liters per second) from canyon walls (Blanchard, 1986). Since the filling of Lake Powell, all springs in Glen Canyon Recreation Area occur at an altitude above about 3,700 feet, the nominal elevation of the lake. The springs and seeps considered in this report (and other selected sites) are listed in table 1, and locations are shown in figure 1.

Table 1. Site Identification and Map Number

Site	Map Number (fig. 1)	Site	Map Number (fig. 1)
Arches National Park		Moqui Canyon Spring	28
Above Freshwater Spring	1	Rana Canyon Garden	29
Seven Mile Spring	2	Ribbon Canyon Garden	30
Sleepy Hollow Garden	3	San Juan Garden	31
		Stevens Arch Garden	32
Canyonlands National Park		Swett Canyon Spring	33
Cabin Spring	4	Wall Spring	34
Cave Spring	5		
Lower Big Springs	6	**Grand Canyon National Park**	
		Bert's Canyon	35
Glen Canyon Nat. Rec. Area		Cove Canyon	36
Bowns Canyon Garden	7	Deer Creek Spring	37
Buoy 114a Spring A	8	Elves Chasm	38
Buoy 114a Spring B	9	Fern Glen	39
Buoy 84 RR	10	Hance Rapid Spring	40
Cottonwood Canyon Garden	11	Keyhole Spring	41
Cow Canyon Garden A	12	Ledges	42
Cow Canyon Garden B	13	Matkatamiba Canyon	43
Cow Canyon Garden C	14	Mohawk Canyon	44
Easter pasture Canyon Garden	15	Nankoweap Twin Springs 1	45
Escalante River Spring A	16	Pumpkin Spring	46
Escalante River Spring B	17	River Mile 125 Spring	47
Escalante River Spring C	18	River Mile 142R Seep	48
Forgotten Canyon Spring	19	River Mile 147R Seep	49
Good Hope Bay Spring A	20	River Mile 213R Spring	50
Good Hope Bay Spring B	21	Saddle Canyon	51
Good Hope Bay Spring C	22	Slimy Tick Canyon	52
Good Hope Bay Spring D	23	Three Springs	53
Gypsum Canyon Spring	24		
Knowles Canyon Garden	25	**Miscellaneous**	
Last Chance Spring	26	Matrimony Spring (near Arches NP)	54
Long Canyon Spring	27		


Vicinity Map
Utah
Arizona
Arches National Park
Canyonlands National Park
Glen Canyon National Recreation Area
Grand Canyon National Park
1
2
3
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20
40 Miles
0
50 Kilometers

Study Design

Selected springs were visited and samples were collected during February-March 1997 and 1998. A total of 54 springs and seeps (3 in Arches National Park, 3 in Canyonlands National Park, 28 in Glen Canyon National Recreation Area, 19 in Grand Canyon National Park, and 1 near Arches National Park were measured and sampled at various times throughout the study. Specific springs selected for sampling were chosen because of their high and obvious visibility of the location, their magnitude of use, and their ease of access.

Acknowledgements

Special thanks are given to Mr. Lex Newcomb from Glen Canyon National Recreation Area for his GIS expertise and assistance in the preparation of the site map.

METHODOLOGY

Onsite measurements

Several onsite measurements were made to characterize each site where water samples were collected. Water temperature was always measured in the field when collecting samples, whereas pH, specific conductance, and dissolved oxygen (O_2) were measured in the field at each location when possible. When logistic difficulty prevented onsite measurements, water samples were transported as soon as possible to a field laboratory for measurement of pH, specific conductance, and dissolved oxygen.

When water flow (velocity from 5 - 75 centimeters per second) was observed in a channelized bed (depth 5 - 50 centimeters), a Price™ Pygmy model current meter was used to measure water velocity for the subsequent calculation of water discharge (Buchanan and Somers, 1976). For discharge measurements in channels too shallow to use of the Pygmy meter, a temporary weir was constructed from plastic to constrict the flowing water to a fixed channel. Under these conditions, flow was determined volumetrically by collecting a volume of water flowing from the weir for a specific period of time. For smaller water discharges, a direct volumetric measurement was made. Water was collected directly into a volumetric container (graduated cylinder) or into a holding vessel (bucket or similar container) where the volume collected was subsequently measured by water transfer into a graduated cylinder or other calibrated container.

Because the nominal discharge of most of these springs (and seeps) was usually very low (<1 L/sec) and frequently diffuse, quantitative measurements often were not possible. At locations where water discharge could not be directly measured, it was estimated using the area of the wetted rock or sand and the configuration of the topography surrounding the spring or seep as a guide to determine cross-sectional area and water was collected in a volumetric container.

The location (Universal Transverse Mercator (UTM) coordinates), geological setting, elevation, aspect (facing direction of spring), temperature, discharge, dissolved oxygen, pH and specific conductance are described in table 2.

Table 2. Site name, description, and onsite field measurement data.

[Abbreviations of geology types: BAS, Bright Angel Shale; CS, Chinle Shale; CM, Cedar Mesa; ES, Entrada Sandstone; KS, Kayenta Sandstone; ML, Muav Limestone; NKI, Navajo-Kayenta Interface; NS, Navajo Sandstone; PCAM, Precambrian quartzite/schist; RW, Redwall Sandstone; SF, Summerville Formation; TS, Tapeats Sandstone; —, No data; Aspect, Direction spring is facing; S=south, N=north, W=west, E=east, e, estimate; m, meters; °C, degrees Celsius; µS/cm, microsiemens per centimeter; mL/s, milliliters per second; mg/L – milligrams per liter; UTM, universal transverse mercator, NAD27, North American Datum, 1927]

Site	Date	UTM Coordinates		Elevation	Geology	Aspect	Temp-erture	Dis-charge	Dissolved Oxygen	pH	Specific Conductance
		Easting	Northing	m			°C	mL/s	mg/L		µS/cm
ARCHES NATIONAL PARK											
Above Freshwater Spring	07/15/98	627920	4289122	1,340	ES	S	18.2	1	7.9	8.20	196
Seven Mile Spring	07/13/98	617427	4280526	1,280	ES	S	18.2	169	8.1	8.26	250
Sleepy Hollow Spring	07/13/98	618434	4281208	1,280	ES	S	18.5	495	7.2	8.08	226
CANYONLANDS NATIONAL PARK											
Big Spring	07/15/98	603489	4226023	1,420	NKI	N	16.8	16	7.6	7.78	508
Cabin Spring	07/14/98	601283	4255058	1,650	NKI	W	15.6	18	7.	7.99	243
Cave Spring	07/15/98	609252	4223729	1,501	NKI	—	17.6	1	5.2	8.22	304
GLEN CANYON NATIONAL RECREATION AREA											
Bouy 114A Spring	08/06/97	539380	4166470	1,155	NKI	W	27.9	1	2.1	7.83	357
Bouy 114B Spring	08/06/98	539150	4166830	1,135	KS	E	22.7	5	6.4	8.43	235
Buoy 84 RR Spring	08/15/97	510960	4132610	1,135	NKI	E	23.3	44	6.9	7.79	192
Bowns Canyon Garden	07/16/97	511160	4138810	1,280	NS	W	23.9	362	6.6	9.07	117
Cottonwood Canyon Garden	09/04/97	516254	4119867	1,240	NS	S	21	246	3.1	8.07	216
Cow Canyon Garden A	07/17/97	506910	4141700	1,310	KS	E	20.3	50	7.1	7.01	157
Cow Canyon Garden B	07/17/97	505920	4141000	1,270	NKI	S	20.9	850	7.3	7.62	163
Cow Canyon Garden C	07/17/97	510780	4145850	1,370	NKI	S	26.3	118	7.6	8.70	207
Easter Pasture Canyon Garden	08/05/98	578180	4208940	1,510	CM	E	28.3	21	6.4	8.94	407
Escalante River Spring A	07/15/97	501700	4140840	1,130	NKI	N	18.9	349	6.8	7.76	171
Escalante River Spring B	07/15/97	502660	4140860	1,160	NKI	W	23	340	—	7.78	182
Escalante River Spring C	07/16/97	502740	4139260	1,140	NKI	E	18.9	913	7.7	7.76	156
Forgotten Canyon Spring	09/04/97	537757	4154846	1,160	NKI	W	19.3	37	6.3	8.26	306
Good Hope Bay, Spring A	08/14/97	546110	4166100	1,170	CS	N	19.4	57	7.8	7.90	503
Good Hope Bay, Spring B	08/14/97	547800	4167480	1,220	CS	N	19.2	41	7.4	7.92	548
Good Hope Bay, Spring C	08/14/97	545420	4165730	1,150	CS	N	18.4	52	8.	7.91	286
Good Hope Bay, Spring D	08/14/97	545190	4165740	1,135	CS	N	19.3	1,890	7.3	8.11	211
Gypsum Canyon Spring	08/05/98	583100	4206300	1,180	CS	M	25.7	239	6.8	6.99	9,570
Knowles Canyon Garden	08/04/98	538240	4159420	1,155	NKI	S	27.6	5	6.2	8.29	167
Last Chance Spring	08/21/97	467100	4114320	1,150	SF	N	19.3	10	6.3	8.26	306
Long Canyon Spring	07/16/97	551644	4178072	1,250	NKI	E	19	344	7.4	7.70	142
Moqui Canyon Spring	09/04/97	539979	4145796	1,200	NKI	S	19.8	32	4.4	7.83	397
Rana Canyon Garden	07/17/97	504170	4141240	1,160	NKI	S	23.5	140	7.2	8.21	203
Ribbon Canyon, Grand Daddy Spring	06/19/97	514300	4123510	1,155	NKI	S	19	74	—	7.70	322
San Juan Garden	06/18/97	511460	4116600	1,130	NKI	E	20.5	214	6.5	7.36	177
Stevens Arch Garden	09/05/97	502645	4141780	1,250	KS	W	22.3	1	6.8	8.17	183
Swett Canyon Spring	08/05/98	543670	4186860	1,220	CS	—	31.9	5	6.2	7.83	1240
Wall Spring	08/13/97	541950	4173310	1,130	NS	E	20.6	282	8.1	8.03	408

Table 2. Site name, description, and onsite field measurement data. (Continued)

[Abbreviations of geology types: BAS, Bright Angel Shale; CS, Chinle Shale; CM, Cedar Mesa; ES, Entrada Sandstone; KS, Kayenta Sandstone; ML, Muav Limestone; NKI, Navajo-Kayenta Interface; NS, Navajo Sandstone; PCAM, Precambrian quartzite/schist; RW, Redwall Sandstone; SF, Summerville Formation; TS, Tapeats Sandstone. —, No data; Aspect, Direction spring is facing; e, estimate; m, meters; oC, degrees, Celsius; µS/cm, microsiemens per centimeter; mL/s, milliliters per second; mg/L – milligrams per liter; UTM, universal transverse mercator, North American Datum, 1927]

Site	Date	UTM Coordinates		Elevation	Geology	Aspect	Temp-erature	Discharge	Dissolved Oxygen	pH	Specific Conductance
		Easting	Northing	m			°C	mL/s	mg/L		µS/cm
GRAND CANYON NATIONAL PARK											
Berts Canyon	05/11/98	420561	4028259	975.	ML	N	13.5	54.	9.6	7.91	453
Cove Canyon	05/19/98	318924	4012881	540.	ML	E	17.	93.		8.43	2,790
Deer Creek Spring	05/16/98	364612	4027987	600.	ML	S	17.8	—	—	—	—
Elves Chasm	05/15/98	369234	4005685	750.	ML	N	9.	621.	10.4	8.43	612
Fern Glen	05/19/98	327710	4014470	550.	ML	N	14.5	5.		8.14	2,010
Hance Rapid Spring	05/13/98	416872	3990117	920.	PCAM	S	18.8	91.	8.3	8.32	911
Keyhole Spring	05/11/98	358063	4027010	975.	ML	N	14.	57.	9.3	8.50	457
Ledges	05/17/98	345492	4023693	575.	ML	S	20.	191.	—	8.11	2,020
Matkatamiba Canyon	05/17/98	350096	4022800	640.	ML	E	16.	5.	—	8.04	1,275
Mohawk Canyon	05/19/98	323183	4010459	560.	ML	W	16.	5.	—	8.31	2,200
Nankoweap Twin Spring	05/12/98	420166	4015360	1,060.	PCAM	E	17.	6,345.	8.9	8.30	705
Pumpkin Spring	05/21/98	291744e	3973467e	480.	TS	—	23.	200.	—	7.00	12,900
River Mile 125 Spring	05/15/98	363175	4014068	670.	ML	E	19.	10.	—	8.39	1,647
River Mile 142 Seep	05/16/98	357500	4028707	590.	ML	S	—	—	—	—	—
River Mile 147 Seep	05/17/98	349600	4023102	585.	ML	S	20.5	428.	—	7.82	1,353
River Mile 213 Spring	05/21/98	289236	3977233	490.	BAS	E	18.5	5.	—	9.22	586
Saddle Canyon	05/11/98	418855	4024029	975.	ML	E	15.	5.	8.4	7.70	503
Slimy Tick Spring	05/18/98	342552	4021289	610.	ML	E	15.	7,080.	—	8.30	2,650
Three Springs	05/21/98	291641e	3973840e	500.	ML	N	20.	5,000.	—	8.09	627
MISCELLANOUS											
Matrimony Spring	07/14/98	624393	4273683	1,443.	—	N	19.3	540.	10	7.86	296

Sampling and sample processing

Samples were collected and analyzed for major cations, major anions, nutrirents, dissolved organic carbon (DOC), trace constituents, and mercucry.

Sampling kits consisting of filtration equipment, precleaned bottles (some containing preservative) with labels, hermetically sealed in a plastic bag, were prepared in the laboratory prior to a sampling trip. Each sampling kit was designated for one use only at a specific site. New kits were used at every sampling site. This approach eliminated the need for field cleaning of equipment, minimized the possibility of contamination, and greatly improved the quality control of the process.

Sample processing for trace constituent analysis consisted of filtration with a dedicated 60-mL polystyrene syringe (soaked in nitric acid in the laboratory for a minimum of 48 hours) through a disposable 25-mm diameter polysulfone membrane syringe filter with a nominal pore size of 0.45 μm. Samples for dissolved organic carbon determinations were filtered through a 47-mm diameter 0.45-micrometer pore-size silver membrane filter housed in a stainless steel filter holder.

Subsamples for laboratory analysis were filtered into sample bottles as follows: one 60-mL baked glass bottle (for dissolved organic carbon determinations (DOC)); one 30-ml deionized water-soaked opaque brown polyethylene bottle (for nutrient determinations); one deionized water-soaked clear 60-mL polyethylene bottle (for major anion determinations); and one 125-mL nitric acid-soaked polyethylene bottle with 1-mL concentrated sub-boiling distilled nitric acid included in the bottle for trace constituent and major-cation determinations. In addition, one 125-mL nitric acid-soaked glass bottle with 5-mL of a mixture of concentrated ultrapure nitric acid and 1 percent weight/volume (w/v) ultrapure potassium dichromate included in the bottle for mercury determinations was packaged separately from the kit to minimize cross-contamination problems. All sample bottles were acid soaked in the laboratory for 24 hours prior to use.

The field processing procedure is described as follows:

1. The kit was unsealed and the polyvinylchloride (PVC) gloves were immediately placed on the hands of the person collecting the sample.
2. The 60-mL syringe was removed from its container and without a filter in place was filled with sample directly from the spring or seep. If it was not possible to fill the syringe from the back with the plunger removed, the syringe was filled by using the suction of the plunger to draw small volumes from shallow depressions near the source of the spring. This is a particularly important technique for sampling springs with small volumes of running water.
3. The initial filling of the syringe was discarded as a sample rinse prior to the filtration step.
4. A disposable filter was placed on the syringe (using the Luer-lock connector), and a small quantity of sample was forced through the filter to rinse it (approximately 10-mL). A portion of this rinse solution was transferred to the appropriate sample bottle for rinsing prior to filling with filtered sample.
5. After rinsing, the remainder of the sample in the syringe was filtered into the appropriate sample bottles.
6. The sample bottles were filled in the following order: 30-mL nutrient bottle, 60-mL anion bottle, 125-mL trace constituent bottle and finally, the 125-mL mercury bottle. Each bottle was thoroughly sealed before a subsequent bottle was opened. Nutrient samples were immediately chilled.
7. As the disposable filters became clogged, reducing the filtration rate, the old filter was discarded and replaced with a new filter. Each new filter was rinsed as described in step 4 above.
8. Dissolved organic carbon samples were chilled after processing.

Laboratory analysis

All samples were analyzed at the USGS laboratory located in Boulder, Colorado. Upon arrival at the laboratory, samples for nutrients and DOC were analyzed immediately. Ammonium (NH_4), nitrate (NO_3), nitrite (NO_2) and orthophosphate (PO_4) were determined by ultraviolet-visible absorption spectrophotometry. Measurements were made using a continuous-flow automated method described by Antweiler and others (1993). Dissolved organic carbon (DOC) was determined by oxidation of the organic carbon in the sample to carbon dioxide, which was measured using an infrared absorption spectrophotometric technique.

The specific method is described by Wershaw and others (1983).

Total alkalinity was determined on the unpreserved filtered sample by an automated Gran titrimetric procedure using sulfuric acid as the titrant (Skougstad and others, 1979). Alkalinity was expressed in the units of milliequivalents per liter and was used in conjunction with pH to calculate dissolved inorganic carbon (DIC) as carbonate and bicarbonate. Major anions (chloride (Cl), fluoride (F) and sulfate (SO_4)) were determined on the unpreserved filtered sample using an automated ion chromatographic technique (Brinton and others, 1996).

Major cations (sodium (Na), calcium (Ca), magnesium (mg), potassium (K) and silica (as SiO_2)) were determined on the filtered and acidified sample using an inductively coupled plasma-atomic emission spectrometric method. The method previously has been described by Garbarino and Taylor (1979).

Trace constituents (aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), bismuth (Bi), boron (B), bromide (Br), cadmium (Cd), cerium (Ce), cesium (Cs), chromium (Cr), cobalt (Co), copper (Cu), dysprosium (Dy), erbium (Er), europium (Eu), fluoride (F), gadolinium (Gd), holmium (Ho), iodine (I), lanthanum, (La), lead (Pb), lithium (Li), lutetium (Lu), manganese (Mn), molybdenum (Mo), neodymium (Nd), nickel (Ni), praseodymium (Pr), rhenium (Re), rubidium (Rb), samarium (Sm), selenium (Se), silver (Ag), strontium (Sr), tellurium (Te), terbium (Tb), thallium (Tl), thorium (Th), thulium (Tm), tin (Sn), titanium (Ti), tungsten (W), uranium (U), vanadium (V), yttrium (Y), ytterbium (Yb), zinc (Zn), and zirconium (Zr) were determined by an inductively coupled plasma-mass spectrometric technique as described in Taylor and Garbarino (1991), Garbarino and Taylor (1994), and Taylor (2001). A cold-vapor atomic fluorescence spectrometric technique reported by Roth (1994) was used for the trace determination of mercury (Hg). Iron (Fe) was determined by the inductively coupled plasma-atomic emission technique previously described.

Quality control/quality assurance

All laboratory sample determinations were performed randomly in triplicate (randomly throughout a single analysis session). After statistical evaluation, outliers were rejected (Meier and Zünd, 1993) and analytical determinations rerun as necessary. Calibration curves for instrumental determinations were established by the use of at least five separate concentration calibration standards, prepared gravimetrically from pure metals or metal salts. Laboratory reagent blanks were run in triplicate at a rate of about 5 percent of the total samples analyzed. Field process blanks were analyzed as part of the quality-control program. Laboratory blanks were used to correct analytical data, and field blanks were used to evaluate the possibility of contamination during the sampling process.

The accuracy of the analytical determinations was further ensured by the periodic analysis of standard reference materials within each set of laboratory samples. Natural water matrix reference standards routinely comprised at least 20 percent of each batch of sample analysis. Different standard reference materials were used for each analytical method. A number of separate reference samples, having constituent concentrations that bracketed the expected analyte concentrations in the spring and seeps samples, were routinely analyzed in an identical fashion to the samples. National Institute of Standards and Technology (NIST), Standard Reference Materials, and USGS, Standard Reference Water Samples were extensively used to evaluate the accuracy of all analytical trace element determinations. A summary of the results of these standards are shown on bar graphs in figures 2 and 3. The white bars represent the certified or “most probable” value of the trace elements in the reference material. The dark bars are mean concentrations measured by the laboratory for the reference material during the analysis of the samples. The degree of agreement between the certified or “most probable” values and the measured values represent an estimate of the level of accuracy of these determinations. Depending on concentration level of the analyte, the degree of agreement between the certified and measured values was generally between 1 and 10 percent.

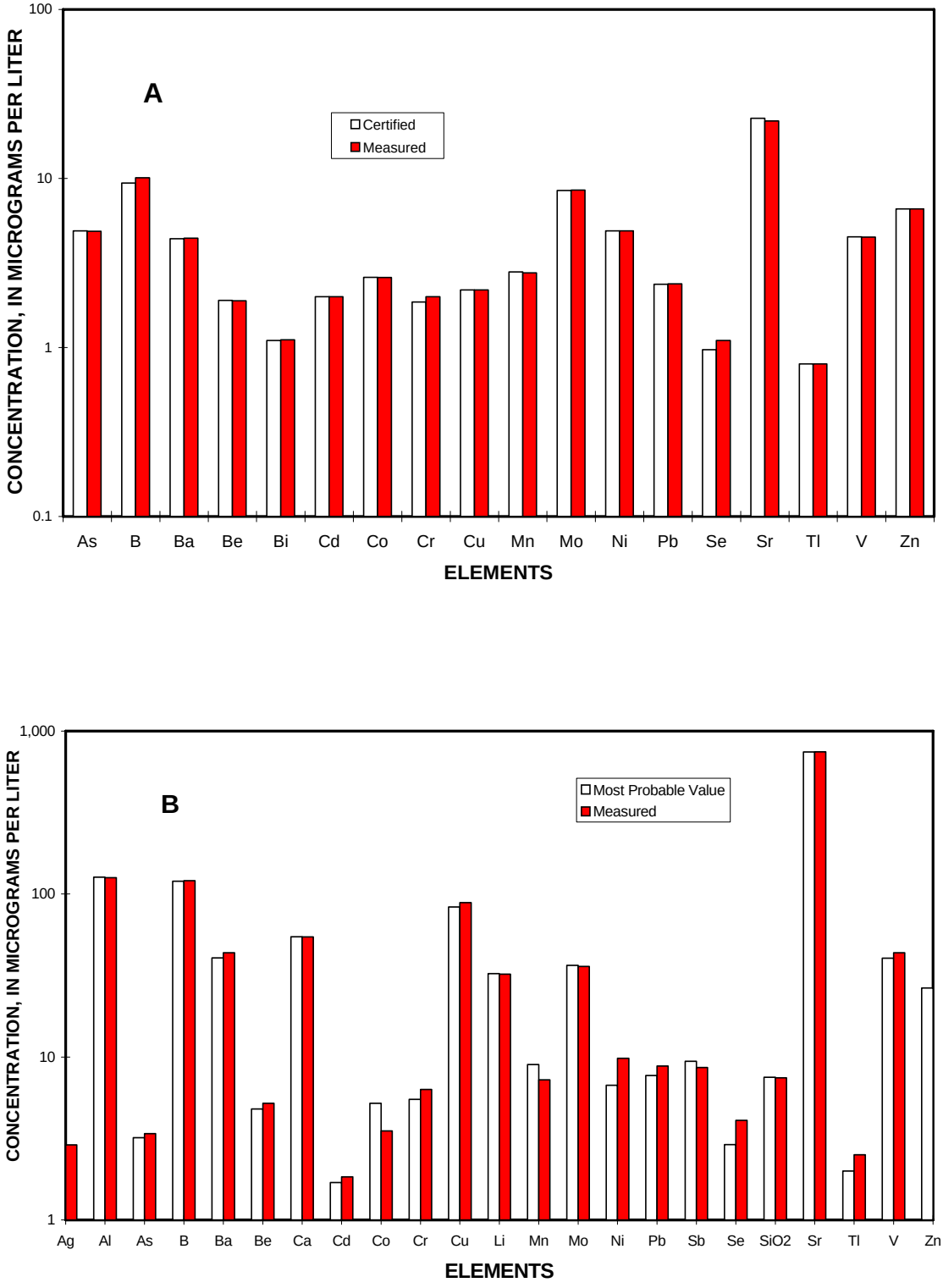


Figure 2. Comparison of certified and measured values for: **A**. National Institute of Standards SRM 1643b at a 1:10 dilution, (As, Bi, B are Most Probable Values). **B**. U.S. Geological Survey Standard Reference Water Sample T103 (Ca and SiO_2 in milligrams per liter)

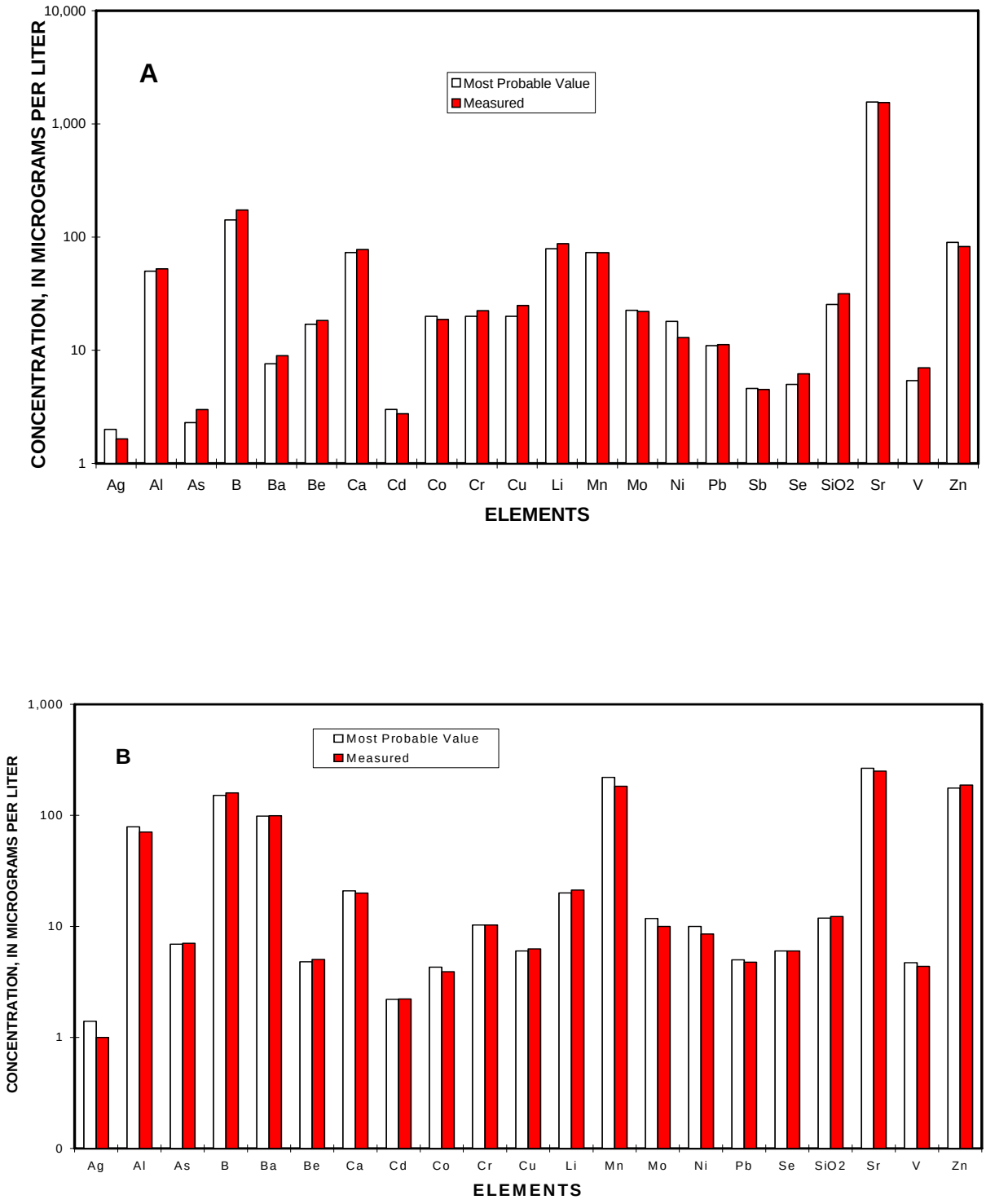


Figure 3. Comparison of certified and measured values for: **A**. U.S. Geological Survey Standard Reference Water Sample T105 (Ca and SiO2 in milligrams per liter) **B**. U.S. Geological Survey Standard Reference Water Sample T117 (Ca and SiO2 in milligrams per liter)

WATER QUALITY AND QUANTITY DATA

A summary of all field measurements and the mean values and standard deviations of the replicate laboratory determinations are tabulated in tables 2 and 3. Concentrations of major anions and cations, nutrients, dissolved inorganic carbon, and DOC are reported in milligrams per liter (mg/L). Alkalinity and specific conductance are reported in the units of milliequivalents per liter (meq/L) and microsiemens per centimeter (μS/cm), respectively. Mercury concentrations are reported in nanograms per liter (ng/L) All other trace constituents are tabulated in units of micrograms per liter (μg/L). Where appropriate, detection limits are determined by the method described by Skogerboe and Grant (1970) and data are reported as "less than" values (<) in the table. Detection limits may vary for a given constituent on the basis of factors such as variation in the sensitivity of the laboratory instrument or sample dilutions that were made at the time of analysis to minimize interelement interference effects. Observations including the biological characteristics of each spring and seep are tabulated table 4.

The water-quantity results tabulated from this study (table 2) show that water discharge ranges from unmeasureable (seeps) to a high of about 7,000 mL/s at Slimey Tick Spring in Grand Canyon National Park. The magnitude of water discharge is highly variable dependent on the season of the year and the overall climatic and hydrologic conditions prior to measurement (Blanchard, 1986).

Hydrogen ion concentration, expressed in pH, is ranges from 6.99 to 9.22. Alkalinity is variable, ranging from about 1 to 30 meq/L, suggesting significant variation in the bicarbonate contributions. Specific conductance (an indication of dissolved solids content) also is variable, ranging from 117 μS/cm at Bowns Canyon Spring in Glen Canyon National Recreation Area to 12,900 μS/cm at Pumpkin Spring in Grand Canyon National Park. Other major water quality constituents such as, Ca, K, Mg, Na, Cl and SO_4, show a similar distribution to the specific conductance, indicating that the majority of the springs are freshwater, with a few springs having nominally high salinity (for example, Gypsum Canyon Spring and Pumpkin Spring). Nutrients, including ammonium ion, nitrate, nitrite and phosphate, were measured at very low and variable concentrations.

Several of the trace constituents seldom were measured at concentrations above their respective detection limits (usually sub μg/L levels). These included Ag, Be, Co, Ni, P, Te and Tl. Concentrations of other trace elements including Cd, Ce, Cr, Cs, Cu, Dy, Er, Eu, Fe, Gd, Hg, Ho, Lu, Mo, Nd, Pb, Pr, Re, Sb, Se, Sm, Sn, Tb, Th, Tm, W, Yb and Zn, ranged from their respective detection limit to nominally moderate values depending on the specific spring sampled. Elements including Al, As, B, Ba, Br, DIC, DOC, I, La, Li, Mn, Rb, Sr, U, V, Y and Zn, were present at measureable concentrations in essentially all springs and seeps sampled. Silica (SiO_2) ranged from 0.03 to 130 mg/L.

CONCLUSIONS

Water is a critical, limited resource in the arid environment of the national parks and recreation areas on the Colorado Plateau. Although many of these springs and seeps are small and sometimes temporary, collectively they result in the greatest and most widespread source of surface water in the four national parks aside from Lake Powell and the major river channels. Because of the presence and range of these ground-water sources of surface water, they are an essential resource to maintain the riparian and aquatic habitat that supports the local flora and fauna of the high desert. The ecosystems that develop around the springs and seeps represent a unique environment in the desert. This study, described in this report, represents a water quality and quantity assessment of selected springs and seeps that were flowing at the time of sampling and that were accessible with reasonable effort. Additional sampling and assessment of these and other springs and seeps in the future is warranted to identify potentially unique floral and faunal species that may be present and provide information to assist in the management of this important resource.

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government

LITERATURE CITED

Antweiler. R.C., Patton, C.J., and Taylor, H.E., 1993, Automated, colorimetric methods for determination of nitrate plus nitrite, nitrite, ammonium and orthophosphate ions in natural water samples: U.S. Geological Survey Open-File Report 93-638, 40 p.

Blanchard, P.J., 1986, Ground-water conditions in the Lake Powell area, Utah: Utah Department of Natural Resources, Technical Publication No. 84., 64 pp.

Brinton, T.I., Antweiter, R.C., and Taylor, H.E., 1996, Method for the determination of dissolved chloride, nitrate and sulfate in natural water using ion chromatography: U.S. Geological Survey Open-File Report 95-426A, 16 p.

Brown, B.T. and Moran, M.S., 1979, An inventory of surface water resources in Grand Canyon National Park, Arizona. Final report to the Division of Resource Management, Grand Canyon National Park, 208 Water Quality Report, Part I, Water Resources Inventory, p. 2.

Buchanan, T. J. and Somers, W.P., 1976, Discharge Measurements at Gaging Stations*:* U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A8, 65 p.

Cooley, M.E., 1965, Stratigraphic sections and records of springs in the Glen Canyon region of Utah and Arizona. Museum of Northern Arizona, Technical Series No. 6, Flagstaff, Ariz., Northern Society of Science and Art, 140 p.

Davis, G.E., Hardt, W.F., Thompson, L.K. and Cooley, M.E., 1963, Geohydrologic data in the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah. Part I, Records of ground-water supplies: Tucson, Ariz., Arizona State Land Department Water Resources Report No. 12-A. 159 pp.

Garbarino, J.R. and Taylor, H.E., 1979, An inductively-coupled plasma atomic emission spectrometric method for routine water quality testing: Applied Spectroscopy, v. 33, p. 220.

Garbarino, J.R. and Taylor, H.E., 1994, Inductively coupled plasma-mass spectrometric method for the determination of dissolved trace elements in natural water: U.S. Geological Survey Open-File Report 94-358, 88 p.

Goings, D.B., 1985, Spring flow in a portion of Grand Canyon National Park, Arizona: University of Nevada-Las Vegas, unpublished Master's thesis, 35 p.

Kister, L.R. and Hatchett, J.L., 1963, Geohydrologic data in the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah. Part II, Selected chemical analysis of the ground water: Tucson, Ariz., Arizona State Land Department Water Resources Report No. 12-B. 58p.

Lively-Schall, W. and Foust, Jr., R.D., 1988, Surface water within Glen Canyon National Recreation Area: Report from Ralph M. Bilby Research Center, Northern Arizona University, Flagstaff, Ariz., 56 p.

Meier, P.C. and Zünd, R.E., 1993, Statistical Methods in Analytical Chemistry, vol. 123 in Chemical Analysis, J.D. Wineforder and I.M. Kolthoff, eds., John Wiley and Sons, New York, p. 49-51.

Metzger, D.G., 1961, Geology in relation to availability of water along the south rim Grand Canyon National Park: U.S. Geological Survey Water-Supply Paper 1475-C, 138 p.

Potter, L.D. and Drake, C.L., 1989, Lake Powell Virgin Flow to Dynamo: Albuquerque, New Mex. University of New Mexico Press, 289 p..

Rihs, J., 2001, Native Waters: A Study of Grand Canyon's seeps and springs, 2001: National Park Service Fact Sheet.

Roth, D.A., 1994, Ultratrace analysis of mercury and its distribution in some natural waters in the United States: Ft. Collins, Colo., Colorado State University, Department of Chemistry, Ph.D. dissertation, 309 p.

Skogerboe, R.K. and Grant, C.L., 1970, Comments on the definitions of terms sensitivity and detection limit: Spectroscopy Letters, v. 3, no. 8/9, p. 215-219.

Skougstad, M.W., Fishman, M.J., Friedman, L.C., Erdman, D.E., and Duncan, S.S., 1979, Methods for the determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 626 p.

Taylor, H.E., 2001, Inductively Coupled Plasma-Mass Spectrometry: Practices and Techniques: Academic Press, San Diego, CA., 294 p.

Taylor, H.E., and Garbarino, J.R., 1991, The measurement of trace metals in water resource monitoring samples by inductively-coupled plasma mass spectrometry: Spectrochimica Acta Reviews, v. 14, p. 33.

Taylor, H.E., Berghoff, K., Andrews, E.D., Antweiler, R.C., Brinton, T.I., Miller, C., Peart, D.B., and Roth, D.A., 1997, Water Quality of Springs

and Seeps in Glen Canyon National Recreation Area: National Park Service Technical Report NPS/NRWRD/NRTR-97/128, 26 p.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., 1983. Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A3, p. 22.

Williamson, R.R. 1985. A baseline chemical analysis of selected springs in Glen Canyon National Recreation Area. Written communication, 22 pp.

Zukosky, K.A., 1995, An assessment of the potential to use water chemistry parameters to define ground water flow pathways at Grand Canyon National Park, Arizona: University of Nevada-Las Vegas, unpublished Master's thesis, 105 p.

Table 3. Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98.

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; mg/L, milligrams per liter, ng/L, nanograms per per liter, C/L, carbon per liter, N/L, nitrogen per liter, <, less than; ±, plus or minus, ± --, no data]

Site	Alkalinity meq/L	Silver µg/L	Aluminum µg/L	Arsenic µg/L	Boron µg/L	Barium µg/L	Beryllium µg/L	Bismuth µg/L	Bromine µg/L
ARCHES NATIONAL PARK									
Above Freshwater Spring	1.45	< 0.5 ± 0.2	0.23 ± 0.3	0.26 ± 0.018	9.8 ± 0.3	220. ± 0	< 0.03 ± 0.01	< 0.006 ± 0.001	19 ± 4
Seven Mile Spring	2.15	< 0.5 ± 0.15	0.20 ± 0.3	0.22 ± 0.045	13.1 ± 2	310. ± 0	< 0.03 ± 0.01	< 0.006 ± 0.001	20 ± 4
Sleepy Hollow Spring	1.96	< 0.5 ± 0.2	1.24 ± 0.3	0.42 ± 0.082	15. ± 1	290. ± 0	< 0.03 ± 0.02	< 0.006 ± 0.000	15 ± 2
CANYONLANDS NATIONAL PARK									
Big Spring	4.94	< 0.5 ± 0.08	< 0.08 ± 0.4	0.69 ± 0.052	47.6 ± 0.6	160. ± 0	< 0.03 ± 0.02	< 0.006 ± 0.002	60 ± 2
Cabin Spring	1.99	< 0.5 ± 0.2	0.23 ± 0.4	2.40 ± 0.003	18. ± 1	180. ± 0	< 0.03 ± 0.01	< 0.006 ± 0.003	30 ± 6
Cave Spring	2.92	< 0.7 ± 0.25	1.24 ± 0.0	0.31 ± 0.079	10.5 ± 8	280. ± 0	< 0.02 ± 0.02	< 0.003 ± 0.001	8 ± 0
GLEN CANYON NATIONAL RECREATION AREA									
Bouy 114A Spring	—	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
Bouy 114B Spring	2.26	< 0.7 ± 0.5	0.61 ± 0.0	2.71 ± 0.057	14.5 ± 6	420. ± 20	< 0.02 ± 0.02	< 0.003 ± 0.000	6 ± 1
Buoy 84 RR Spring	1.66	< 0.8 ± 0.07	4.33 ± 0.9	0.86 ± 0.024	11.9 ± 0.7	42. ± 0	< 0.02 ± 0.01	< 0.003 ± 0.002	7 ± 1
Bowns Canyon Garden	1.05	< 0.8 ± 0.01	3.44 ± 0.1	0.05 ± 0.021	4.8 ± 0.7	25. ± 1	< 0.02 ± 0.02	< 0.003 ± 0.001	19 ± 1
Cottonwood Canyon Garden	2.18	< 0.8 ± 0.04	8.35 ± 0.3	1.44 ± 0.038	12.4 ± 1	51. ± 1	< 0.02 ± 0.02	< 0.003 ± 0.000	12 ± 1
Cow Canyon Garden A	1.39	< 0.8 ± 0.02	2.11 ± 0.4	0.08 ± 0.007	7.6 ± 0.9	62. ± 2	< 0.02 ± 0.01	< 0.003 ± 0.002	26 ± 3
Cow Canyon Garden B	1.49	< 0.8 ± 0.08	4.42 ± 0.0	0.04 ± 0.028	8.9 ± 1	41. ± 1	< 0.02 ± 0.02	0.004 ± 0.000	13 ± 2
Cow Canyon Garden C	1.85	< 0.8 ± 0.05	3.70 ± 0.2	0.83 ± 0.023	12.2 ± 0.5	160. ± 10	< 0.02 ± 0.01	< 0.003 ± 0.002	28 ± 2
Easter Pasture Canyon Garden	2.66	< 0.7 ± 0.4	0.95 ± 0.1	0.79 ± 0.073	58.6 ± 6.3	67. ± 0	< 0.02 ± 0.01	< 0.003 ± 0.001	29 ± 1
Escalante River Spring A	1.42	< 0.8 ± 0.1	6.18 ± 0.2	2.67 ± 0.05	12.7 ± 0.6	32. ± 1	< 0.02 ± 0.01	< 0.003 ± 0.000	21 ± 2
Escalante River Spring B	1.45	< 0.8 ± 0.09	2.97 ± 0.0	0.19 ± 0.021	11.1 ± 0.9	37. ± 0	< 0.02 ± 0.02	< 0.003 ± 0.000	21 ± 2
Escalante River Spring C	1.51	< 0.8 ± 0.03	1.09 ± 0.2	7.31 ± 0.217	10.7 ± 1	120. ± 0	< 0.02 ± 0.02	< 0.003 ± 0.001	13 ± 0
Forgotten Canyon Spring	4.35	< 0.8 ± 0.09	2.32 ± 0.5	0.79 ± 0.05	17.1 ± 1	300. ± 0	< 0.02 ± 0.02	< 0.003 ± 0.000	21 ± 1
Good Hope Bay, Spring A	3.57	< 0.8 ± 0.14	2.67 ± 1.3	4.60 ± 0.06	37.5 ± 1	160. ± 0	< 0.02 ± 0.02	< 0.003 ± 0.000	24 ± 0
Good Hope Bay, Spring B	5.05	< 0.8 ± 0.07	4.97 ± 4.4	4.05 ± 0.009	87.9 ± 0.1	160. ± 0	< 0.02 ± 0.02	< 0.003 ± 0.002	23 ± 1
Good Hope Bay, Spring C	2.54	< 0.8 ± 0.04	1.25 ± 0.3	3.67 ± 0.025	30.6 ± 0.4	140. ± 10	< 0.02 ± 0.02	< 0.003 ± 0.001	18 ± 2
Good Hope Bay, Spring D	2.51	< 0.8 ± 0.	1.27 ± 0.1	3.23 ± 0.008	24. ± 3	140. ± 0	< 0.02 ± 0.01	< 0.003 ± 0.001	18 ± 2
Gypsum Canyon Spring	4.58	< 0.7 ± 0.2	0.88 ± 0.3	9.92 ± 0.05	750. ± 10	35. ± 0	< 0.02 ± 0.01	0.008 ± 0.003	290 ± 0
Knowles Canyon Garden	1.47	< 0.7 ± 0.1	1.20 ± 0.1	1.01 ± 0.026	12.9 ± 1.5	240. ± 10	< 0.02 ± 0.01	< 0.003 ± 0.000	5 ± 1
Last Chance Spring	7.88	< 0.8 ± 0.1	3.19 ± 0.3	0.30 ± 0.026	270. ± 10	32. ± 1	< 0.02 ± 0.01	< 0.003 ± 0.002	33 ± 2
Long Canyon Spring	1.27	< 0.8 ± 0.06	5.18 ± 0.0	0.10 ± 0.026	10. ± 0.5	32. ± 0	< 0.02 ± 0.02	< 0.003 ± 0.001	14 ± 2
Moqui Canyon Spring	3.75	< 0.8 ± 0.05	2.88 ± 1.8	0.47 ± 0.015	19.1 ± 1	110. ± 0	< 0.02 ± 0.02	< 0.003 ± 0.001	20 ± 2
Rana Canyon Garden	1.90	< 0.8 ± 0.1	3.75 ± 0.4	0.25 ± 0.034	14.8 ± 0.2	45. ± 0	< 0.02 ± 0.00	< 0.003 ± 0.002	16 ± 2
Ribbon Canyon, Grand Daddy Spring	1.99	< 0.8 ± 0.05	1.18 ± 0.1	1.27 ± 0.114	10.7 ± 0.9	25. ± 1	< 0.02 ± 0.01	< 0.003 ± 0.000	14 ± 1
San Juan Garden	1.51	< 0.8 ± 0.1	1.67 ± 0.1	1.47 ± 0.017	8.7 ± 1.6	58. ± 1	< 0.02 ± 0.00	< 0.003 ± 0.000	10 ± 1
Stevens Arch Garden	1.65	< 0.8 ± 0.07	0.96 ± 0.5	0.23 ± 0.014	13.3 ± 0.4	39. ± 2	< 0.02 ± 0.01	< 0.003 ± 0.001	11 ± 1
Swett Canyon Spring	9.20	< 0.7 ± 0.4	1.11 ± 0.1	3.79 ± 0.029	439.7 ± 0	82. ± 1	< 0.02 ± 0.02	< 0.003 ± 0.001	38 ± 1
Wall Spring	3.68	< 0.8 ± 0.04	1.06 ± 0.0	1.36 ± 0.043	30.4 ± 0.2	150. ± 0	< 0.02 ± 0.02	< 0.003 ± 0.001	12 ± 1

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (Continued)

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Alkalinity meq/L	Silver µg/L	Aluminum µg/L	Arsenic µg/L	Boron µg/L	Barium µg/L	Beryllium µg/L	Bismuth µg/L	Bromine µg/L
GRAND CANYON NATIONAL PARK									
Berts Canyon	4.00	< 0.7 ± 0.19	0.3 ± 0.	0.28 ± 0.	35. ± 8.	140. ± 2.	< 0.02 ± 0.02	< 0.003 ± 0.001	16 ± 0
Cove Canyon	1.80	< 0.7 ± 0.15	0.8 ± 0.2	0.88 ± 0.04	180. ± 10.	22. ± 1.	< 0.02 ± 0.02	< 0.003 ± 0.001	28 ± 1
Elves Chasm	3.17	< 0.7 ± 0.1	0.24 ± 0.1	2.3 ± 0.07	75. ± 8.	31. ± 1.	< 0.02 ± 0.02	< 0.003 ± 0.000	31 ± 0
Fern Glen	3.11	< 0.7 ± 0.33	9.6 ± 7.	0.59 ± 0.05	240. ± .	16. ± 0.2	< 0.02 ± 0.02	< 0.003 ± 0.002	26 ± 1
Hance Spring	4.94	< 0.7 ± 0.13	1. ± 0.3	54. ± 0.9	610. ± 10.	32. ± 1.	0.035 ± 0.02	< 0.003 ± 0.001	36 ± 2
Keyhole Spring	3.94	< 0.7 ± 0.3	0.67 ± 0.3	3.4 ± 0.09	43. ± 3.	160. ± 0.4	< 0.02 ± 0.01	< 0.003 ± 0.001	21 ± 0
Mohawk Canyon	2.16	< 0.7 ± 0.05	0.5 ± 0.2	0.21 ± 0.1	230. ± 30.	11. ± 0.4	< 0.02 ± 0.01	< 0.003 ± 0.001	32 ± 1
Nankoweap Twin Spring	4.49	< 0.7 ± 0.39	0.76 ± 0.5	0.13 ± 0.02	130. ± 10.	32. ± 0.6	< 0.02 ± 0.01	< 0.003 ± 0.000	14 ± 1
Pumpkin Spring	29.6	< 0.7 ± 0.19	5.4 ± 0.2	— ± —	13,600. ± 2,900.	120. ± 0.0	0.67 ± 0.02	0.004 ± 0.002	3,300 ± 0
River Mile 125 Spring	2.78	< 0.7 ± 0.26	0.56 ± 0.1	1.2 ± 0.04	210. ± 10.	11. ± 0.1	< 0.02 ± 0.02	< 0.003 ± 0.001	46 ± 2
River Mile147 Seep	3.03	< 0.7 ± 0.22	18.5 ± 16.	0.93 ± 0.01	150. ± 10.	13. ± 0.3	< 0.02 ± 0.00	< 0.003 ± 0.000	19 ± 1
River Mile 213 Spring	3.37	< 0.7 ± 0.12	1.4 ± 0.3	24. ± 1.	200. ± 10.	39. ± 0.5	< 0.02 ± 0.02	< 0.003 ± 0.003	63 ± 1
Saddle Canyon	3.94	< 0.7 ± 0.24	0.32 ± 0.2	0.95 ± 0.02	44. ± 6.	87. ± 1.3	< 0.02 ± 0.01	< 0.003 ± 0.001	21 ± 0
Slimy Tick Spring	2.34	< 0.7 ± 0.28	0.82 ± 0.5	1.2 ± 0.09	220. ± 10.	15. ± 0.7	< 0.02 ± 0.02	< 0.003 ± 0.000	24 ± 1
The Ledges	1.95	< 0.7 ± 0.23	1.9 ± 1.5	0.73 ± 0.05	190. ± .	12. ± 0.1	< 0.02 ± 0.02	< 0.003 ± 0.003	23 ± 1
Three Springs	4.97	< 0.7 ± 0.24	0.51 ± 0.1	7.4 ± 0.4	110. ± .	73. ± 1.6	< 0.02 ± 0.01	< 0.003 ± 0.001	51 ± 0
MISCELLANEOUS									
Matrimony Spring	2.11	< 0.5 ± 0.16	0.52 ± 0.5	0.83 ± 0.05	20. ± 1.	71. ± 0.9	0.038 ± 0.01	< 0.006 ± 0.001	17 ± 4

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (Continued)

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Calcium mg/L	Cadmium µg/L	Cerium µg/L	Chlorine mg/L	Cobalt µg/L	Chromium µg/L	Cesium µg/L	Copper µg/L
ARCHES NATIONAL PARK								
Above Freshwater Spring	31.9 ± 0.5	< 0.009 ± 0.0039	< 0.0005 ± 0.001	2.3 ± 0.1	< 0.009 ± 0.01	< 0.1 ± 0.05	< 0.005 ± 0.002	0.12 ± 0.03
Seven Mile Spring	38.5 ± 0.6	< 0.009 ± 0.002	< 0.0005 ± 0.	3.5 ± 0.1	< 0.009 ± 0.01	< 0.1 ± 0.04	0.023 ± 0.003	0.14 ± 0.06
Sleepy Hollow Spring	38.1 ± 0.	< 0.009 ± 0.005	0.0018 ± 0.001	2.2 ± —	< 0.009 ± 0.	< 0.1 ± 0.13	0.019 ± 0.	0.13 ± 0.03
CANYONLANDS NATIONAL PARK								
Big Spring	61.2 ± 0.4	< 0.009 ± 0.0045	< 0.0005 ± 0.	12. ± —	< 0.009 ± 0.01	< 0.1 ± 0.04	0.013 ± 0.001	0.68 ± 0.05
Cabin Spring	33.7 ± 0.6	< 0.009 ± 0.007	< 0.0005 ± 0.	5.1 ± —	< 0.009 ± 0.01	< 0.1 ± 0.11	0.029 ± 0.001	0.1 ± 0.03
Cave Spring	28.5 ± 0.9	< 0.008 ± 0.003	0.004 ± 0.001	4.7 ± —	< 0.005 ± 0.	< 0.1 ± 0.08	< 0.005 ± 0.007	2.45 ± 0.24
GLEN CANYON NATIONAL RECREATION AREA								
Bouy 114A Spring	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
Bouy 114B Spring	25.2 ± 0.1	< 0.008 ± 0.006	0.0026 ± 0.001	3.5 ± —	< 0.005 ± 0.01	< 0.1 ± 0.01	< 0.005 ± 0.006	0.16 ± 0.07
Buoy 84 RR Spring	18.5 ± 0.1	0.016 ± 0.006	0.0037 ± 0.	2.3 ± —	< 0.005 ± 0.	0.7 ± 0.04	0.008 ± 0.003	0.07 ± 0.01
Bowns Canyon Garden	10.4 ± 0.1	< 0.008 ± 0.0025	0.0089 ± 0.	1.4 ± —	< 0.005 ± 0.	0.5 ± 0.01	0.029 ± 0.002	0.8 ± 0.03
Cottonwood Canyon Garden	27. ± 0.9	0.019 ± 0.0085	0.0055 ± 0.	2.7 ± 0.1	< 0.005 ± 0.	0.4 ± 0.07	0.024 ± 0.006	0.34 ± 0.04
Cow Canyon Garden A	13.1 ± 0.4	0.014 ± 0.003	0.0033 ± 0.001	1.8 ± —	< 0.005 ± 0.	1. ± 0.	0.062 ± 0.011	0.09 ± 0.04
Cow Canyon Garden B	13.8 ± 0.3	0.025 ± 0.005	< 0.001 ± 0.	2.1 ± —	< 0.005 ± 0.	1. ± 0.06	0.08 ± 0.005	0.05 ± 0.06
Cow Canyon Garden C	20.7 ± 0.3	0.008 ± 0.004	0.003 ± 0.001	4.4 ± —	< 0.005 ± 0.	1.1 ± 0.08	0.095 ± 0.007	0.11 ± 0.18
Easter Pasture Canyon Garden	23.1 ± 0.4	< 0.008 ± 0.003	< 0.001 ± 0.	17. ± —	< 0.005 ± 0.	0.8 ± 0.3	0.284 ± 0.001	0.3 ± 0.12
Escalante River Spring A	14.8 ± 0.1	0.01 ± 0.002	0.0033 ± 0.	1.7 ± —	< 0.005 ± 0.	0.7 ± 0.07	0.078 ± 0.006	0.07 ± 0.04
Escalante River Spring B	15.1 ± 0.3	0.017 ± 0.009	0.0015 ± 0.001	2.5 ± —	< 0.005 ± 0.	1.1 ± 0.07	0.112 ± 0.006	< 0.04 ± 0.03
Escalante River Spring C	15. ± 0.2	< 0.008 ± 0.005	< 0.001 ± 0.	1.7 ± —	< 0.005 ± 0.01	0.8 ± 0.	0.135 ± 0.007	< 0.04 ± 0.01
Forgotten Canyon Spring	46.2 ± 1.8	< 0.008 ± 0.003	0.0153 ± 0.002	9.3 ± —	< 0.005 ± 0.	0.4 ± 0.02	< 0.006 ± 0.003	0.16 ± 0.03
Good Hope Bay, Spring A	37.4 ± 1.1	0.008 ± 0.006	0.0067 ± 0.001	12.3 ± —	< 0.005 ± 0.	0.6 ± 0.13	0.006 ± 0.005	< 0.04 ± 0.03
Good Hope Bay, Spring B	39.9 ± 0.4	0.01 ± 0.003	0.002 ± 0.001	9.2 ± 0.1	< 0.005 ± 0.	0.3 ± 0.26	0.011 ± 0.001	0.19 ± 0.11
Good Hope Bay, Spring C	21.4 ± 0.1	< 0.008 ± 0.002	< 0.001 ± 0.	8.1 ± —	< 0.005 ± 0.01	1.2 ± 0.09	0.007 ± 0.004	< 0.04 ± 0.04
Good Hope Bay, Spring D	22.8 ± 0.9	< 0.008 ± 0.002	0.0025 ± 0.	7.8 ± —	< 0.005 ± 0.	0.6 ± 0.03	0.009 ± 0.002	< 0.04 ± 0.05
Gypsum Canyon Spring	680. ± 20.	0.049 ± 0.01	0.0329 ± 0.003	2600. ± —	< 0.005 ± 0.12	< 0.3 ± 0.19	0.025 ± 0.006	< 0.07 ± 0.08
Knowles Canyon Garden	18. ± 0.3	< 0.008 ± 0.002	0.0029 ± 0.001	1.7 ± 0.1	< 0.005 ± 0.01	< 0.1 ± 0.11	< 0.005 ± 0.003	0.68 ± 0.12
Last Chance Spring	240. ± 10.	0.03 ± 0.003	0.0038 ± 0.	20.4 ± —	0.01392 ± 0.	< 0.09 ± 0.05	0.026 ± 0.002	0.67 ± 0.07
Long Canyon Spring	13.1 ± 0.2	0.035 ± 0.01	< 0.001 ± 0.	2.1 ± —	< 0.005 ± 0.	0.7 ± 0.07	0.055 ± 0.002	< 0.04 ± 0.04
Moqui Canyon Spring	46.2 ± 0.7	< 0.008 ± 0.002	0.0165 ± 0.	7.2 ± 0.7	< 0.005 ± 0.	< 0.09 ± 0.02	0.007 ± 0.004	0.19 ± 0.07
Rana Canyon Garden	17.2 ± 0.2	0.018 ± 0.001	< 0.001 ± 0.	3. ± 0.1	< 0.005 ± 0.01	1. ± 0.01	0.132 ± 0.005	0.18 ± 0.04
Ribbon Canyon, Grand Daddy Spring	23.3 ± 0.5	0.016 ± 0.0003	< 0.001 ± 0.	2.1 ± 0	< 0.005 ± 0.	0.8 ± 0.07	0.028 ± 0.004	< 0.04 ± 0.03
San Juan Garden	18.1 ± 0.2	0.016 ± 0.007	0.0055 ± 0.002	2.4 ± —	< 0.005 ± 0.	0.6 ± 0.07	0.019 ± 0.007	< 0.04 ± 0.03
Stevens Arch Garden	16.9 ± 0.3	< 0.008 ± 0.0045	< 0.001 ± 0.	2.3 ± 0.2	< 0.005 ± 0.	0.1 ± 0.04	0.091 ± 0.006	< 0.04 ± 0
Swett Canyon Spring	41.2 ± 0.8	0.043 ± 0.002	0.0066 ± 0.	46. ± —	< 0.005 ± 0.01	< 0.1 ± 0.2	0.136 ± 0.011	0.55 ± 0.12
Wall Spring	35.8 ± 0.5	< 0.008 ± 0.0025	< 0.001 ± 0.001	7.2 ± —	< 0.005 ± 0.	0.4 ± 0.04	0.021 ± 0.002	< 0.04 ± 0.03

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (Continued)

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Calcium mg/L	Cadmium µg/L	Cerium µg/L	Chlorine mg/L	Cobalt µg/L	Chromium µg/L	Cesium µg/L	Copper µg/L
GRAND CANYON NATIONAL PARK								
Berts Canyon	41 ± 2.	< 0.008 ± 0.001	0.015 ± 0.002	8.8 ± —	< 0.005 ± 0.007	0.4 ± 0.	0.24 ± 0.005	0.6 ± 0.1
Cove Canyon	530 ± 0.2	0.015 ± 0.002	0.001 ± 0.0008	32 ± —	< 0.005 ± 0.02	< 0.3 ± 0.25	0.035 ± 0.005	1.4 ± 0.06
Elves Chasm	69 ± 0.4	< 0.008 ± 0.004	0.001 ± 0.0003	20 ± —	< 0.005 ± 0.02	< 0.3 ± 0.09	0.097 ± 0.005	0.1 ± 0.07
Fern Glen	330 ± 0.	< 0.008 ± 0.005	< 0.001 ± 0.0007	22 ± —	< 0.005 ± 0.008	< 0.3 ± 0.2	0.184 ± 0.005	1.5 ± 0.4
Hance Spring	57 ± 1.	0.028 ± 0.003	0.001 ± 0.0006	47 ± —	< 0.005 ± 0.002	< 0.3 ± 0.05	1.241 ± 0.008	0.2 ± 0.2
Keyhole Spring	41 ± 0.7	< 0.008 ± 0.008	0.003 ± 0.002	9.4 ± —	< 0.005 ± 0.012	< 0.3 ± 0.1	0.224 ± 0.001	3.4 ± 0.06
Mohawk Canyon	290 ± 10.	< 0.008 ± 0.004	0.002 ± 0.0005	27 ± —	< 0.005 ± 0.005	< 0.3 ± 0.2	0.307 ± 0.005	0.6 ± 0.09
Nankoweap Twin Spring	58 ± 2.	< 0.008 ± 0.003	0.003 ± 0.001	8.2 ± —	< 0.005 ± 0.001	< 0.3 ± 0.03	0.055 ± 0.003	0.6 ± 0.15
Pumpkin Spring	190 ± 20.	0.054 ± 0.005	0.016 ± 0.0000	5,100 ± —	< 0.005 ± 0.01	3. ± 0.09	39.979 ± 0.697	1. ± 0.1
River Mile 125 Spring	200 ± 0.	< 0.008 ± 0.004	0.002 ± 0.0005	32 ± —	< 0.005 ± 0.01	< 0.3 ± 0.2	0.126 ± 0.008	0.1 ± 0.1
River Mile147 Seep	190 ± 0.	0.029 ± 0.02	0.005 ± 0.0006	14 ± —	< 0.005 ± 0.03	< 0.3 ± 0.2	0.486 ± 0.014	1.5 ± 0.25
River Mile 213 Spring	42 ± 1.	0.012 ± 0.008	0.006 ± 0.0001	31 ± —	< 0.005 ± 0.006	< 0.3 ± 0.1	0.612 ± 0.014	5.1 ± 0.2
Saddle Canyon	45 ± 0.7	< 0.008 ± 0.008	0.001 ± 0.0006	12 ± —	< 0.005 ± 0.006	< 0.3 ± 0.12	0.585 ± 0.008	< 0.07 ± 0.01
Slimy Tick Spring	350 ± 10.	< 0.008 ± 0.008	< 0.001 ± 0.0008	11 ± —	< 0.005 ± 0.1	< 0.3 ± 0.1	0.376 ± 0.006	1.2 ± 0.2
The Ledges	560 ± 0.	< 0.008 ± 0.005	0.001 ± 0.001	14 ± —	< 0.005 ± 0.015	< 0.3 ± 0.08	0.683 ± 0.006	2.6 ± 0.15
Three Springs	66 ± 1.	< 0.008 ± 0.004	0.001 ± 0.001	23 ± —	< 0.005 ± 0.005	< 0.3 ± 0.04	0.065 ± 0.004	1.7 ± 0.04
MISCELLANOUS								
Matrimony Spring	29 ± 0.2	< 0.009 ± 0.004	< 0.0005 ± 0.0007	9 ± —	< 0.009 ± 0.004	0.3 ± 0.08	0.014 ± 0.001	0.1 ± 0.1

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (Continued)

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Dissolved inorganic carbon mg C/L	Dissolved organic carbon mg C/L	Dysprosium µg/L	Erbium µg/L	Europium µg/L	Fluorine mg/L	Iron µg/L	Gadolinium µg/L	Mercury ng/L
ARCHES NATIONAL PARK									
Above Freshwater Spring	21 ± 0.3	1.4	< 0.002 ± 0.000	< 0.002 ± 0.0017	< 0.001 ± 0.0007	0.08 ± —	< 12 ± 7	0.003 ± 0.0	0.8 ± 0.
Seven Mile Spring	27 ± 0.2	0.8	< 0.002 ± 0.001	0.002 ± 0.0007	< 0.001 ± 0.0062	0.1 ± 0.008	< 12 ± 2	< 0.002 ± 0.0	0.6 ± 0.2
Sleepy Hollow Spring	25 ± 0.2	0.6	< 0.002 ± 0.002	0.002 ± 0.001	< 0.001 ± 0.0071	0.11 ± —	< 12 ± 5	< 0.002 ± 0.001	0.6 ± 0.2
CANYONLANDS NATIONAL PARK									
Big Spring	62 ± 0.2	0.9	< 0.002 ± 0.000	< 0.002 ± 0.0006	0.001 ± 0.0000	0.09 ± —	< 12 ± 1	< 0.002 ± 0.002	<0.3 ± 0.
Cabin Spring	25 ± 0.2	0.8	< 0.002 ± 0.000	< 0.002 ± 0.0009	< 0.001 ± 0.0001	0.1 ± —	< 12 ± 13	< 0.002 ± 0.001	<0.3 ± 0.2
Cave Spring	35 ± 0.2	0.9	< 0.003 ± 0.001	< 0.004 ± 0.002	< 0.001 ± 0.0027	0.13 ± —	< 9 ± 2	< 0.003 ± 0.001	0.4 ± 0.2
GLEN CANYON NATIONAL RECREATION AREA									
Bouy 114A Spring	— ± —	—	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
Bouy 114B Spring	29 ± 0.2	1.6	< 0.003 ± 0.001	< 0.004 ± 0.0005	0.007 ± 0.0020	0.11 ± —	< 9 ± 8	0.003 ± 0.002	0.6 ± 0.1
Buoy 84 RR Spring	22 ± 0.2	1.7	< 0.004 ± 0.001	0.005 ± 0.001	< 0.002 ± 0.0008	0.09 ± —	< 5 ± 6	0.005 ± 0.001	1.7 ± 0.1
Bowns Canyon Garden	13 ± 0	4.4	< 0.004 ± 0.001	< 0.003 ± 0.0007	< 0.002 ± 0.0010	0.1 ± —	< 5 ± 1	< 0.002 ± 0.0	1.3 ± 0.2
Cottonwood Canyon Garden	28 ± 0.5	1.0	< 0.004 ± 0.000	< 0.003 ± 0.001	< 0.002 ± 0.0030	0.11 ± —	< 5 ± 9	0.002 ± 0.002	<0.3 ± 0.
Cow Canyon Garden A	19 ± 0.1	1.2	< 0.004 ± 0.001	< 0.003 ± 0.003	< 0.002 ± 0.0001	0.08 ± —	< 5 ± 1	< 0.002 ± 0.0	0.9 ± 0.1
Cow Canyon Garden B	19 ± 0	1.2	< 0.004 ± 0.001	< 0.003 ± 0.0006	< 0.002 ± 0.0019	0.08 ± —	< 5 ± 5	0.002 ± 0.0	1. ± 0.2
Cow Canyon Garden C	24 ± 0.2	0.9	< 0.004 ± 0.000	< 0.003 ± 0.002	0.003 ± 0.0021	0.09 ± —	< 5 ± 7	< 0.002 ± 0.002	1. ± 0.2
Easter Pasture Canyon Garden	30 ± 0.4	1.9	< 0.003 ± 0.002	< 0.004 ± 0.001	< 0.001 ± 0.0010	0.21 ± —	12 ± 10	< 0.003 ± 0.002	0.8 ± 0.2
Escalante River Spring A	19 ± 0.1	0.9	< 0.004 ± 0.001	< 0.003 ± 0.001	< 0.002 ± 0.0010	0.1 ± —	< 5 ± 2	< 0.002 ± 0.001	1.1 ± 0.1
Escalante River Spring B	15 ± 0	1.9	< 0.004 ± 0.001	< 0.003 ± 0.0007	< 0.002 ± 0.0020	0.08 ± —	< 5 ± 2	< 0.002 ± 0.001	1. ± 0.1
Escalante River Spring C	20 ± 0.1	0.9	< 0.004 ± 0.001	< 0.003 ± 0.0004	< 0.002 ± 0.0009	0.08 ± —	< 5 ± 6	< 0.002 ± 0.001	0.8 ± 0.1
Forgotten Canyon Spring	54 ± 0.6	3.4	0.017 ± 0.003	0.007 ± 0.0003	0.004 ± 0.0020	0.27 ± —	< 5 ± 14	0.020 ± 0.0	1.6 ± 0.1
Good Hope Bay, Spring A	44 ± 1.1	1.2	< 0.004 ± 0.002	0.003 ± 0.0004	< 0.002 ± 0.0024	0.16 ± —	< 5 ± 4	0.004 ± 0.001	4. ± 0.1
Good Hope Bay, Spring B	64 ± 0.8	0.9	0.013 ± 0.000	0.012 ± 0.004	0.011 ± 0.0029	0.26 ± —	< 5 ± 9	0.012 ± 0.001	0.3 ± 0.1
Good Hope Bay, Spring C	32 ± 0.5	0.4	< 0.004 ± 0.000	< 0.003 ± 0.0003	< 0.002 ± 0.0030	0.19 ± —	< 5 ± 5	< 0.002 ± 0.001	3.1 ± 0.2
Good Hope Bay, Spring D	31 ± 0.6	0.3	< 0.004 ± 0.001	< 0.003 ± 0.0008	< 0.002 ± 0.0003	0.18 ± —	< 5 ± 4	< 0.002 ± 0.0	2.3 ± 0.1
Gypsum Canyon Spring	66 ± 1	1.8	0.005 ± 0.001	0.008 ± 0.0009	< 0.001 ± 0.0011	2.24 ± —	1,500 ± 100	0.010 ± 0.002	1.2 ± 0.2
Knowles Canyon Garden	20 ± 0.4	0.8	< 0.003 ± 0.002	< 0.004 ± 0.0007	< 0.001 ± 0.0008	< 0.05 ± —	< 9 ± 2	< 0.003 ± 0.001	0.6 ± 0.3
Last Chance Spring	61 ± 1	2.2	< 0.004 ± 0.002	< 0.003 ± 0.0006	< 0.002 ± 0.0008	0.66 ± —	< 5 ± 4	< 0.002 ± 0.001	2.9 ± 0.1
Long Canyon Spring	16 ± 0.1	0.9	< 0.004 ± 0.000	< 0.003 ± 0.0005	< 0.002 ± 0.0015	0.09 ± —	< 5 ± 3	< 0.002 ± 0.0	1. ± 0.2
Moqui Canyon Spring	44 ± 0.7	3.2	0.004 ± 0.002	0.004 ± 0.002	0.002 ± 0.0017	0.22 ± —	110 ± 10	0.006 ± 0.001	<0.3 ± 0.2
Rana Canyon Garden	25 ± 0.2	2.0	< 0.004 ± 0.001	< 0.003 ± 0.001	< 0.002 ± 0.0020	0.12 ± 0.002	< 5 ± 4	< 0.002 ± 0.001	1.1 ± 0.1
Ribbon Canyon, Grand Daddy Spring	26 ± 0.1	1.2	< 0.004 ± 0.001	< 0.003 ± 0.0005	< 0.002 ± 0.0020	0.09 ± 0.002	< 5 ± 7	0.003 ± 0.001	2.1 ± 0.1
San Juan Garden	19 ± 0.3	1.7	< 0.004 ± 0.000	< 0.003 ± 0.0009	< 0.002 ± 0.0035	0.1 ± —	< 5 ± 2	< 0.002 ± 0.0	1.5 ± 0.1
Stevens Arch Garden	21 ± 0.5	1.0	< 0.004 ± 0.001	< 0.003 ± 0.0005	< 0.002 ± 0.0020	0.09 ± —	< 5 ± 6	< 0.002 ± 0.002	<0.3 ± 0.2
Swett Canyon Spring	119 ± 0.2	3.1	< 0.003 ± 0.002	< 0.004 ± 0.0008	0.003 ± 0.0015	0.5 ± —	< 9 ± 14	< 0.003 ± 0.001	<0.3 ± 0.
Wall Spring	44 ± 0.8	0.4	< 0.004 ± 0.001	< 0.003 ± 0.001	< 0.002 ± 0.0010	0.23 ± —	< 5 ± 9	< 0.002 ± 0.001	0.7 ± 0.

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (Continued)

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Dissolved inorganic carbon mg C/L	Dissolved organic carbon mg C/L	Dysprosium µg/L	Erbium µg/L	Europium µg/L	Fluorine mg/L	Iron µg/L	Gadolinium µg/L	Mercury ng/L
GRAND CANYON NATIONAL PARK									
Berts Canyon	50 ± 0.6	0.8	< 0.003 ± 0.001	< 0.004 ± 0.001	0.003 ± 0.000	0.17	< 9 ± 10	< 0.003 ± 0.001	2.9 ± 0.2
Cove Canyon	23 ± 0.1	1.5	< 0.003 ± 0.001	< 0.004 ± 0.001	0.002 ± 0.002	0.81	< 30 ± 20	< 0.003 ± 0.000	0.5 ± 0.09
Elves Chasm	35 ± 0.2	0.8	< 0.003 ± 0.000	< 0.004 ± 0.001	< 0.001 ± 0.001	0.35	< 30 ± 10	< 0.003 ± 0.001	<0.3 ± 0.09
Fern Glen	— ± —	—	< 0.003 ± 0.000	< 0.004 ± 0.001	< 0.001 ± 0.001	0.6	< 30 ± 10	< 0.003 ± 0.000	<0.3 ± 0.2
Hance Spring	62 ± 0.7	0.7	< 0.003 ± 0.001	< 0.004 ± 0.002	< 0.001 ± 0.001	0.49	28 ± 3	< 0.003 ± 0.002	<0.3 ± 0.1
Keyhole Spring	49 ± 0.3	0.9	< 0.003 ± 0.001	< 0.004 ± 0.001	< 0.001 ± 0.001	0.18	15 ± 18	< 0.003 ± 0.000	<0.3 ± 0.2
Mohawk Canyon	— ± —	—	< 0.003 ± 0.001	< 0.004 ± 0.001	< 0.001 ± 0.001	0.61	< 30 ± 8	< 0.003 ± 0.001	<0.3 ± 0.2
Nankoweap Twin Spring	63 ± 0.8	1.0	< 0.003 ± 0.001	< 0.004 ± 0.001	< 0.001 ± 0.001	0.06	25 ± 20	< 0.003 ± 0.001	<0.3 ± 0.08
Pumpkin Spring	490 ± —	2.0	0.029 ± 0.001	0.036 ± 0.001	0.003 ± 0.003	3.19	240 ± 20	0.014 ± 0.003	<0.3 ± 0.17
River Mile 125 Spring	41 ± 0.1	0.8	< 0.003 ± 0.001	< 0.004 ± 0.001	< 0.001 ± 0.001	0.69	< 30 ± 25	< 0.003 ± 0.002	0.4 ± 0.15
River Mile147 Seep	29 ± 0.2	0.8	< 0.003 ± 0.001	< 0.004 ± 0.00	< 0.001 ± 0.000	0.57	< 30 ± 20	< 0.003 ± 0.001	<0.3 ± 0.1
River Mile 213 Spring	40 ± 0.4	1.7	< 0.003 ± 0.001	< 0.004 ± 0.001	< 0.001 ± 0.001	0.4	16 ± 0	< 0.003 ± 0.002	<0.3 ± 0.3
Saddle Canyon	49 ± 0.2	0.6	< 0.003 ± 0.000	< 0.004 ± 0.001	0.002 ± 0.000	0.11	< 9 ± 7	< 0.003 ± 0.000	<0.3 ± 0.2
Slimy Tick Spring	28 ± 0.3	0.6	< 0.003 ± 0.001	< 0.004 ± 0.001	< 0.001 ± 0.000	0.75	< 30 ± 20	< 0.003 ± 0.000	1.1 ± 0.3
The Ledges	34 ± 0.2	1.3	< 0.003 ± 0.001	< 0.004 ± 0.001	< 0.001 ± 0.002	0.52	< 30 ± 25	< 0.003 ± 0.001	<0.3 ± 0.09
Three Springs	57 ± 0.1	1.9	< 0.003 ± 0.003	< 0.004 ± 0.001	< 0.001 ± 0.003	0.25	20 ± 20	< 0.003 ± 0.001	— ± —
MISCELLANEOUS									
Matrimony Spring	26 ± 0.3	0.5	< 0.002 ± 0.001	< 0.002 ± 0.002	< 0.001 ± 0.001	0.11	< 12 ± 13	< 0.002 ± 0.002	0.5 ± 0.09

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (Continued)

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Holmium µg/L	Iodine µg/L	Potassium mg/L	Lanthanum µg/L	Lithium µg/L	Lutecium µg/L
ARCHES NATIONAL PARK						
Above Freshwater Spring	< 0.0004 ± 0.0001	9 ± 0.4	1.4 ± 0.01	0.0043 ± 0.0013	0.6 ± 0.1	< 0.0005 ± 0.0001
Seven Mile Spring	< 0.0004 ± 0.0003	40 ± 0	1.4 ± 0.01	0.0045 ± 0.0007	0.9 ± 0.1	< 0.0005 ± 0.0001
Sleepy Hollow Spring	< 0.0004 ± 0.0001	15 ± 0.2	1.8 ± 0.04	0.0052 ± 0.0006	1.0 ± 0.0	< 0.0005 ± 0.0003
CANYONLANDS NATIONAL PARK						
Big Spring	< 0.0004 ± 0.0004	35 ± 2.8	3.6 ± 0.09	0.0026 ± 0.0005	23 ± 0.2	< 0.0005 ± 0.0004
Cabin Spring	< 0.0004 ± 0.0000	23 ± 3	2.0 ± 0.01	0.0036 ± 0.0007	1.9 ± 0.0	< 0.0005 ± 0.0001
Cave Spring	< 0.0007 ± 0.0005	24 ± 16	1.2 ± 0.02	0.0046 ± 0.0006	2.0 ± 0.2	< 0.0006 ± 0.0004
GLEN CANYON NATIONAL RECREATION AREA						
Bouy 114A Spring	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
Bouy 114B Spring	< 0.0007 ± 0.0003	35 ± 15	2.0 ± 0.04	0.0098 ± 0.0004	7.0 ± 0.4	< 0.0006 ± 0.0003
Buoy 84 RR Spring	< 0.0007 ± 0.0002	41 ± 0.5	1.3 ± 0.02	0.0058 ± 0.0002	5.1 ± 0.1	< 0.0006 ± 0.0003
Bowns Canyon Garden	< 0.0007 ± 0.0003	13 ± 2.0	0.8 ± 0.00	0.0057 ± 0.0009	2.4 ± 0	0.0009 ± 0.0002
Cottonwood Canyon Garden	< 0.0007 ± 0.0003	32 ± 2	1.4 ± 0.02	0.0043 ± 0.0008	3.8 ± 0.1	< 0.0006 ± 0.0003
Cow Canyon Garden A	< 0.0007 ± 0.0001	19 ± 0.4	0.8 ± 0.01	0.0035 ± 0.0003	2.8 ± 0.1	< 0.0006 ± 0.0002
Cow Canyon Garden B	< 0.0007 ± 0.0004	26 ± 2	1.0 ± 0.01	0.0015 ± 0.0004	3.3 ± 0.2	< 0.0006 ± 0.0004
Cow Canyon Garden C	< 0.0007 ± 0.0002	39 ± 0.6	1.2 ± 0.01	0.0034 ± 0.0003	2.9 ± 0	< 0.0006 ± 0.0002
Easter Pasture Canyon Garden	< 0.0007 ± 0.0002	88 ± 23	2.6 ± 0.01	0.0014 ± 0.0003	11 ± 0	< 0.0006 ± 0.0003
Escalante River Spring A	< 0.0007 ± 0.0003	22 ± 2	0.9 ± 0.01	0.0027 ± 0.0006	4.7 ± 0.1	< 0.0006 ± 0.0004
Escalante River Spring B	< 0.0007 ± 0.0005	30 ± 2	1.0 ± 0.01	0.0017 ± 0.0007	5.9 ± 0	< 0.0006 ± 0.0002
Escalante River Spring C	< 0.0007 ± 0.0000	31 ± 3	1.1 ± 0.02	0.0012 ± 0.0012	4.0 ± 0.1	< 0.0006 ± 0.0001
Forgotten Canyon Spring	0.0031 ± 0.0001	52 ± 2	1.2 ± 0.02	0.0209 ± 0.0005	8.8 ± 0.2	0.0010 ± 0.0008
Good Hope Bay, Spring A	0.0011 ± 0.0005	79 ± 2	1.2 ± 0.01	0.0137 ± 0.0010	24 ± 0.4	0.0007 ± 0.0004
Good Hope Bay, Spring B	0.0026 ± 0.0010	74 ± 3	3.5 ± 0.04	0.0454 ± 0.0012	35 ± 0.8	0.0023 ± 0.0007
Good Hope Bay, Spring C	< 0.0007 ± 0.0005	62 ± 2	1.3 ± 0.02	0.0034 ± 0.0006	16 ± 0.2	< 0.0006 ± 0.0001
Good Hope Bay, Spring D	< 0.0007 ± 0.0003	52 ± 4	1.2 ± 0.01	0.0050 ± 0.0010	13 ± 0.5	< 0.0006 ± 0.0006
Gypsum Canyon Spring	0.0045 ± 0.0006	490 ± 10	12 ± 0.3	0.0236 ± 0.0002	98 ± 0.9	0.0011 ± 0.0002
Knowles Canyon Garden	< 0.0007 ± 0.0003	35 ± 20	1.7 ± 0.02	0.0035 ± 0.0001	1.9 ± 0	< 0.0006 ± 0.0004
Last Chance Spring	0.0013 ± 0.0005	51 ± 3	11 ± 0.5	0.0026 ± 0.0004	190 ± 0.1	< 0.0006 ± 0.0006
Long Canyon Spring	< 0.0007 ± 0.0002	27 ± 2	1.0 ± 0.01	< 0.0007 ± 0.0006	4.0 ± 0.1	0.0008 ± 0.0000
Moqui Canyon Spring	0.0013 ± 0.0007	51 ± 2	0.2 ± 0.01	0.0132 ± 0.0015	6.7 ± 0	0.0009 ± 0.0000
Rana Canyon Garden	< 0.0007 ± 0.0004	28 ± 3	1.3 ± 0.02	0.0026 ± 0.0004	5.7 ± 0.1	< 0.0006 ± 0.0001
Ribbon Canyon, Grand Daddy Spring	< 0.0007 ± 0.0000	22 ± 2	1.1 ± 0.01	0.0025 ± 0.0004	4.0 ± 0	< 0.0006 ± 0.0004
San Juan Garden	< 0.0007 ± 0.0001	34 ± 3	1.0 ± 0.01	0.0047 ± 0.0001	3.6 ± 0.1	< 0.0006 ± 0.0004
Stevens Arch Garden	< 0.0007 ± 0.0003	43 ± 3	1.1 ± 0.01	0.0014 ± 0.0009	7.1 ± 0.1	< 0.0006 ± 0.0005
Swett Canyon Spring	< 0.0007 ± 0.0001	22 ± 10	16 ± 0.33	0.0025 ± 0.0004	140 ± 0	< 0.0006 ± 0.0003
Wall Spring	< 0.0007 ± 0.0002	29 ± 5	2.6 ± 0.01	0.0021 ± 0.0007	14 ± 0.1	< 0.0006 ± 0.0002

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (Continued)

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Holmium µg/L	Iodine µg/L	Potassium mg/L	Lanthanum µg/L	Lithium µg/L	Lutecium µg/L
GRAND CANYON NATIONAL PARK						
Berts Canyon	< 0.0007 ± 0.0003	26 ± 0.7	1.8 ± 0.03	0.0088 ± 0.0014	6.0 ± 0.5	< 0.0006 ± 0.0002
Cove Canyon	< 0.0007 ± 0.0005	13 ± 8	13.2 ± 0.39	< 0.0009 ± 0.0004	47 ± 1.5	< 0.0006 ± 0.0001
Elves Chasm	< 0.0007 ± 0.0002	32 ± 10	3.5 ± 0.03	< 0.0009 ± 0.0006	14 ± 0.9	< 0.0006 ± 0.0005
Fern Glen	< 0.0007 ± 0.0004	33 ± 15	11.7 ± 0.41	< 0.0009 ± 0.0003	60 ± 2.	0.0007 ± 0.0005
Hance Spring	< 0.0007 ± 0.0004	45 ± 9	13. ± 0.03	< 0.0009 ± 0.0009	170 ± 0.5	< 0.0006 ± 0.0002
Keyhole Spring	< 0.0007 ± 0.0002	25 ± 4	1.9 ± 0.01	0.0027 ± 0.0001	7.4 ± 0.1	< 0.0006 ± 0.0005
Mohawk Canyon	< 0.0007 ± 0.0003	40 ± 3	9.3 ± 0.00	0.0010 ± 0.0007	56 ± 1.5	< 0.0006 ± 0.0005
Nankoweap Twin Spring	< 0.0007 ± 0.0007	15 ± 7	4.1 ± 0.01	0.0013 ± 0.0007	22 ± 0.7	< 0.0006 ± 0.0002
Pumpkin Spring	0.0113 ± 0.001	2,700 ± 0	110. ± 0.00	0.0117 ± 0.0002	2,700 ± 0.	0.0037 ± 0.0002
River Mile 125 Spring	< 0.0007 ± 0.0004	60 ± 10	7.6 ± 0.05	0.0020 ± 0.0002	56 ± 1.	< 0.0006 ± 0.0000
River Mile147 Seep	< 0.0007 ± 0.0006	85 ± 15	6.4 ± 0.02	0.0018 ± 0.002	40 ± 0.4	< 0.0006 ± 0.0004
River Mile 213 Spring	< 0.0007 ± 0.0007	170 ± 20	5.2 ± 0.02	0.0041 ± 0.001	30 ± 0.9	< 0.0006 ± 0.0002
Saddle Canyon	< 0.0007 ± 0.0003	42 ± 20	3.2 ± 0.01	0.0017 ± 0.0003	7.9 ± 0.1	< 0.0006 ± 0.0003
Slimy Tick Spring	< 0.0007 ± 0.0004	56 ± 10	11. ± 0.06	< 0.0009 ± 0.0004	62 ± 1.	< 0.0006 ± 0.0001
The Ledges	< 0.0007 ± 0.0002	100 ± 20	7.7 ± 0.10	0.0013 ± 0.0005	49 ± 0.2	< 0.0006 ± 0.0003
Three Springs	< 0.0007 ± 0.0007	83 ± 1	2.5 ± 0.02	0.0016 ± 0.0004	16 ± 0.4	< 0.0006 ± 0.0003
MISCELLANEOUS						
Matrimony Spring	< 0.0004 ± 0.0004	12 ± 1	1.7 ± 0.03	0.0014 ± 0.0008	3.3 ± 0.1	< 0.0005 ± 0.0004

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (Continued)

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Magnesium mg/L	Manganese µg/L	Molybdenum µg/L	Ammonium mg N/L	Nitrite mg N/L	Nitrate mg N/L	Sodium mg/L
ARCHES NATIONAL PARK							
Above Freshwater Spring	2.8 ± 0.0	0.11 ± 0.01	< 0.2 ± 0.012	0.008 ± 0.005	0.003 ± 0.	0.61 ± 0.00	1.9 ± 0.6
Seven Mile Spring	3.6 ± 0.1	< 0.02 ± 0.01	< 0.2 ± 0.019	0.005 ± 0.004	< 0.003 ± 0.001	0.92 ± 0.003	2.8 ± 1.
Sleepy Hollow Spring	2.8 ± 0.1	0.42 ± 0.03	< 0.2 ± 0.016	0.011 ± 0.001	< 0.003 ± 0.	1.1 ± 0.02	2.2 ± 0.2
CANYONLANDS NATIONAL PARK							
Big Spring	16. ± 0.1	< 0.02 ± 0.	0.5 ± 0.013	0.007 ± 0.003	< 0.003 ± 0.	0.83 ± 0.002	31.6 ± 0.6
Cabin Spring	5.5 ± 0.1	0.27 ± 0.02	< 0.2 ± 0.035	0.009 ± 0.005	0.004 ± 0.	0.57 ± 0.01	2.7 ± 0.4
Cave Spring	17.9 ± 0.2	2.28 ± 0.01	< 0.2 ± 0.035	< 0.005 ± 0.004	0.003 ± 0.	0.62 ± 0.002	4.5 ± 0.5
GLEN CANYON NATIONAL RECREATION AREA							
Bouy 114A Spring	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
Bouy 114B Spring	11.7 ± 0.4	0.15 ± 0.01	< 0.2 ± 0.065	0.007 ± 0.002	0.001 ± 0.	0.09 ± 0	3. ± 0.2
Buoy 84 RR Spring	10.3 ± 0.2	0.42 ± 0.02	< 0.2 ± 0.029	— ± —	— ± —	0.85 ± —	2.2 ± 0.5
Bowns Canyon Garden	6.9 ± 0.2	0.25 ± 0.01	< 0.2 ± 0.021	< 0.007 ± 0.	0.014 ± 0.001	0.20 ± 0.01	1.2 ± 0.1
Cottonwood Canyon Garden	10.3 ± 0.5	3.5 ± 0.08	< 0.2 ± 0.012	— ± —	— ± —	0.39 ± 0.02	1.9 ± 0.3
Cow Canyon Garden A	9.4 ± 0.0	0.89 ± 0.04	< 0.2 ± 0.031	< 0.007 ± 0.	0.009 ± 0.002	0.46 ± 0.02	0.9 ± 0.1
Cow Canyon Garden B	9.8 ± 0.2	0.09 ± 0.02	< 0.2 ± 0.022	0.007 ± 0.005	< 0.005 ± 0.005	0.56 ± 0.01	1.5 ± 0.2
Cow Canyon Garden C	11.1 ± 0.1	0.06 ± 0.01	< 0.2 ± 0.018	< 0.007 ± 0.	< 0.005 ± 0.	0.67 ± 0.02	3. ± 0.7
Easter Pasture Canyon Garden	26. ± 1.2	0.12 ± 0.03	1.1 ± 0.034	0.007 ± 0.001	0.003 ± 0.	0.35 ± 0	12.8 ± 0.2
Escalante River Spring A	8.6 ± 0.1	0.19 ± 0.02	< 0.2 ± 0.061	0.017 ± 0.001	< 0.005 ± 0.	0.73 ± 0.01	1.4 ± 0.1
Escalante River Spring B	9.5 ± 0.0	0.03 ± 0.01	< 0.2 ± 0.009	< 0.007 ± 0.	< 0.005 ± 0.	0.62 ± 0.01	1.6 ± 0.2
Escalante River Spring C	9.6 ± 0.0	0.02 ± 0.	< 0.2 ± 0.011	< 0.007 ± 0.	< 0.005 ± 0.	0.69 ± 0.004	1.3 ± 0.2
Forgotten Canyon Spring	27.4 ± 2.1	0.4 ± 0.	< 0.2 ± 0.014	— ± —	— ± —	0.01 ± —	5.7 ± 1.7
Good Hope Bay, Spring A	20.2 ± 0.4	15. ± 0.33	1.1 ± 0.029	— ± —	— ± —	0.30 ± —	33.7 ± 7.4
Good Hope Bay, Spring B	18.2 ± 0.1	0.06 ± 0.02	0.5 ± 0.027	— ± —	— ± —	0.31 ± —	48.8 ± 2.5
Good Hope Bay, Spring C	12.1 ± 0.1	0.06 ± 0.01	0.4 ± 0.031	— ± —	— ± —	0.80 ± —	22. ± 26.
Good Hope Bay, Spring D	12.4 ± 0.3	0.13 ± 0.01	0.3 ± 0.042	— ± —	— ± —	0.78 ± —	17.1 ± 8.
Gypsum Canyon Spring	190. ± 20.	67. ± 0.8	11 ± 0.323	0.37 ± 0.009	0.004 ± 0.	0.05 ± 0.003	1,300. ± 100.
Knowles Canyon Garden	7. ± 0.1	0.13 ± 0.02	< 0.2 ± 0.086	< 0.004 ± 0.004	0.002 ± 0.	0.59 ± 0.01	1.5 ± 0.6
Last Chance Spring	57.4 ± 9.0	110. ± 0.	3.4 ± 0.003	— ± —	— —	< 0.0 ± —	200. ± 50.
Long Canyon Spring	7.9 ± 0.1	0.03 ± 0.	< 0.2 ± 0.006	< 0.007 ± 0.	< 0.005 ± 0.	0.66 ± 0.002	1.6 ± 0.2
Moqui Canyon Spring	17. ± 0.1	14. ± 0.13	< 0.2 ± 0.005	— ± —	— ± —	0.13 ± 0.01	8.1 ± 1.2
Rana Canyon Garden	12.6 ± 0.1	0.17 ± 0.	< 0.2 ± 0.03	< 0.007 ± 0.005	< 0.005 ± 0.	0.44 ± 0.02	2.4 ± 0.7
Ribbon Canyon, Grand Daddy Spring	10.7 ± 0.5	0.04 ± 0.	< 0.2 ± 0.003	< 0.007 ± 0.	< 0.001 ± 0.	0.82 ± 0.01	1.8 ± 0.1
San Juan Garden	8.3 ± 0.1	0.21 ± 0.01	< 0.2 ± 0.013	< 0.007 ± 0.	< 0.001 ± 0.	0.70 ± 0.01	1.9 ± 0.1
Stevens Arch Garden	9.4 ± 0.2	0.07 ± 0.	< 0.2 ± 0.026	— ± —	— —	0.18 ± 0.01	1.8 ± 0.3
Swett Canyon Spring	38. ± 0.0	20. ± 0.06	1.9 ± 0.018	0.017 ± 0.001	< 0.001 ± 0.	0.01 ± 0	160. ± 0.
Wall Spring	19.8 ± 0.1	0.05 ± 0.	1.3 ± 0.063	— ± —	— ± —	0.65 ± —	13.3 ± 2.

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (Continued)

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Magnesium mg/L	Manganese µg/L	Molybdenum µg/L	Ammonium mg N/L	Nitrite mg N/L	Nitrate mg N/L	Sodium mg/L
GRAND CANYON NATIONAL PARK							
Berts Canyon	25 ± 8.	0.03 ± 0.02	0.4 ± 0.04	< 0.004 ± 0.004	< 0.003 ± 0.	0.29 ± 0.005	5.6 ± 3.0
Cove Canyon	130 ± 60.	1.82 ± 0.01	8.4 ± 0.06	0.299 ± 0.01	< 0.003 ± 0.	0.06 ± 0.	35 ± 20
Elves Chasm	47 ± 6.	0.02 ± 0.01	2.9 ± 0.03	0.016 ± 0.001	< 0.003 ± 0.	0.92 ± 0.023	18 ± 6
Fern Glen	190 ± 0.	0.08 ± 0.04	8.3 ± 0.06	0.128 ± 0.01	0.005 ± 0.	0.02 ± 0.002	51 ± 3
Hance Spring	39 ± 3.	0.02 ± 0.01	3.8 ± 0.09	0.005 ± 0.001	< 0.003 ± 0.	0.35 ± 0.002	100 ± 20
Keyhole Spring	28 ± 3.	0.06 ± 0.01	0.7 ± 0.07	< 0.004 ± 0.	< 0.003 ± 0.001	0.23 ± 0.003	9.1 ± 2
Mohawk Canyon	180 ± 30.	0.08 ± 0.03	5.6 ± 0.02	0.137 ± 0.004	< 0.003 ± 0.	0.11 ± 0.003	38 ± 11
Nankoweap Twin Spring	53 ± 10.	0.46 ± 0.01	0.4 ± 0.1	0.008 ± 0.002	0.004 ± 0.	0.04 ± 0.002	26 ± 9
Pumpkin Spring	60 ± 12.	180. ± 0.	1.7 ± 0.09	0.152 ± 0.2	< 0.003 ± 0.	0.01 ± 0.008	2,100 ± 200
River Mile 125 Spring	120 ± 0.	1.17 ± 0.01	4.3 ± 0.07	0.042 ± 0.006	< 0.003 ± 0.	0.29 ± 0.003	51 ± 3
River Mile147 Seep	110 ± 0.3	0.23 ± 0.11	8.0 ± 0.11	0.046 ± 0.002	< 0.003 ± 0.001	0.12 ± 0.001	31 ± 9
River Mile 213 Spring	39 ± 10.	0.1 ± 0.02	5.4 ± 0.06	< 0.004 ± 0.003	< 0.003 ± 0.	1.4 ± 0.02	23 ± 3
Saddle Canyon	26 ± 5.	< 0.01 ± 0.01	2.5 ± 0.05	0.005 ± 0.003	< 0.003 ± 0.	0.55 ± 0.002	9.1 ± 4
Slimy Tick Spring	170 ± 10.	0.27 ± 0.01	5.3 ± 0.05	0.297 ± 0.011	< 0.003 ± 0.	0.25 ± 0.001	33 ± 5
The Ledges	240 ± 10.	0.12 ± 0.03	6.2 ± 0.06	0.165 ± 0.009	0.005 ± 0.	0.04 ± 0.007	43 ± 4
Three Springs	29 ± 0.6	0.54 ± 0.02	1.4 ± 0.04	< 0.004 ± 0.002	0.007 ± 0.	1.1 ± 0.	11 ± 6
MISCELLANEOUS							
Matrimony Spring	12 ± 0.1	0.05 ± 0.02	2.2 ± 0.01	< 0.005 ± 0.003	< 0.003 ± 0.	0.46 ± 0.003	10 ± 3.1

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (*Continued)*

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Neodymium µg/L	Nickel µg/L	Phosphorus µg/L	Phosphate µg P/L	Lead µg/L	Praseodymium µg/L	Rubidium µg/L
ARCHES NATIONAL PARK							
Above Freshwater Spring	< 0.004 ± 0.002	< 0.03 ± 0.06	— ± —	< 20 ± —	< 0.01 ± 0.01	< 0.0005 ± 0.0001	0.37 ± 0.00
Seven Mile Spring	< 0.004 ± 0.001	< 0.03 ± 0.1	— ± —	< 20 ± —	< 0.01 ± 0.006	< 0.0005 ± 0.0002	0.98 ± 0.01
Sleepy Hollow Spring	< 0.004 ± 0.003	< 0.03 ± 0.09	— ± —	< 20 ± —	< 0.01 ± 0.004	< 0.0005 ± 0.0004	0.85 ± 0.01
CANYONLANDS NATIONAL PARK							
Big Spring	< 0.004 ± 0.002	< 0.03 ± 0.2	— ± —	< 20 ± —	< 0.01 ± 0.	< 0.0005 ± 0.0004	1.2 ± 0.04
Cabin Spring	< 0.004 ± 0.001	< 0.03 ± 0.09	— ± —	< 20 ± —	< 0.01 ± 0.004	< 0.0005 ± 0.0003	1.98 ± 0.01
Cave Spring	< 0.005 ± 0.002	< 0.02 ± 0.13	< 4 ± 1.	< 20 ± —	< 0.02 ± 0.007	< 0.0007 ± 0.0006	0.84 ± 0.01
GLEN CANYON NATIONAL RECREATION AREA							
Bouy 114A Spring	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
Bouy 114B Spring	0.012 ± 0.	< 0.02 ± 0.11	< 4 ± 0.8	< 30 ± 1	< 0.02 ± 0.003	0.0019 ± 0.0010	1.25 ± 0.01
Buoy 84 RR Spring	0.014 ± 0.001	< 0.03 ± 0.07	< 3 ± 0.5	— ± —	< 0.01 ± 0.005	0.0027 ± 0.0004	1.11 ± 0.02
Bowns Canyon Garden	0.013 ± 0.002	< 0.03 ± 0.04	8.1 ± 0.8	< 5 ± —	0.02 ± 0.011	0.0026 ± 0.0002	0.9 ± 0.01
Cottonwood Canyon Garden	0.006 ± 0.003	< 0.03 ± 0.07	< 3 ± 0.7	— ± —	0.05 ± 0.016	0.0014 ± 0.0002	1.02 ± 0.01
Cow Canyon Garden A	0.005 ± 0.001	< 0.03 ± 0.01	< 3 ± 2.5	< 5 ± —	0.05 ± 0.011	< 0.0007 ± 0.0006	0.92 ± 0.02
Cow Canyon Garden B	< 0.004 ± 0.002	< 0.03 ± 0.03	< 3 ± 0.3	< 5 ± —	0.02 ± 0.01	< 0.0007 ± 0.0001	1.2 ± 0.02
Cow Canyon Garden C	< 0.004 ± 0.002	< 0.03 ± 0.01	< 3 ± 0.6	< 5 ± —	0.02 ± 0.001	0.0008 ± 0.0001	1.2 ± 0.01
Easter Pasture Canyon Garden	< 0.005 ± 0.001	< 0.02 ± 0.15	< 4 ± 0.9	< 30 ± 2	< 0.02 ± 0.01	< 0.0007 ± 0.0004	4.9 ± 0.12
Escalante River Spring A	< 0.004 ± 0.001	< 0.03 ± 0.04	< 3 ± 0.7	< 5 ± 4	0.03 ± 0.01	< 0.0007 ± 0.0003	1.7 ± 0.01
Escalante River Spring B	0.005 ± 0.001	< 0.03 ± 0.04	< 3 ± 0.1	< 5 ± —	< 0.01 ± 0.009	< 0.0007 ± 0.0003	1.4 ± 0.01
Escalante River Spring C	< 0.004 ± 0.001	< 0.03 ± 0.1	< 3 ± 0.9	< 5 ± —	< 0.01 ± 0.003	< 0.0007 ± 0.0004	2.3 ± 0.02
Forgotten Canyon Spring	0.046 ± 0.001	< 0.03 ± 0.07	< 3 ± 0.9	— ± —	< 0.01 ± 0.005	0.0076 ± 0.0001	0.53 ± 0.01
Good Hope Bay, Spring A	0.014 ± 0.001	< 0.03 ± 0.01	< 3 ± 1.	— ± —	0.02 ± 0.006	0.0037 ± 0.0007	0.48 ± 0.00
Good Hope Bay, Spring B	0.041 ± 0.001	< 0.03 ± 0.02	< 3 ± 1.	— ± —	< 0.01 ± 0.01	0.0083 ± 0.0000	1. ± 0.01
Good Hope Bay, Spring C	< 0.004 ± 0.002	< 0.03 ± 0.03	< 3 ± 2.	— ± —	< 0.01 ± 0.003	< 0.0007 ± 0.0006	0.61 ± 0.00
Good Hope Bay, Spring D	0.005 ± 0.001	< 0.03 ± 0.03	< 3 ± 0.8	— ± —	< 0.01 ± 0.008	0.0007 ± 0.0007	0.63 ± 0.01
Gypsum Canyon Spring	0.017 ± 0.001	0.28 ± 2.9	8.1 ± 3.	< 30 ± 3	< 0.02 ± 0.002	0.0045 ± 0.0002	3.4 ± 0.04
Knowles Canyon Garden	0.006 ± 0.001	< 0.02 ± 0.08	< 4 ± 2.	< 30 ± 5	0.03 ± 0.009	0.0009 ± 0.0007	1.3 ± 0.02
Last Chance Spring	< 0.004 ± 0.003	1.2 ± 0.05	< 3 ± 0.3	— ± —	0.01 ± 0.002	0.0009 ± 0.0003	5.5 ± 0.00
Long Canyon Spring	< 0.004 ± 0.	< 0.03 ± 0.06	< 3 ± 1.	< 5 ± —	< 0.01 ± 0.01	< 0.0007 ± 0.0003	1.2 ± 0.01
Moqui Canyon Spring	0.028 ± 0.002	< 0.03 ± 0.06	< 3 ± 2.	— ± —	0.03 ± 0.008	0.0043 ± 0.0004	0.06 ± 0.01
Rana Canyon Garden	< 0.004 ± 0.	< 0.03 ± 0.04	4.8 ± 2.	< 5 ± —	0.03 ± 0.013	< 0.0007 ± 0.0002	1.8 ± 0.01
Ribbon Canyon, Grand Daddy Spring	< 0.004 ± 0.003	< 0.03 ± 0.04	< 3 ± 0.6	< 5 ± —	< 0.01 ± 0.004	< 0.0007 ± 0.0002	1.03 ± 0.01
San Juan Garden	< 0.004 ± 0.001	< 0.03 ± 0.04	< 3 ± 1.	< 5 ± —	0.02 ± 0.008	0.0009 ± 0.0005	0.95 ± 0.00
Stevens Arch Garden	< 0.004 ± 0.002	< 0.03 ± 0.01	< 3 ± 1.	— ± —	< 0.01 ± 0.003	< 0.0007 ± 0.0004	1.4 ± 0.01
Swett Canyon Spring	< 0.005 ± 0.003	< 0.02 ± 0.2	< 4 ± 1.	< 30 ± 1	< 0.02 ± 0.003	0.0009 ± 0.0003	7.1 ± 0.30
Wall Spring	< 0.004 ± 0.002	< 0.03 ± 0.03	< 3 ± 0.9	— ± —	0.01 ± 0.005	< 0.0007 ± 0.0004	1.5 ± 0.01

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (*Continued)*

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Neodymium µg/L	Nickel µg/L	Phosphorus µg/L	Phosphate µg P/L	Lead µg/L	Praseodymium µg/L	Rubidium µg/L
GRAND CANYON NATIONAL PARK							
Berts Canyon	< 0.005 ± 0.003	< 0.02 ± 0.17	< 4 ± 0.9	< 20 ± 12	< 0.02 ± 0.007	0.0014 ± 0.0006	3.2 ± 0.11
Cove Canyon	< 0.005 ± 0.003	< 0.02 ± 0.54	< 4 ± 0.4	93 ± 77	0.08 ± 0.004	0.000819 ± 0.0001	5.5 ± 0.06
Elves Chasm	< 0.005 ± 0.001	< 0.02 ± 0.04	< 4 ± 2.	< 20 ± 3	< 0.02 ± 0.011	< 0.0007 ± 0.0007	3.2 ± 0.06
Fern Glen	< 0.005 ± 0.002	< 0.02 ± 0.2	< 4 ± 2.	< 20 ± 2	< 0.02 ± 0.013	< 0.0007 ± 0.0004	11. ± 0.02
Hance Spring	< 0.005 ± 0.002	< 0.02 ± 0.04	< 4 ± 1.	< 20 ± 7	< 0.02 ± 0.004	< 0.0007 ± 0.0005	33. ± 0.52
Keyhole Spring	< 0.005 ± 0.001	< 0.02 ± 0.19	< 4 ± 2.	< 20 ± 12	< 0.02 ± 0.006	0.000955 ± 0.0002	3.2 ± 0.07
Mohawk Canyon	< 0.005 ± 0.000	< 0.02 ± 0.2	8.7 ± 0.9	42 ± 87	< 0.02 ± 0.004	< 0.0007 ± 0.0006	12. ± 0.06
Nankoweap Twin Spring	< 0.005 ± 0.002	< 0.02 ± 0.07	< 4 ± 1.3	< 20 ± 9	< 0.02 ± 0.004	< 0.0007 ± 0.0005	2.8 ± 0.04
Pumpkin Spring	0.020 ± 0.001	< 0.02 ± 0.03	4.9 ± 0.1	36 ± 33	< 0.02 ± 0.007	0.0024 ± 0.0003	470. ± 0.
River Mile 125 Spring	< 0.005 ± 0.003	< 0.02 ± 0.2	< 4 ± 0.1	< 20 ± 15	< 0.02 ± 0.004	< 0.0007 ± 0.0003	9.4 ± 0.11
River Mile147 Seep	< 0.005 ± 0.003	< 0.02 ± 0.4	< 4 ± 0.3	< 20 ± 8	0.05 ± 0.019	< 0.0007 ± 0.0002	8.8 ± 0.17
River Mile 213 Spring	0.006 ± 0.003	< 0.02 ± 0.1	< 4 ± 2.	25 ± 45	< 0.02 ± 0.004	< 0.0007 ± 0.0004	11. ± 0.31
Saddle Canyon	< 0.005 ± 0.003	< 0.02 ± 0.04	< 4 ± 0.1	< 20 ± 15	< 0.02 ± 0.004	< 0.0007 ± 0.0002	3.8 ± 0.04
Slimy Tick Spring	< 0.005 ± 0.002	0.30 ± 1.	< 4 ± 0.2	< 20 ± 12	< 0.02 ± 0.002	< 0.0007 ± 0.0006	14. ± 0.23
The Ledges	< 0.005 ± 0.001	< 0.02 ± 1.	< 4 ± 1.	< 20 ± 12	< 0.02 ± 0.002	< 0.0007 ± 0.0001	11. ± 0.11
Three Springs	< 0.005 ± 0.001	< 0.02 ± 0.1	< 4 ± 2.	< 20 ± 37	< 0.02 ± 0.002	< 0.0007 ± 0.0002	3.1 ± 0.06
MISCELLANEOUS							
Matrimony Spring	< 0.004 ± 0.001	< 0.03 ± 0.06	— ± —	< 20 ± —	< 0.01 ± 0.008	< 0.0005 ± 0.0002	1. ± 0.02

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (*Continued)*

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Rhenium µg/L	Sulfate mg/L	Antimony µg/L	Selenium µg/L	Silica mg/L	Samarium µg/L	Tin µg/L
ARCHES NATIONAL PARK							
Above Freshwater Spring	0.024 ± 0.0006	11.8 ± 0.6	0.006 ± 0.004	< 0.3 ± 0.1	11. ± 0.07	< 0.003 ± 0.002	< 0.5 ± 0.02
Seven Mile Spring	0.012 ± 0.002	8.3 ± 0.3	0.027 ± 0.006	.37 ± 0.1	8.3 ± 0.2	< 0.003 ± 0.002	< 0.5 ± 0.04
Sleepy Hollow Spring	0.013 ± 0.0012	9.2 ± —	0.02 ± 0.001	.33 ± 0.1	10. ± 0.2	< 0.003 ± 0.003	< 0.5 ± 0.01
CANYONLANDS NATIONAL PARK							
Big Spring	0.021 ± 0.0001	33.3 ± —	0.026 ± 0.003	5.15 ± 0.05	10.1 ± 0.02	< 0.003 ± 0.002	< 0.5 ± 0.06
Cabin Spring	0.004 ± 0.0007	6.7 ± —	0.021 ± 0.002	< 0.3 ± 0.2	9.7 ± 0.1	< 0.003 ± 0.002	< 0.5 ± 0.09
Cave Spring	0.016 ± 0.0021	12.5 ± —	< 0.01 ± 0.002	< 0.3 ± 0.1	11.9 ± 0.4	< 0.003 ± 0.001	< 0.8 ± 0.1
GLEN CANYON NATIONAL RECREATION AREA							
Bouy 114A Spring	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
Bouy 114B Spring	< 0.001 ± 0.0007	5.2 ± —	< 0.01 ± 0.002	< 0.3 ± 0.2	14. ± 0.1	0.007 ± 0.002	< 0.8 ± 0.03
Buoy 84 RR Spring	0.001 ± 0.0009	4.9 ± —	< 0.007 ± 0.003	< 0.2 ± 0.15	10. ± 0.1	< 0.003 ± 0.001	< 0.5 ± 0.08
Bowns Canyon Garden	0.003 ± 0.0015	2.8 ± —	< 0.007 ± 0.001	< 0.2 ± 0.1	10. ± 0.1	0.003 ± 0.001	< 0.5 ± 0.03
Cottonwood Canyon Garden	< 0.001 ± 0.0001	3.8 ± 0.3	0.008 ± 0.004	< 0.2 ± 0.07	11. ± 0.3	0.003 ± 0.002	< 0.5 ± 0.03
Cow Canyon Garden A	< 0.001 ± 0.0005	2.9 ± —	< 0.007 ± 0.004	< 0.2 ± 0.2	9.4 ± 0.3	0.003 ± 0.003	< 0.5 ± 0.05
Cow Canyon Garden B	< 0.001 ± 0.0007	3.6 ± —	< 0.007 ± 0.003	.22 ± 0.2	9.1 ± 0.3	< 0.003 ± 0.002	< 0.5 ± 0.04
Cow Canyon Garden C	0.001 ± 0.0003	6.6 ± —	< 0.007 ± 0.004	< 0.2 ± 0.1	9.1 ± 0.2	0.003 ± 0.002	< 0.5 ± 0.03
Easter Pasture Canyon Garden	0.013 ± 0.0008	40. ± —	< 0.01 ± 0.000	5.18 ± 0.06	11. ± 0.08	< 0.003 ± 0.002	< 0.8 ± 0.06
Escalante River Spring A	< 0.001 ± 0.0003	2.8 ± —	< 0.007 ± 0.004	< 0.2 ± 0.01	9.3 ± 0.1	< 0.003 ± 0.001	< 0.5 ± 0.02
Escalante River Spring B	0.002 ± 0.0013	4. ± —	< 0.007 ± 0.005	< 0.2 ± 0.12	9.8 ± 0.2	< 0.003 ± 0.003	< 0.5 ± 0.04
Escalante River Spring C	< 0.001 ± 0.0005	3.2 ± —	< 0.007 ± 0.001	< 0.2 ± 0.08	9.5 ± 0.2	< 0.003 ± 0.001	< 0.5 ± 0.01
Forgotten Canyon Spring	0.004 ± 0.0015	14. ± —	0.039 ± 0.004	< 0.2 ± 0.1	20. ± 0.7	0.018 ± 0.005	< 0.5 ± 0.04
Good Hope Bay, Spring A	0.026 ± 0.0012	61. ± —	0.019 ± 0.003	1.55 ± 0.1	18. ± 0.5	0.005 ± 0.001	< 0.5 ± 0.06
Good Hope Bay, Spring B	0.007 ± 0.0004	23. ± —	0.01 ± 0.005	.6 ± 0.2	19. ± 0.3	0.009 ± 0.004	< 0.5 ± 0.02
Good Hope Bay, Spring C	0.003 ± 0.0003	13. ± —	< 0.007 ± 0.001	.61 ± 0.1	15. ± 0.07	< 0.003 ± 0.001	< 0.5 ± 0.01
Good Hope Bay, Spring D	0.002 ± 0.0001	12. ± —	< 0.007 ± 0.001	.51 ± 0.2	15. ± 0.1	< 0.003 ± 0.002	< 0.5 ± 0.05
Gypsum Canyon Spring	0.369 ± 0.0162	2,100. ± —	0.047 ± 0.003	1.21 ± 0.5	17. ± 0.05	0.006 ± 0.003	5.3 ± 0.8
Knowles Canyon Garden	0.002 ± 0.0001	3.9 ± 0.2	< 0.01 ± 0.004	< 0.3 ± 0.3	9.9 ± 0.05	< 0.003 ± 0.002	< 0.8 ± 0.07
Last Chance Spring	0.050 ± 0.0025	1,100. ± —	0.11 ± 0.007	.58 ± 0.2	17. ± 0.4	< 0.003 ± 0.001	< 0.5 ± 0.01
Long Canyon Spring	< 0.001 ± 0.0004	3.7 ± —	< 0.007 ± 0.003	< 0.2 ± 0.04	9.2 ± 0.1	< 0.003 ± 0.002	< 0.5 ± 0.04
Moqui Canyon Spring	0.003 ± 0.0012	23. ± 1.	0.035 ± 0.002	< 0.2 ± 0.2	19. ± 0.07	0.005 ± 0.002	< 0.5 ± 0.03
Rana Canyon Garden	0.001 ± 0.0007	4.4 ± 0.1	< 0.007 ± 0.004	< 0.2 ± 0.2	11. ± 0.15	0.004 ± 0.001	< 0.5 ± 0.05
Ribbon Canyon, Grand Daddy Spring	< 0.001 ± 0.0001	4. ± 0.	< 0.007 ± 0.004	.23 ± 0.05	9.5 ± 0.2	< 0.003 ± 0.002	< 0.5 ± 0.01
San Juan Garden	0.001 ± 0.0005	4.4 ± —	< 0.007 ± 0.000	< 0.2 ± 0.1	9.2 ± 0.1	< 0.003 ± 0.001	< 0.5 ± 0.02
Stevens Arch Garden	0.001 ± 0.0006	3.4 ± —	< 0.007 ± 0.003	< 0.2 ± 0.04	10. ± 0.2	< 0.003 ± 0.002	< 0.5 ± 0.08
Swett Canyon Spring	0.108 ± 0.0032	160. ± —	0.061 ± 0.003	.6 ± 0.04	20. ± 0.3	< 0.003 ± 0.001	< 0.8 ± 0.08
Wall Spring	0.013 ± 0.0012	21. ± —	< 0.007 ± 0.002	1.38 ± 0.02	15. ± 0.1	< 0.003 ± 0.003	< 0.5 ± 0.08

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (*Continued)*

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Rhenium µg/L	Sulfate mg/L	Antimony µg/L	Selenium µg/L	Silica mg/L	Samarium µg/L	Tin µg/L
GRAND CANYON NATIONAL PARK							
Berts Canyon	0.012 ± 0.0008	20 ± —	0.069 ± 0.005	2.2 ± 0.1	9.5 ± 0.2	< 0.003 ± 0.002	< 0.8 ± 0.1
Cove Canyon	0.31 ± 0.0117	2,000 ± —	0.059 ± 0.005	7.1 ± 0.1	16. ± 0.3	< 0.003 ± 0.001	< 0.8 ± 0.1
Elves Chasm	0.059 ± 0.0022	210 ± —	0.016 ± 0.005	6.1 ± 0.1	11. ± 0.2	< 0.003 ± 0.002	< 0.8 ± 0.1
Fern Glen	0.3 ± 0.0029	1300 ± —	< 0.01 ± 0.005	12. ± 0.1	14. ± 0.2	< 0.003 ± 0.001	< 0.8 ± 0.2
Hance Spring	0.015 ± 0.0019	160 ± —	< 0.01 ± 0.004	0.9 ± 0.2	12. ± 0.21	< 0.003 ± 0.001	< 0.8 ± 0.09
Keyhole Spring	0.023 ± 0.0016	20 ± —	0.05 ± 0.003	2.9 ± 0.2	9.7 ± 0.1	< 0.003 ± 0.002	< 0.8 ± 0.
Mohawk Canyon	0.21 ± 0.0025	1,400 ± —	< 0.01 ± 0.007	12. ± 0.2	14. ± 0.08	< 0.003 ± 0.002	< 0.8 ± 0.03
Nankoweap Twin Spring	0.016 ± 0.0006	120 ± —	< 0.01 ± 0.005	1.4 ± 0.1	9.6 ± 0.06	< 0.003 ± 0.004	< 0.8 ± 0.06
Pumpkin Spring	0.002 ± 0.001	330 ± 10	0.062 ± 0.001	6.7 ± 0.1	130. ± 0.	0.010 ± 0.001	7.2 ± 2.
River Mile 125 Spring	0.18 ± 0.0024	720 ± —	< 0.01 ± 0.001	14. ± 0.5	13. ± 0.3	< 0.003 ± 0.002	< 0.8 ± 0.09
River Mile147 Seep	0.16 ± 0.0069	640 ± —	< 0.01 ± 0.004	11. ± 0.4	12. ± 0.06	< 0.003 ± 0.003	< 0.8 ± 0.1
River Mile 213 Spring	0.039 ± 0.0034	130 ± —	< 0.01 ± 0.003	3.6 ± 0.0	15. ± 0.03	< 0.003 ± 0.002	< 0.8 ± 0.2
Saddle Canyon	0.014 ± 0.0005	36 ± —	0.061 ± 0.003	3. ± 0.3	9.3 ± 0.1	< 0.003 ± 0.000	< 0.8 ± 0.04
Slimy Tick Spring	0.21 ± 0.003	2,000 ± —	0.024 ± 0.011	6.6 ± 0.0	14. ± 0.2	< 0.003 ± 0.001	< 0.8 ± 0.08
The Ledges	0.19 ± 0.0001	1,300 ± —	< 0.01 ± 0.003	6.3 ± 0.3	12. ± 0.2	< 0.003 ± 0.002	< 0.8 ± 0.02
Three Springs	0.033 ± 0.003	70 ± —	0.014 ± 0.008	2.8 ± 0.4	15. ± 0.5	< 0.003 ± 0.001	< 0.8 ± 0.09
MISCELLANEOUS							
Matrimony Spring	0.005 ± 0.0012	33 ± —	0.005 ± 0.003	0.6 ± 0.1	9. ± 0.09	< 0.003 ± 0.005	< 0.5 ± 0.04

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (*Continued)*

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Strontium µg/L	Terbium µg/L	Tellurium µg/L	Thorium µg/L	Titanium µg/L	Thallium µg/L	Thullium µg/L
ARCHES NATIONAL PARK							
Above Freshwater Spring	100 ±	< 0.0005 ± 0.0002	< 0.05 ± 0.01	< 0.0008 ± 0.0001	0.87 ± 0.3	< 0.01 ± 0.0003	< 0.0005 ± 0.0002
Seven Mile Spring	120 ±	< 0.0005 ± 0.0003	< 0.05 ± 0.03	< 0.0008 ± 0.0004	0.93 ± 0.09	< 0.01 ± 0.0031	< 0.0005 ± 0.0001
Sleepy Hollow Spring	140 ±	< 0.0005 ± 0.0003	< 0.05 ± 0.01	< 0.0008 ± 0.0005	1.1 ± 0.2	< 0.01 ± 0.001	< 0.0005 ± 0.0001
CANYONLANDS NATIONAL PARK							
Big Spring	770 ±	< 0.0005 ± 0.0002	< 0.05 ± 0.01	< 0.0008 ± 0.0004	0.82 ± 0.1	< 0.01 ± 0.002	< 0.0005 ± 0.0001
Cabin Spring	86 ± 2	< 0.0005 ± 0.0001	< 0.05 ± 0.01	< 0.0008 ± 0.0007	1.2 ± 0.01	< 0.01 ± 0.0005	< 0.0005 ± 0.0002
Cave Spring	170 ±	< 0.0007 ± 0.0001	< 0.03 ± 0.02	< 0.001 ± 0.0002	< 0.1 ± 0.05	< 0.02 ± 0.001	< 0.0005 ± 0.0003
GLEN CANYON NATIONAL RECREATION AREA							
Bouy 114A Spring	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
Bouy 114B Spring	310 ±	< 0.0007 ± 0.0003	< 0.03 ± 0.02	< 0.001 ± 0.0007	0.22 ± 0.04	< 0.02 ± 0.001	< 0.0005 ± 0.0002
Buoy 84 RR Spring	100 ±	0.0007 ± 0.0001	< 0.03 ± 0.01	< 0.001 ± 0.0008	0.23 ± 0.04	< 0.02 ± 0.0007	< 0.0007 ± 0.0005
Bowns Canyon Garden	46 ± 1	0.0006 ± 0.0003	< 0.03 ± 0.	0.0021 ± 0.0009	< 0.1 ± 0.04	< 0.02 ± 0.0007	< 0.0007 ± 0.0004
Cottonwood Canyon Garden	110 ±	< 0.0003 ± 0.0001	< 0.03 ± 0.01	< 0.001 ± 0.0008	0.17 ± 0.1	< 0.02 ± 0.0007	< 0.0007 ± 0.0005
Cow Canyon Garden A	73 ± 2	< 0.0003 ± 0.0003	< 0.03 ± 0.01	< 0.001 ± 0.0003	< 0.1 ± 0.05	< 0.02 ± 0.002	< 0.0007 ± 0.0006
Cow Canyon Garden B	72 ± 1	< 0.0003 ± 0.0002	< 0.03 ± 0.01	< 0.001 ± 0.	0.31 ± 0.03	< 0.02 ± 0.0004	< 0.0007 ± 0.0004
Cow Canyon Garden C	120 ±	< 0.0003 ± 0.0002	< 0.03 ± 0.01	< 0.001 ± 0.0001	0.18 ± 0.07	< 0.02 ± 0.002	< 0.0007 ± 0.0002
Easter Pasture Canyon Garden	180 ±	< 0.0007 ± 0.0003	< 0.03 ± 0.01	< 0.001 ± 0.0007	0.36 ± 0.08	< 0.02 ± 0.004	< 0.0005 ± 0.0003
Escalante River Spring A	64 ± 1	< 0.0003 ± 0.0004	< 0.03 ± 0.01	< 0.001 ± 0.0005	0.12 ± 0.03	< 0.02 ± 0.0004	< 0.0007 ± 0.0002
Escalante River Spring B	80 ±	< 0.0003 ± 0.0002	< 0.03 ± 0.01	< 0.001 ± 0.0001	0.23 ± 0.04	< 0.02 ± 0.001	< 0.0007 ± 0.0003
Escalante River Spring C	120 ±	< 0.0003 ± 0.0001	< 0.03 ± 0.01	< 0.001 ± 0.0003	0.24 ± 0.04	< 0.02 ± 0.001	< 0.0007 ± 0.0001
Forgotten Canyon Spring	290 ±	0.0018 ± 0.0006	< 0.03 ± 0.02	0.0038 ± 0.0001	0.33 ± 0.2	< 0.02 ± 0.004	< 0.0007 ± 0.0002
Good Hope Bay, Spring A	360 ±	0.0004 ± 0.0002	< 0.03 ± 0.01	< 0.001 ± 0.0005	0.24 ± 0.1	< 0.02 ± 0.0006	< 0.0007 ± 0.0002
Good Hope Bay, Spring B	610 ±	0.0020 ± 0.0004	< 0.03 ± 0.01	< 0.001 ± 0.0008	< 0.1 ± 0.04	< 0.02 ± 0.001	0.0013 ± 0.0006
Good Hope Bay, Spring C	230 ±	< 0.0003 ± 0.0003	< 0.03 ± 0.01	< 0.001 ± 0.0003	< 0.1 ± 0.1	< 0.02 ± 0.0001	< 0.0007 ± 0.0003
Good Hope Bay, Spring D	220 ±	< 0.0003 ± 0.0001	< 0.03 ± 0.01	< 0.001 ± 0.0008	< 0.1 ± 0.03	< 0.02 ± 0.0007	< 0.0007 ± 0.0004
Gypsum Canyon Spring	14,000 ± 1,000	0.0053 ± 0.0005	0.14 ± 0.02	0.0037 ± 0.0014	1.3 ± 0.2	< 0.02 ± 0.002	0.001 ± 0.0008
Knowles Canyon Garden	71 ± 1	< 0.0007 ± 0.0006	< 0.03 ± 0.02	< 0.001 ± 0.0009	0.29 ± 0.07	< 0.02 ± 0.001	< 0.0005 ± 0.0002
Last Chance Spring	4,600 ±	0.0014 ± 0.0003	0.04 ± 0.01	< 0.001 ± 0.0009	0.86 ± 0.2	0.02 ± 0.0007	< 0.0007 ± 0.
Long Canyon Spring	79 ± 1	< 0.0003 ± 0.0003	< 0.03 ± 0.	< 0.001 ± 0.0006	0.12 ± 0.04	< 0.02 ± 0.0004	< 0.0007 ± 0.0001
Moqui Canyon Spring	220 ±	0.0011 ± 0.0001	< 0.03 ± 0.01	0.0018 ± 0.0008	0.58 ± 0.03	< 0.02 ± 0.002	< 0.0007 ± 0.0004
Rana Canyon Garden	94 ± 1	< 0.0003 ± 0.0003	< 0.03 ± 0.	< 0.001 ± 0.	< 0.1 ± 0.03	< 0.02 ± 0.001	< 0.0007 ± 0.0001
Ribbon Canyon, Grand Daddy Spring	98 ±	< 0.0003 ± 0.0004	< 0.03 ± 0.01	< 0.001 ± 0.002	< 0.1 ± 0.04	< 0.02 ± 0.0008	< 0.0007 ± 0.0003
San Juan Garden	97 ± 1	< 0.0003 ± 0.0002	< 0.03 ± 0.01	< 0.001 ± 0.0005	< 0.1 ± 0.1	< 0.02 ± 0.002	< 0.0007 ± 0.0003
Stevens Arch Garden	81 ± 1	< 0.0003 ± 0.0001	< 0.03 ± 0.	< 0.001 ± 0.0007	0.48 ± 0.09	< 0.02 ± 0.002	< 0.0007 ± 0.0002
Swett Canyon Spring	1200 ±	< 0.0007 ± 0.0006	< 0.03 ± 0.04	< 0.001 ± 0.001	< 0.2 ± 0.08	0.03 ± 0.002	< 0.0005 ± 0.0001
Wall Spring	380 ±	< 0.0003 ± 0.0002	< 0.03 ± 0.01	< 0.001 ± 0.0001	< 0.1 ± 0.04	< 0.02 ± 0.001	< 0.0007 ± 0.0003

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (*Continued)*

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Strontium µg/L	Terbium µg/L	Tellurium µg/L	Thorium µg/L	Titanium µg/L	Thallium µg/L	Thullium µg/L
GRAND CANYON NATIONAL PARK							
Berts Canyon	110 ± 0	< 0.0007 ± 0.0003	< 0.03 ± 0.02	< 0.001 ± 0.0004	< 0.1 ± 0.1	< 0.02 ± 0.005	< 0.0005 ± 0.0003
Cove Canyon	4,300 ± 0	0.0010 ± 0.0002	< 0.03 ± 0.001	< 0.001 ± 0.0006	1.4 ± 0.2	0.02 ± 0.003	< 0.0005 ± 0.0005
Elves Chasm	640 ± 10	< 0.0007 ± 0.0001	< 0.03 ± 0.01	< 0.001 ± 0.0009	1.3 ± 0.3	< 0.02 ± 0.001	< 0.0005 ± 0.0005
Fern Glen	3,800 ± 100	0.0008 ± 0.0005	< 0.03 ± 0.02	< 0.001 ± 0.0004	0.33 ± 0.	0.05 ± 0.005	< 0.0005 ± 0.0003
Hance Spring	870 ± 10	< 0.0007 ± 0.0001	< 0.03 ± 0.01	< 0.001 ± 0.0009	0.15 ± 0.01	0.04 ± 0.0005	< 0.0005 ± 0.0001
Keyhole Spring	120 ± 0	< 0.0007 ± 0.0005	< 0.03 ± 0.02	< 0.001 ± 0.0005	< 0.1 ± 0.07	0.03 ± 0.001	< 0.0005 ± 0.0004
Mohawk Canyon	3,700 ± 0	< 0.0007 ± 0.0000	< 0.03 ± 0.02	0.002 ± 0.0013	1.6 ± 0.05	0.05 ± 0.001	< 0.0005 ± 0.0005
Nankoweap Twin Spring	220 ± 0	< 0.0007 ± 0.0004	< 0.03 ± 0.01	< 0.001 ± 0.0005	0.18 ± 0.06	< 0.02 ± 0.002	< 0.0005 ± 0.0003
Pumpkin Spring	5,700 ± 500	0.0049 ± 0.0011	0.16 ± 0.001	0.005 ± 0.0003	0.81 ± 0.7	0.02 ± 0.005	0.0039046 ± 0.0006
River Mile 125 Spring	2,900 ± 100	< 0.0007 ± 0.0000	< 0.03 ± 0.02	< 0.001 ± 0.0009	1.6 ± 0.09	0.04 ± 0.0008	< 0.0005 ± 0.0002
River Mile147 Seep	2,500 ± 100	< 0.0007 ± 0.0003	< 0.03 ± 0.04	< 0.001 ± 0.0006	0.33 ± 0.1	0.10 ± 0.004	< 0.0005 ± 0.0003
River Mile 213 Spring	350 ± 10	< 0.0007 ± 0.0003	< 0.03 ± 0.01	< 0.001 ± 0.0008	0.18 ± 0.05	< 0.02 ± 0.002	< 0.0005 ± 0.0001
Saddle Canyon	130 ± 0	< 0.0007 ± 0.0003	< 0.03 ± 0.02	< 0.001 ± 0.0005	1.4 ± 0.3	0.14 ± 0.003	< 0.0005 ± 0.0003
Slimy Tick Spring	4,200 ± 200	0.0008 ± 0.0003	< 0.03 ± 0.03	0.002 ± 0.0016	2.2 ± 0.04	0.16 ± 0.02	< 0.0005 ± 0.0003
The Ledges	6,200 ± 300	< 0.0007 ± 0.0004	< 0.03 ± 0.01	< 0.001 ± 0.0004	0.37 ± 0.1	0.13 ± 0.003	< 0.0005 ± 0.0003
Three Springs	210 ± 0	< 0.0007 ± 0.0004	< 0.03 ± 0.02	< 0.001 ± 0.0005	1.2 ± 0.04	< 0.02 ± 0.002	< 0.0005 ± 0.0002
MISCELLANEOUS							
Matrimony Spring	410 ±	< 0.0005 ± 0.0003	< 0.05 ± 0.01	< 0.0008 ± 0.0004	1.1 ± 0.2	< 0.01 ± 0.0002	< 0.0005 ± 0.0002

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 - (*Continued)*

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Uranium µg/L	Vanadium µg/L	Tungsten µg/L	Yttrium µg/L	Ytterbium µg/L	Zinc µg/L	Zirconium µg/L
ARCHES NATIONAL PARK							
Above Freshwater Spring	0.08 ± 0.003	1.2 ± 0.03	< 0.05 ± 0.001	0.0093 ± 0.0007	< 0.002 ± 0.0013	2.7 ± 0.1	< 0.006 ± 0.002
Seven Mile Spring	0.35 ± 0.01	1.9 ± 0.02	< 0.05 ± 0.008	0.0068 ± 0.001	< 0.002 ± 0.0004	12. ± 0.5	0.007 ± 0.003
Sleepy Hollow Spring	0.28 ± 0.007	1.8 ± 0.03	< 0.05 ± 0.019	0.01 ± 0.0006	0.0017 ± 0.0014	16. ± 0.3	< 0.006 ± 0.001
CANYONLANDS NATIONAL PARK							
Big Spring	14. ± 0.04	2.8 ± 0.04	< 0.05 ± 0.016	0.012 ± 0.001	< 0.002 ± 0.0012	3.6 ± 0.1	0.028 ± 0.014
Cabin Spring	0.47 ± 0.02	0.95 ± 0.06	< 0.05 ± 0.03	0.0069 ± 0.0008	< 0.002 ± 0.0008	31. ± 0.2	< 0.006 ± 0.001
Cave Spring	0.41 ± 0.01	0.18 ± 0.04	< 0.008 ± 0.011	0.0079 ± 0.0005	< 0.002 ± 0.0003	5.9 ± 0.3	0.0019 ± 0.001
GLEN CANYON NATIONAL RECREATION. AREA							
Bouy 114A Spring	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —	— ± —
Bouy 114B spring	0.5 ± 0.02	9.8 ± 0.02	0.024 ± 0.005	0.023 ± 0.003	< 0.002 ± 0.0004	1.8 ± 0.5	0.0029 ± 0.
Buoy 84 RR spring	0.22 ± 0.006	5.4 ± 0.02	< 0.007 ± 0.005	0.016 ± 0.004	< 0.002 ± 0.0007	16. ± 0.3	0.003 ± 0.001
Bowns Canyon Garden	0.23 ± 0.005	9.1 ± 0.04	0.011 ± 0.004	0.011 ± 0.0005	< 0.002 ± 0.0011	8.6 ± 0.2	0.0052 ± 0.001
Cottonwood Canyon Garden	0.25 ± 0.003	2.9 ± 0.06	0.009 ± 0.004	0.0099 ± 0.0004	< 0.002 ± 0.0006	14. ± 1.	0.0042 ± 0.004
Cow Canyon Garden A	0.17 ± 0.007	5.5 ± 0.12	0.01 ± 0.009	0.0055 ± 0.0003	< 0.002 ± 0.0011	18. ± 0.4	0.0034 ± 0.001
Cow Canyon Garden B	0.3 ± 0.009	3.3 ± 0.08	< 0.007 ± 0.007	0.0024 ± 0.0007	< 0.002 ± 0.0005	27. ± 0.3	0.0032 ± 0.002
Cow Canyon Garden C	0.39 ± 0.003	2.7 ± 0.07	< 0.007 ± 0.004	0.0034 ± 0.0003	< 0.002 ± 0.0011	15. ± 0.3	< 0.002 ± 0.001
Easter Pasture Canyon Garden	1.5 ± 0.05	0.76 ± 0.11	0.135 ± 0.008	0.0035 ± 0.0004	< 0.002 ± 0.0006	4.3 ± 0.6	0.0029 ± 0.003
Escalante River Spring A	0.06 ± 0.006	4.3 ± 0.01	0.009 ± 0.007	0.0032 ± 0.001	< 0.002 ± 0.0005	13. ± 0.1	0.0025 ± 0.001
Escalante River Spring B	0.26 ± 0.002	3.5 ± 0.04	< 0.007 ± 0.004	0.0033 ± 0.001	< 0.002 ± 0.0002	27. ± 0.9	< 0.002 ± 0.001
Escalante River Spring C	0.22 ± 0.002	7.5 ± 0.20	0.014 ± 0.005	0.0033 ± 0.001	0.0017 ± 0.0001	16. ± 0.1	< 0.002 ± 0.001
Forgotten Canyon Spring	0.55 ± 0.009	5.9 ± 0.04	0.022 ± 0.003	0.099 ± 0.0003	0.0068 ± 0.0009	14. ± 2.	0.0207 ± 0.002
Good Hope Bay, Spring A	5.3 ± 0.1	14. ± 0.30	0.013 ± 0.004	0.037 ± 0.0004	0.0045 ± 0.0002	19. ± 0.	0.004 ± 0.001
Good Hope Bay, Spring B	3.5 ± 0.1	18. ± 0.20	< 0.007 ± 0.005	0.14 ± 0.007	0.01 ± 0.0006	14. ± 0.2	< 0.002 ± 0.001
Good Hope Bay, Spring C	1.27 ± 0.037	11. ± 0.03	0.021 ± 0.	0.0054 ± 0.001	< 0.002 ± 0.0021	13. ± 0.5	< 0.002 ± 0.002
Good Hope Bay, Spring D	1.2 ± 0.04	10. ± 0.30	0.018 ± 0.004	0.0036 ± 0.002	< 0.002 ± 0.0006	4.9 ± 0.2	0.0038 ± 0.002
Gypsum Canyon Spring	23. ± 0.5	< 0.07 ± 0.02	0.349 ± 0.008	0.12 ± 0.007	0.0029 ± 0.0007	3.1 ± 0.3	0.039 ± 0.007
Knowles Canyon Garden	0.14 ± 0.009	12. ± 0.30	0.056 ± 0.02	0.0045 ± 0.0009	< 0.002 ± 0.0002	2.8 ± 0.7	0.0043 ± 0.002
Last Chance Spring	2.8 ± 0.03	< 0.05 ± 0.01	< 0.007 ± 0.005	0.032 ± 0.002	0.0023 ± 0.0015	23. ± 0.3	0.0066 ± 0.001
Long Canyon Spring	0.27 ± 0.001	4.8 ± 0.05	< 0.007 ± 0.008	0.0022 ± 0.001	< 0.002 ± 0.0005	20. ± 0.2	< 0.002 ± 0.001
Moqui Canyon Spring	0.03 ± 0.003	1.3 ± 0.05	< 0.007 ± 0.001	0.029 ± 0.002	0.0024 ± 0.0023	2.8 ± 0.1	0.017 ± 0.002
Rana Canyon Garden	0.31 ± 0.01	3.3 ± 0.08	< 0.007 ± 0.01	0.0108 ± 0.001	< 0.002 ± 0.0002	20. ± 0.2	< 0.002 ± 0.
Ribbon Canyon, Grand Daddy Spring	0.3 ± 0.005	3.3 ± 0.06	< 0.007 ± 0.001	0.0076 ± 0.0009	< 0.002 ± 0.0004	13. ± 0.4	< 0.002 ± 0.001
San Juan Garden	0.23 ± 0.009	3.5 ± 0.05	< 0.007 ± 0.004	0.0036 ± 0.002	< 0.002 ± 0.0005	18. ± 0.4	0.0028 ± 0.002
Stevens Arch Garden	0.13 ± 0.005	3.6 ± 0.07	< 0.007 ± 0.002	0.0031 ± 0.0005	< 0.002 ± 0.002	3.1 ± 0.3	< 0.002 ± 0.001
Swett Canyon Spring	16. ± 0.03	11. ± 0.02	0.036 ± 0.005	0.019 ± 0.002	< 0.002 ± 0.0013	9.1 ± 0.2	0.013 ± 0.002
Wall Spring	2.9 ± 0.01	4.4 ± 0.05	< 0.007 ± 0.004	0.0083 ± 0.002	0.0028 ± 0.0009	11. ± 0.2	0.0029 ± 0.001

Table 3 Summary of water quality concentration data (mean and standard deviation) of selected springs and seeps, 1997-98 – (*Continued)*

[meq/L, milliequivalents per liter; µg/L, micrograms per liter; <, less than; --, no data]

Site	Uranium µg/L	Vanadium µg/L	Tungsten µg/L	Yttrium µg/L	Ytterbium µg/L	Zinc µg/L	Zirconium µg/L
GRAND CANYON NATIONAL PARK							
Berts Canyon	1.4 ± 0.02	0.14 ± 0.	0.014 ± 0.007	0.0037 ± 0.001	< 0.002 ± 0.0007	8.5 ± 0.	0.0015 ± 0.002
Cove Canyon	11. ± 0.3	0.33 ± 0.06	0.016 ± 0.007	0.033 ± 0.003	< 0.002 ± 0.0002	38. ± 1.3	0.0045 ± 0.003
Elves Chasm	3.1 ± 0.06	1.4 ± 0.01	0.011 ± 0.003	0.0055 ± 0.001	< 0.002 ± 0.0007	14. ± 0.2	0.0016 ± 0.002
Fern Glen	18. ± 0.1	0.46 ± 0.06	< 0.008 ± 0.003	0.02 ± 0.0009	< 0.002 ± 0.0002	15. ± 0.3	0.0042 ± 0.002
Hance Spring	4.8 ± 0.2	< 0.07 ± 0.04	< 0.008 ± 0.001	0.0089 ± 0.002	< 0.002 ± 0.0004	10. ± 0.3	0.0018 ± 0.001
Keyhole Spring	1.7 ± 0.05	0.8 ± 0.03	0.011 ± 0.008	0.0029 ± 0.0008	< 0.002 ± 0.0007	3.7 ± 0.3	< 0.001 ± 0.001
Mohawk Canyon	18. ± 0.9	0.42 ± 0.08	< 0.008 ± 0.01	0.022 ± 0.003	< 0.002 ± 0.001	4.4 ± 0.3	0.0038 ± 0.001
Nankoweap Twin Spring	1.5 ± 0.03	0.21 ± 0.03	< 0.008 ± 0.01	0.0066 ± 0.0002	< 0.002 ± 0.0003	7.7 ± 0.3	0.0022 ± 0.001
Pumpkin Spring	13. ± 0.02	< 5. ± 0.	0.49 ± 0.005	0.52 ± 0.006	0.023 ± 0.0001	4.8 ± 0.	0.55 ± 0.001
River Mile 125 Seep	6.3 ± 0.1	< 0.07 ± 0.03	< 0.008 ± 0.007	0.0188 ± 0.001	< 0.002 ± 0.002	13. ± 0.3	0.0023 ± 0.001
River Mile147 Spring	9. ± 0.1	0.66 ± 0.04	< 0.008 ± 0.008	0.016 ± 0.0001	< 0.002 ± 0.001	5.4 ± 0.2	0.0055 ± 0.003
River Mile 213 Spring	3.4 ± 0.1	3. ± 0.2	0.027 ± 0.02	0.022 ± 0.0008	< 0.002 ± 0.0005	15. ± 0.7	0.0037 ± 0.002
Saddle Canyon	2.6 ± 0.04	0.17 ± 0.05	0.02 ± 0.007	0.0061 ± 0.0004	< 0.002 ± 0.0001	58. ± 0.2	0.0084 ± 0.
Slimy Tick Spring	18. ± 0.4	0.87 ± 0.06	0.02 ± 0.01	0.034 ± 0.001	< 0.002 ± 0.0008	7.5 ± 0.5	0.0082 ± 0.002
The Ledges	13. ± 0.2	0.21 ± 0.04	< 0.008 ± 0.009	0.025 ± 0.003	< 0.002 ± 0.002	22. ± 1.1	0.004 ± 0.001
Three Springs	2.2 ± 0.1	2.3 ± 0.02	0.036 ± 0.006	0.0099 ± 0.0008	< 0.002 ± 0.001	9.9 ± 0.1	0.0096 ± 0.001
MISCELLANEOUS							
Matrimony Spring	1.2 ± 0.01	1.6 ± 0.04	< 0.05 ± 0.009	0.009 ± 0.0004	0.0017 ± 0.001	39. ± 0.4	0.0081 ± 0.005

Table 4. Summary of physical setting, vegetation types, invertebrate habitats and invertebrate.

[D, detritus slopes; B, backwall; S, spring/soil; P, plunge pool; R, sloping slickrock; BW, hanging garden backwall herbaceous vegetation; DS, hanging garden detritus slope herbaceous vegetation; DS, hanging garden detritus slope herbaceous vegetation; SW, spring-associated woodland; WL, wetland/marsh; SP, spring with good flow and stream outlet; P1, pool isolated from spring/seep source except during high flows; P2, pool which is part of a spring compex under most flows; ST, stream or rivulet; M, madicolous; LS, laminar seepage over bare rock, detritus or algae; SS, sediment sample from low velocity habitat; C, Chara sample from low velocity habitat; LP, leaf pack, consisting of allocthonous materials; SW, sweep of pool with net including rock surfaces; —, no data]

Site	Physiscal setting	Vegetation types	Invertebrate habitats	Invertebrate microhabitats
ARCHES NATIONAL PARK				
Above Freshwater Seep	B, D	BW, DS	P2	SW, SS
Seven Mile Spring	B, D	BW, DS	—	—
Sleepy Hollow Garden	B, D, P	BW, DS, WL	P2,S	C, M, L, SW
CANYONLANDS NATIONAL PARK				
Big Springs	B, D, P	BW, DS	S	M
Cabin Spring	B, D, P	BW, DS, SW	SP, S, P2	SW, SS, LS
Cave Spring	S	—	S	LS
GLEN CANYON NATIONAL RECREATION AREA				
Bouy 114A Spring	D, R	DS, SW	S	LS
Bouy 114B Spring	S	SW	P2	SW
Buoy 73 Garden	B, D	BW, DS	ST	LP
Bowns Canyon Garden	B, D, P	BW, DS, WL	S, P2	M, LS, SS, SW
Cottonwood Canyon Garden	D, P	SW, WL	P2	SS, SW
Cow Canyon Garden A	B, P	SW, WL	P2	SS, SW
Cow Canyon Garden B	D	SW	P2	SS, SW
Cow Canyon Garden C	B, D, P	SW, WL	S, P2	SS, SW, LS
Easter pasture Canyon Garden	B, D, P	BW, DS, SW	P2	SW
Escalante River Spring A	D, R	SW	S	M, LS
Escalante River Spring B	D, R	DS	S	M, LS
Escalante River Spring C	S	SW	S	M
Forgotten Canyon Spring	S	SW	ST	LP
Good Hope Bay Spring A	S	SW	ST	LP
Good Hope Bay Spring B	S	SW	ST	LP
Good Hope Bay Spring C	S	SW	ST	LP
Good Hope Bay Spring D	S	SW	ST	LP
Gypsum Canyon Spring	S	SW	ST, P2	SW
Knowles Canyon Garden	B, D	BW, DS, SW	S, P2	LS, SW
Last Chance Spring	S	SW	ST	LP
Long Canyon Spring	D, P	SW, WL	S, P2, ST	M, LS, SS, SW
Moqui Canyon Spring	S, R	DS	P2, ST	SS, SW
Rana Canyon Garden	B, D, P	BW, DS, SW, WL	S, P2, ST	M, LS, SS, SW
Ribbon Canyon, Grand Daddy Spring	B, D, P	BW, DS, SW, WT	S, P2	M, C, SS, SW
San Juan Garden	B, D	DS	S, P2	LS, SS
Stevens Arch Garden	B, D	BW, DS		
Swett Canyon Spring	S	SW	P2	SW

Table 4 Summary of physical setting, vegetation types, invertebrate habitats and invertebrate microhabitats – (*Continued)*

[D, detritus slopes; B, backwall; S, spring/soil; P, plunge pool; R, sloping slickrock; BW, hanging garden backwall herbaceous vegetation; DS, hanging garden detritus slope herbaceous vegetation; DS, hanging garden detritus slope herbaceous vegetation; SW, spring-associated woodland; WL, wetland/marsh; SP, spring with good flow and stream outlet; P1, pool isolated from spring/seep source except during high flows; P2, pool which is part of a spring compex under most flows; ST, stream or rivulet; M, madicolous; LS, laminar seepage over bare rock, detritus or algae; SS, sediment sample from low velocity habitat; C, Chara sample from low velocity habitat; LP, leaf pack, consisting of allocthonous materials; SW, sweep of pool with net including rock surfaces; —, no data]

Site	Physical setting	Vegetation types	Invertebrate habitats	Invertebrate microhabitats
GRAND CANYON NATIONAL PARK				
Bert's Canyon	B, D	BW, DS, SW	P2, SP	SS
Cove Canyon	B	BW	S	M
Deer Creek Spring	S	SW	ST, P2	SS
Elves Chasm	B, D	BW, DS	P2, ST, S	M, SW, LS
Fern Glen	B	BW, DS	S, P1	LS, M, SW
Hance Rapid Spring	B, D, P	BW,WL	SP, P	LS, M, SS
Honga Spring	S	—	—	—
Keyhole Spring	B, D	BW, DS	—	—
Ledges	B, D	BW, DS, WL	S, P2	M, SW
Matkatamiba Canyon	B, D, R	BW, DS	—	—
Mohawk Canyon	B	BW	S	M
Nankoweap Twin Springs	S	WL	ST, P2	LP, SS
Pumpkin Spring	S	—	—	—
River Mile 126 Spring	S	SW	S	M, LS
River Mile 142 Seep	B, D	BW, DS	S	M
River Mile 147 Seep	B, D	BW, DS	S	M
River Mile 213 Spring	S	SW	—	—
Saddle Canyon	B	BW, DS	SP	M
Seven Mile Spring	D	DS	SP	M, ST
Slimy Tick Canyon	B, P	BW, WL	S, P2	M, SW, C, LS
MISCELLANEOUS				
Matrimony Spring	S	NONE	—	—