


# Chemical Characteristics of Surface Waters of Great Basin National Park

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United States Department of Interior - National Park Service - Pacific Northwest Region



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Great Basin National Park is a 31,215-ha (77,100-acre) park in the heart of the Great Basin Region in the South Snake Range. Some of the outstanding features of the park are its vistas, high mountains, forests of bristlecone pines (*Pinus longaeva*), limestone caves, riparian areas, and water quality. Water quality in the park is a concern in terms of management of park resources because the high-elevation lakes and streams contain exceptionally pure water and because land uses, such as livestock grazing in the park's drainages, may be adversely affecting water quality. Information about the characteristics of surface waters of Great Basin National Park is limited. Water-quality monitoring in the park by the National Park Service has been conducted since October 1991 with bi-annual measurements of pH and conductivity at the six lakes in the park - Stella, Teresa, Brown, Baker, Johnson, and Dead - and at Strawberry, Lehman, Baker, Snake, South Fork of Big Wash, Pine, Ridge, and Shingle creeks (Pfaff 1991). This monitoring is conducted to provide early warning of any major changes in some basic characteristics of the park's surface waters (Metcalf et al. 1989). Park personnel also have conducted monthly sampling since 1988 to assess concentrations of fecal coliform and fecal streptococci bacteria in untreated surface waters of Lehman Creek and Rowland Springs as specified in the discharge permit for vault toilets and the sewage lagoon system of the park (L. Foster, Great Basin National Park, pers. comm. Jul. 1992). Metcalf et al. (1989) surveyed representative streams and lakes in the park for baseline water quality characteristics during June of 1988 and February, March, and May of 1989. In the summer of 1992, additional reconnaissance-level sampling of water quality was conducted in the park. Results of this sampling are reported here.

### Methods

Water samples were collected at monthly intervals from two sites in the park, one on Lehman Creek and the other on Baker Creek from June through October, 1992. The Baker Creek site was at the intersection of the stream with the park's boundary. The Lehman Creek site was at the intersection of the stream with the park's boundary for the



June collection. It was moved about 100 m upstream for subsequent collections because a dense growth of willow made it difficult to reach the boundary without wading in the stream. These samples were collected by the park's physical science technician, Kurt Pfaff. A minimum of 250 ml of unfiltered water was collected at each site in the early afternoon, transported to park headquarters on ice, frozen for up to two weeks, and shipped to the Cooperative Chemical Analytical Laboratory (CCAL) of the Forest Science Laboratory at Oregon State University for analysis of pH, conductivity, and alkalinity. Collection bottles were rinsed at the collection site with stream water before each sample was taken. Although express shipping services were used, the June samples arrived at CCAL five days after shipment and was not suitable for processing. The July samples arrived in a fully thawed condition and were analyzed. The September and October samples arrived the day following shipment in a partially thawed condition.

During the last two weeks of August, Ruth Jacobs, with assistance from Kurt Pfaff, sampled 18 sites in the park (Table 1). Original intentions were to include sampling at Dry Canyon at its intersection with the park's boundary, but flow there was not sufficient to conduct the sampling. Sampling at Mill Creek was substituted for sampling at Dry Canyon. The time of sampling was early afternoon, with the vast majority of the samples collected between 1:00-2:00 p.m. Two 1-liter bottles and two 150-ml bottles were filled at each sampling site. All stream samples were taken from the bank, with stream samples collected at mid-stream depths and lake samples collected just below the surface. All samples were collected in acid-washed polyethylene bottles supplied by the CCAL. Water temperature was measured at the time of sampling at the same depth at which the sample was taken (Table 1).

Care was taken to collect representative samples at all sites. The liter bottle used to collect the sample from the stream or lake and the two 150-ml bottles were rinsed three times at the collection site with stream or lake water. The 150-ml bottles were then filled with unfiltered water. The liter collection bottle that was rinsed with unfiltered water was used to repeatedly fill the filter head of a Nalgene polysulfone filtering flask. The flask was used to filter samples on site through prewashed glass-fiber filters with a retention of 1.2  $\mu\text{m}$  using a hand pump. Filtered water was used to rinse (three times) both of the liter collection bottles before they were filled with filtered

Table 1. Sample numbers and dates. CPSU and CCAL refer to Coop. Pk. Studies Unit and Coop. Chemical Analytical Lab.

CPSU No.	CCAL No.	Sample Site	Date/Comments	Water Temp (cent.)	
None	101	Baker Creek	Jun. 15	Frozen	8
None	102	Baker Creek	Jun. 15	Frozen	8
None	103	Baker Creek	Jun. 15	Frozen	8
None	104	Baker Creek	Jul. 15	Frozen	5
None	105	Baker Creek	Jul. 15	Frozen	5
None	106	Lehman Creek	Jul. 15	Frozen	5
None	107	Lehman Creek	Jul. 15	Frozen	5
GRBA 1	108	S. Fk. Baker Ck	Aug. 18	Frozen	13
GRBA 2	109	Timber Creek	Aug. 18	Frozen	15
GRBA 3	110	S. Fk. Big Wash	Aug. 19	Frozen	15
GRBA 4	111	Shingle Creek	Aug. 20	Frozen	11
GRBA 5	112	Shingle Creek	Aug. 20	Frozen	11
GRBA 6	113	Williams Creek	Aug. 21	Frozen	8
GRBA 7	114	Strawberry Creek	Aug. 22	Frozen	15
GRBA 8	115	Strawberry Creek	Aug. 22	Frozen	15
GRBA 9	116	Brown Lake	Aug. 23	Frozen	18
GRBA 10	117	Teresa Lake	Aug. 23	Frozen	15
GRBA 11	118	Stella Lake	Aug. 23	Frozen	14
GRBA 12	119	Baker Creek	Aug. 25	Frozen	12
GRBA 13	120	Lehman Creek	Aug. 25	Frozen	12
GRBA 14	121	Baker Lake	Aug. 26	Frozen	11
GRBA 15	122	Johnson Lake	Aug. 27	Frozen	13
GRBA 16	123	Dead Lake	Aug. 27	Frozen	16
GRBA 17	124	Mill Creek	Aug. 28	Frozen	13
GRBA 19	125	Pine Creek	Aug. 29	Frozen	7
GRBA 20	126	Ridge Creek	Aug. 29	Frozen	7
GRBA 23	127	Snake Creek	Aug. 30	Fresh	10
GRBA 24	128	Lehman Creek	Aug. 30	Fresh	not measured
GRBA 27	129	Corvallis	Sept. 1	Fresh	not measured
GRBA 22	130	Snake Creek	Aug. 30	Frozen	10
GRBA 22A	131	Snake Creek	Aug. 30	Frozen	10
GRBA 25	132	Lehman Creek	Aug. 30	Frozen	not measured
GRBA 26	133	Corvallis	Sept. 1	Frozen	not measured
None	134	Baker Creek	Sept. 15	Frozen	12
None	135	Lehman Creek	Sept. 15	Frozen	14
None	136	Baker Creek	Oct. 16	Frozen	8
None	137	Lehman Creek	Oct. 16	Frozen	9

water. Following sampling at each site, the filter head and flask were washed and rinsed with deionized water.

Samples were placed on ice and transported to park headquarters where they were frozen, with the exceptions noted below. Immediately prior to freezing, a small volume of water was poured from each bottle to allow for expansion. Some of this filtered water from each site was used to fill a 125-ml bottle that contained a small amount of nitric acid ( $\text{HNO}_3$ ). The bottles with  $\text{HNO}_3$  were always maintained separate from the other collection supplies to avoid contamination. The acid-fixed samples, which were never frozen, were submitted for trace metal analyses.

Three laboratories participated in sample analyses: The CCAL, where all samples were initially shipped; the U.S. Environmental Protection Agency (EPA) Research Laboratory, Corvallis; and University of Washington, Forest Resources Laboratory, Seattle. A summary of the analyses is presented in Table 2.

To compare the effect of freezing on samples, two sets of duplicate filtered samples were collected and maintained on ice for two days while the samples were transported from the park to Corvallis, Oregon. An additional set of samples contained water from a site in Corvallis. One of each of these sets was frozen for two weeks and then analyzed. The fresh sample from each set was kept refrigerated and analyzed on the third day after collection. For purposes of quality control, duplicate samples were collected at two sampling sites in the park and subjected to equal treatment. Additional duplicate analyses were performed by the various laboratories.

A rough estimate of discharge was made at each sampling site by measuring the width of the wetted channel, the depth of the channel at increments across the width, and the time for a small leaf to float 1 m downstream. Discharge was estimated by multiplying the average channel depth times the channel width times the surface velocity times a correction factor of 0.8 (R. Beschta, Oregon State Univ., pers. comm. Feb. 1993). The correction factor was incorporated because surface velocity was presumed to be faster than velocity at depths in the stream channel.



Table 2. Sample analysis description.

Analysis	Method <sup>1</sup> /Modifications (Chemical form, Detection Limit)
<b><u>Cooperative Chemical Analytical Laboratory</u></b>	
Alkalinity	403, Procedure 4c, titrate to pH 4.5; modifications: use 0.02N Na <sub>2</sub> CO <sub>3</sub> , use 0.02N H <sub>2</sub> SO <sub>4</sub> (HCO <sub>3</sub> -C, 0.2 mg/l)
Ammonia-nitrogen	417F (NH <sub>3</sub> -N, 0.005 mg/l)
Conductivity	205; Wheatstone bridge (0.4 μS/cm)
Nitrate-nitrogen	418F, Technicon Industrial Method 100-70W; different formulations for color and ammonium chloride. (NO <sub>3</sub> -N, 0.001 mg/l)
Nitrogen, total Kjeldahl	Kjeldahl digestion, H <sub>2</sub> SO <sub>4</sub> , CuSO <sub>4</sub> /KCl, Nessler finish. (TKN, 0.010 mg/l)
pH	423; Calomel reference electrode, glass pH electrode, temperature compensator (0-14 pH units)
Phosphate-Ortho	424F; modifications: ascorbic acid reagent, 2g/100ml (PO <sub>4</sub> -P, 0.001 mg/l)
Phosphorus-Total	424C, 424F; modifications: microwave digestion-60 min, 50-ml analysis volume, ascorbic acid reagent 2g/100ml (P, 0.001 mg/l)
Sodium	303A, flame atomic absorption spectroscopy (Na, 0.01 mg/l)
Potassium	303A, flame atomic absorption spectroscopy (K, 0.03 mg/l)
Calcium	303A, flame atomic absorption spectroscopy; modifications: nitrous oxide/acetylene flame since May 1978, addition of 1 ml 50,000 mg/l lanthanum oxide to 10 ml sample to control ionization (Ca, 0.06 mg/l)
Magnesium	303A, flame atomic absorption spectroscopy (Mg, 0.001 mg/l)
Total Dis. Solids	Total filtrable residue (TDS, 0.1 mg/l)
<b><u>University of Washington Laboratory</u></b>	
Chloride	Technicon Industrial Method 99-70W (Cl, 0.200)
Sulfate	Technicon Industrial Method 105-72W (SO <sub>4</sub> -S, 0.200)
<b><u>Environmental Protection Agency Laboratory</u></b>	
EPA's Induction Coupled Plasma Atomic Emissions Spectrophotometer is used to determine concentrations of the following components:	
Calcium (Ca, 0.005)	Magnesium (Mg, 0.015)
Potassium (K, 0.050)	Sodium (Na, 0.020)
Sulfur (S, 0.015)	Phosphorus (P, 0.045)
Silica (Si, 0.015)	Iron (Fe, 0.003)
Manganese (Mn, 0.001)	Zinc (Zn, 0.002)
Aluminum (Al, 0.025)	Boron (B, 0.005)
Copper (Cu, 0.002)	Cadmium (Cd 0.002)
Chromium (Cr, 0.004)	Nickel (Ni, 0.006)
Arsenic (As, 0.015)	Antimony (Sb, 0.025)
Lead (Pb, 0.025)	Molybdenum (Mo, 0.004)
Titanium (Ti, 0.004)	Tin (Sn, 0.010)
Strontium (Sr, 0.001)	

<sup>1</sup> Numbers refer to Standard Methods for the Examination of Water and Wastewater 15th Edition, 1980.

## Results and Discussion

### Data Accuracy and Completeness

Accuracy and completeness of the major ionic constituents for stream and lake samples were checked by the following calculated parameters: cation-anion balance, calculated versus measured conductivity, calculated versus measured alkalinity, and theoretical versus measured pH (laboratory). To enable comparisons, values were computed for the pooled data (streams and lakes together) and separately for streams and for lakes.

Cation-anion balance was expressed as a cation/anion ratio and was computed from equivalent sums of the predominant cations ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ , and  $\text{NH}_4^+$ ) and predominant anions ( $\text{HCO}_3^-$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ , and  $\text{NO}_2^-$ ). A value of 1.0 for this ratio indicates that no predominant cations or anions have been omitted or that a balance of omissions has occurred, and that determined concentrations are accurate or that inaccuracies are balanced. For the pooled data for samples collected in the park, the average value was 1.02 with a standard deviation of 0.08 (Table 3). This provided strong evidence that the major cation and anion data were complete and accurate.

Calculated conductivity was computed as the sum of the ionic conductances of the major cations and anions. Hydrogen and hydroxide ions were not included. The ratio of calculated to measured conductivity (corrected to 25°C) was computed. A value of 1.0 for this ratio indicates that no major ions were omitted. For the pooled data for the samples collected in the park, the average value of this ratio was 1.03 with a standard deviation of 0.15 (Table 3). This provided further support that the major cation and anion data were complete and accurate.

Calculated alkalinity was computed from the difference of the sum of major (base) cations and the sum of acid anions ( $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ , and  $\text{NO}_3^-$ ). The ratio of calculated to measured alkalinity was computed. A value of 1.0 for this ratio indicates that alkalinity has been accurately determined and that no acidification of the water has occurred. For the pooled data from the park, the average value of this ratio was 1.02 with a standard deviation of 0.08 (Table 3), further evidence of the accuracy and completeness of the data.

Table 3. Calculated parameters and ratios of calculated to measured parameters for pooled stream and lake data.<sup>1</sup>

	Cation		Anion		Calc. Cat		Calc. An		Calc. Tot		Ratio		Cb-Ca		Meas		Calc./Meas		Calc. pH			
	Sum	meq/l	Sum	meq/l	Conc.	$\mu\text{S/cm}$	Conc.	$\mu\text{S/cm}$	Conc.	$\mu\text{S/cm}$	Calc./An	Conc.	Calc./Meas	Calc. Alk	meq/l	Alk	meq/l	Ratio	Alk	meq/l	Ratio	
Number	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Average	0.90	0.83	0.83	39.47	90.04	90.04	39.47	90.04	90.04	1.02	1.02	1.03	1.03	0.83	0.76	0.76	0.76	1.02	0.76	0.76	1.02	0.10
Max	4.62	3.58	3.58	164.38	430.60	430.60	164.38	430.60	430.60	1.29	1.29	1.63	1.63	4.46	3.42	3.42	3.42	1.31	3.42	3.42	1.31	1.25
Min	0.14	0.15	0.15	7.93	15.51	15.51	7.93	15.51	15.51	0.90	0.90	0.80	0.80	0.12	0.13	0.13	0.13	0.88	0.13	0.13	0.88	-1.23
Std. Dev.	0.97	0.81	0.81	37.57	92.87	92.87	37.57	92.87	92.87	0.08	0.08	0.15	0.15	0.93	0.76	0.76	0.76	0.08	0.76	0.76	0.08	0.46
Variance	0.95	0.65	0.65	1411.79	8624.78	8624.78	1411.79	8624.78	8624.78	0.01	0.01	0.02	0.02	0.87	0.58	0.58	0.58	0.01	0.58	0.58	0.01	0.21

<sup>1</sup> Values used for the calculated and measured parameters are listed in Appendix I.



Calculated pH was computed assuming carbonate equilibrium with an atmospheric CO<sub>2</sub> concentration of 0.03% (300 ppm). The difference between calculated and laboratory-measured pH was computed. A value of 0.0 for this difference indicates that carbonate buffering is the predominant control of solution pH and that pH was determined accurately. For the pooled data, the average difference was 0.10 pH units with a standard deviation of 0.46 (Table 3). This substantiated the dominant role of the carbonate buffering system and indicated that no other weak acid-base systems were important in pH buffering of these waters.

Metals analyzed by induction coupled plasma emission spectroscopy (ICP) were checked for accuracy by comparison of major cation concentrations with those determined by atomic absorption spectroscopy (AAS). In general, ICP metals concentrations were nearly three times higher than those of AAS. Cation/anion ratio computed using ICP-determined cations yielded an average value of 2.73 for all pooled data, compared to 1.02 for AAS-determined cations. It was apparent that ICP metals, based on the major cation determinations, were not accurate. Furthermore, a field duplicate for water sampled from Shingle Creek further indicated that ICP metals determinations were not precise because nearly all metals differed by a factor of two or more. A check was made of possible contamination of samples by the nitric acid used to fix samples in the field and results were negative, indicating no unexpected contamination. All ICP-determined metals were thus suspect. Further discussion of possible trace metal toxicity based on these data is speculative.

### Fresh Versus Frozen Samples

The chemistry data for the three fresh (unfrozen) samples showed similar values for the three frozen samples (Table 4). The practice of freezing samples to facilitate their transport was not considered to be detrimental to the intent of the study.

### Comparison of Lakes and Streams

Lake chemistry and stream chemistry data were pooled separately and compared to each other and to other lake and stream chemistry data (Tables 5-8). Lakes and streams in the park were found to represent different hydrogeochemical patterns. Using



Table 4. Comparison of fresh versus frozen samples.

Location	Total Kjehl-N mg/l	Unfiltered Total P mg/l	Dslvd. PO4-P mg/l	NO3-N + NO2-N mg/l	NH3-N mg/l	pH	Alkal HCO3-C mg/l	Cond. $\mu$ S/cm per cm	Dslvd NA mg/l	Dslvd K mg/l	Dslvd CA mg/l	Dslvd MG mg/l	Dslvd CL mg/l	Dslvd SO4-S mg/l	TDS mg/l
Lehman Creek (fresh)	0.08	0.007	0.003	0.144	0.010	7.5	3.89	36.6	1.36	0.40	4.13	0.884	0.60	0.51	24
Lehman Creek (frozen)	0.07	0.018	0.005	0.149	0.006	8.0	3.97	37.9	1.33	0.43	4.27	0.927	0.57	0.50	27
Snake Creek (fresh)	0.03	0.011	0.002	bd	0.005	8.4	23.63	213.7	5.47	0.66	32.80	3.260	4.48	1.78	123
Snake Creek (frozen)	0.04	0.012	0.004	bd	0.004	8.1	22.29	171.7	5.36	0.69	31.6	3.285	4.55	1.72	129
Corvallis (fresh)	0.06	0.147	0.115	0.011	0.01	7.6	15.26	161.6	33.8	0.07	0.06	0.009	4.28	4.49	139
Corvallis (frozen)	0.03	0.161	0.097	0.012	0.005	7.6	15.30	161.6	34.1	0.1	0.06	0.011	4.24	4.48	135

Table 5. Chemical characteristics of streams of the park with field and laboratory duplicates deleted.<sup>1</sup>

Location	Total Kjcl.-N mg/l	Unfilter Total P mg/l	Dslvd PO4-P mg/l	NO3-N + NO2-N mg/l	NH3-N mg/l	pH	Alkal HCO3-C mg/l	Cond $\mu$ S/cm per cm	Dslvd NA mg/l	Dslvd K mg/l	Dslvd CA mg/l	Dslvd MG mg/l	Dslvd C1 mg/l	Dslvd SO4-S mg/l	Dslvd Solids mg/l
Strawberry Ck	0.07	0.046	0.019	0.003	0.008	8.0	13.6	121	4.94	0.80	16.65	3.480	2.53	1.24	88
Mill Ck	0.16	0.020	0.009	bd	0.005	7.8	6.25	62.4	2.83	0.69	6.20	1.645	1.78	0.9	55
Lehman Ck	0.07	0.020	0.004	0.117	0.009	7.5	3.72	35.1	1.30	0.31	3.85	0.809	0.51	0.49	28
Baker Ck	0.07	0.020	0.005	0.036	0.010	7.5	3.50	35.5	1.58	0.37	3.70	0.764	0.82	0.80	24
S. Fk. Baker Ck	0.04	0.025	0.007	0.006	0.005	8.3	4.73	44.9	2.58	0.46	4.82	0.847	0.77	0.63	46
Timber Ck	0.14	0.027	0.007	0.034	0.012	8.6	15.6	148	7.75	0.99	19.75	3.260	4.42	1.93	114
S. Fk Big Wash	0.03	0.015	bd	0.052	0.008	7.6	41	264	3.02	0.53	65.80	14.390	3.00	3.4	483
Snake Ck	0.04	0.01	0.004	bd	0.004	8.1	22.3	172	5.36	0.69	31.55	3.285	4.55	1.72	129
Shingle Ck	0.05	0.020	0.007	0.007	0.006	8.2	8.00	71.0	1.82	0.36	10.02	1.748	0.67	0.88	56
Pine Ck	0.05	0.020	0.006	0.046	0.004	7.7	3.69	35.1	1.14	0.24	4.07	0.864	0.43	0.67	31
Ridge Ck	0.03	0.019	0.014	0.242	bd	7.6	3.89	39.7	1.17	0.44	4.43	0.990	0.48	0.74	30
Williams Ck	0.09	0.018	0.007	0.053	0.007	7.5	3.72	40.6	1.46	0.36	4.84	0.701	0.47	1.25	31
Number	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Average	0.07	0.022	0.007	0.050	0.007	7.87	10.83	89.08	2.91	0.52	14.64	2.73	1.70	1.22	92.92
Max	0.16	0.046	0.019	0.242	0.012	8.60	41.01	264.30	7.75	0.99	65.80	14.39	4.55	3.40	483.00
Min	0.03	0.012	0.000	0.000	0.000	7.50	3.50	35.10	1.14	0.24	3.70	0.70	0.43	0.49	24.00
Std. Dev.	0.04	0.008	0.005	0.066	0.003	0.35	10.77	69.80	1.99	0.22	17.49	3.66	1.49	0.78	122.31
Variance	0.002	0.000	0.000	0.004	0.000	0.12	116.05	4872.20	3.96	0.05	305.88	13.42	2.22	0.61	14960.58

<sup>1</sup> bd signifies below detection limits.

Table 6. Chemical characteristics of lakes of the park with field and laboratory duplicates deleted.<sup>1</sup>

Location	Date 1993	Total Kjehl-N mg/l	Unfilter Total P mg/l	Dslvd PO4-P mg/l	NO3-N + NO2-N mg/l	NH3-N mg/l	pH	Alkal HCO3-C mg/l	Cond $\mu$ S/cm per cm	Dslvd NA mg/l	Dslvd K mg/l	Dslvd CA mg/l	Dslvd MG mg/l	Dslvd Cl mg/l	DslvdS SO4-S mg/l	Dslvd Solids mg/l
Brown Lk	Aug 23	0.39	0.012	0.002	0.025	0.019	7.6	2.34	26.1	1.01	0.76	2.41	0.629	0.82	0.51	25
Teresa Lk	Aug 23	0.25	0.019	0.009	0.235	0.051	7.7	1.87	19.9	0.55	0.31	2.09	0.449	0.31	0.44	20
Stella Lk	Aug 23	0.22	0.011	bd	0.003	0.014	7.7	3.79	34.4	1.16	0.50	4.02	0.643	0.49	0.32	20
Baker Lk	Aug 26	0.17	0.034	0.003	bd	0.007	7.4	1.58	15.4	0.60	0.34	1.55	0.314	0.46	0.44	14
Johnson Lk	Aug 27	0.14	0.022	bd	0.006	0.004	9.0	3.35	39.7	0.77	0.05	5.14	0.310	0.09	0.38	33
Dead Lk	Aug 27	0.52	0.031	0.002	0.003	0.012	7.2	1.87	20.1	0.96	0.63	1.85	0.349	0.40	0.54	25
Number		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Average		0.28	0.022	0.003	0.045	0.018	7.77	2.47	25.93	0.84	0.43	2.84	0.45	0.43	0.44	22.83
Max		0.52	0.034	0.009	0.235	0.051	9.00	3.79	39.70	1.16	0.76	5.14	0.64	0.82	0.54	33.00
Min		0.14	0.011	0.000	0.000	0.004	7.20	1.58	15.40	0.55	0.05	1.55	0.31	0.09	0.32	14.00
Std. Dev.		0.13	0.009	0.003	0.085	0.016	0.58	0.82	8.59	0.22	0.23	1.30	0.14	0.22	0.07	5.87
Variance		0.02	0.000	0.000	0.007	0.000	0.34	0.67	73.77	0.05	0.05	1.68	0.02	0.05	0.01	34.47

<sup>1</sup> bd signifies below detection.

Table 7. Calculated parameters for stream data. The measurements used for these calculations are the August data reported in Table 5.

Location	Cation Sum meq/l	Anion Sum meq/l	Calc.Cat Cond. $\mu\text{S}/\text{cm}$	Calc.An Cond $\mu\text{S}/\text{cm}$	Calc.Tot Cond $\mu\text{S}/\text{cm}$	Calc. TDS mg/l	%TDSdef Ms-Cal/Ms %	Calc. Ion.Str. nM	1x100/Cond (= ?2.0)	Ratio Cat/An	Ratio Calc/Meas Cond
Strawberry Ck	1.355	1.231	77.01	57.97	134.98	99	-12	3.010	2.5	1.10	1.12
Mill Ck	0.587	0.590	33.10	28.49	61.59	46	17	1.284	2.1	0.99	0.99
Lehman Ck	0.324	0.343	18.41	16.29	34.70	26	6	0.737	2.1	0.95	0.99
Baker Ck	0.327	0.334	18.49	16.25	34.73	26	-8	0.727	2.0	0.98	0.98
S. Fk. Baker Ck.	0.435	0.429	24.53	20.27	44.80	34	26	0.918	2.0	1.01	1.00
Timber Ck	1.619	1.465	91.76	70.64	162.39	117	-3	3.486	2.4	1.11	1.10
S. Fk Big Wash	4.620	3.575	266.22	164.38	430.60	299	38	10.915	4.1	1.29	1.63
Snake Ck	2.099	2.021	121.20	95.27	216.47	160	-24	4.885	2.8	1.04	1.26
Shingle Ck	0.734	0.704	42.09	32.59	74.68	56	0	1.714	2.4	1.04	1.05
Pine Ck	0.331	0.337	18.82	15.95	34.77	26	15	0.766	2.2	0.98	0.99
Ridge Ck	0.365	0.370	20.88	17.91	38.79	28	6	0.845	2.1	0.99	0.98
Williams Ck	0.373	0.353	21.32	17.14	38.47	28	10	0.851	2.1	1.06	0.95
Number	12	12	12	12	12	12	12	12	12	12	12
Average	1.10	0.98	62.82	46.10	108.91	78.84	5.81	2.51	2.41	1.04	1.09
Max	4.62	3.58	266.22	164.38	430.60	298.66	38.17	10.91	4.13	1.29	1.63
Min	0.32	0.33	18.41	15.95	34.70	25.86	-24.39	0.73	2.04	0.95	0.95
Std. Dev.	1.20	0.94	69.49	43.43	112.73	78.50	16.35	2.84	0.57	0.09	0.18
Variance	1.45	0.89	4829.35	1886.06	12708.30	6161.64	267.26	8.09	0.32	0.01	0.03



Table 7. (continued)

Location	Cb-Ca Calc/Alk. meq/l	Meas. Alk. meq/l	Calc./Meas Alk. Ratio	Calc. pH	Calc.pH -Meas. pH	TKN+NO3/ Tot. P molar ratio	NH3+NO3/ Tot. P molar ratio	NH3+NO3/ PO4-P molar ratio
Strawberry Ck	1.26	1.13	1.11	8.37	0.37	3.5	0.5	1.3
Mill Ck	0.52	0.52	0.99	8.04	0.24	17.7	0.6	1.2
Lehman Ck	0.29	0.31	0.94	7.81	0.31	20.7	14.0	69.8
Baker Ck	0.28	0.29	0.97	7.78	0.28	11.7	5.1	20.4
S. Fk. Baker Ck.	0.40	0.39	1.01	7.92	-0.38	4.1	1.0	3.5
Timber Ck	1.45	1.30	1.12	8.43	-0.17	14.3	3.8	14.6
S. Fk Big Wash	4.46	3.42	1.31	8.85	1.25	12.1	8.9	bd
Snake Ck	1.93	1.86	1.04	8.59	0.49	7.4	0.7	2.2
Shingle Ck	0.70	0.67	1.04	8.14	-0.06	6.3	1.4	4.1
Pine Ck	0.30	0.31	0.98	7.81	0.11	10.6	5.5	18.5
Ridge Ck	0.32	0.32	0.98	7.83	0.23	31.7	28.2	38.3
Williams Ck	0.33	0.31	1.06	7.81	0.31	17.6	7.4	19.0
Number	12	12	12	12	12	12	12	12
Average	1.02	0.90	1.05	8.12	0.25	13.14	6.42	16.06
Max	4.46	3.42	1.31	8.85	1.25	31.70	28.20	69.75
Min	0.28	0.29	0.94	7.78	-0.38	3.51	0.53	0.00
Std. Dev.	1.16	0.90	0.09	0.35	0.39	7.68	7.66	19.58
Variance	1.35	0.81	0.01	0.12	0.15	58.97	58.62	383.35

Table 8. Calculated parameters for lake data. The measurements used for these calculations are the data reported in Table 6.

	Cation Sum meq/l	Anion Sum meq/l	Calc.Cat Cond $\mu\text{S}/\text{cm}$	Calc.An Cond $\mu\text{S}/\text{cm}$	Calc.Tot Cond $\mu\text{S}/\text{cm}$	Calc. TDS mg/l	%TDSdef MS-Ca/Ms %	Calc. Ion.Str. mM	Ix100/Cond (= ?2.0)	Ratio Cat/An	Ratio Calc/Meas Cond
Brown Lk	0.237	0.230	13.55	11.41	24.96	18	28	0.508	1.9	1.03	0.96
Teresa Lk	0.177	0.190	9.96	9.52	19.48	14	31	0.410	2.1	0.93	0.98
Stella Lk	0.318	0.336	18.24	15.65	33.89	26	-32	0.718	2.1	0.95	0.99
Baker Lk	0.139	0.154	7.93	7.58	15.51	12	16	0.315	2.0	0.90	1.01
Johnson Lk	0.318	0.290	18.42	13.27	31.69	24	28	0.739	1.9	1.10	0.80
Dead Lk	0.180	0.178	10.31	8.70	19.01	14	43	0.378	1.9	1.01	0.95
Number	6	6	6	6	6	6	6	6	6	6	6
Average	0.23	0.23	13.07	11.02	24.09	18.02	18.91	0.51	1.98	0.98	0.95
Max	0.32	0.34	18.42	15.65	33.89	26.40	43.05	0.74	2.09	1.10	1.01
Min	0.14	0.15	7.93	7.58	15.51	11.74	-32.01	0.31	1.86	0.90	0.80
Std. Dev.	0.07	0.06	4.07	2.77	6.77	5.39	24.08	0.16	0.09	0.07	0.07
Variance	0.00	0.00	16.54	7.69	45.87	29.04	579.77	0.03	0.01	0.00	0.00

Table 8. (continued)

	Cb-Ca CalcAlk. meq/l	Meas. Alk. meq/l	Calc./Meas. Alk. Ratio	Calc. pH	Calc.pH -Meas. pH	TKN+NO3/ Tot. P molar ratio	NH3+NO3/ Tot. P molar ratio	NH3+NO3/ PO4-P molar ratio
Brown Lk	0.20	0.20	1.03	7.61	0.01	76.6	8.1	48.7
Teresa Lk	0.14	0.16	0.89	7.51	-0.19	56.5	33.3	70.4
Stella Lk	0.30	0.32	0.94	7.82	0.12	44.9	3.4	bd
Baker Lk	0.12	0.13	0.88	7.44	0.04	11.1	0.5	5.2
Johnson Lk	0.31	0.28	1.10	7.77	-1.23	14.7	1.0	bd
Dead Lk	0.16	0.16	1.00	7.51	0.31	37.4	1.1	16.6
Number	6	6	6	6	6	6	6	6
Average	0.20	0.21	0.97	7.61	-0.16	40.19	7.90	23.48
Max	0.31	0.32	1.10	7.82	0.31	76.58	33.33	70.37
Min	0.12	0.13	0.88	7.44	-1.23	11.07	0.46	0.00
Std. Dev.	0.07	0.07	0.08	0.14	0.50	22.80	11.66	26.83
Variance	0.01	0.00	0.01	0.02	0.25	519.80	136.07	720.04

calculated ionic strength to represent total ionic composition, the average stream ionic strength was 2.51 mM (standard deviation 2.84 mM) (Table 7) while that of the lakes was 0.51 mM (standard deviation 0.16 mM) (Table 8), a ratio of nearly 5 to 1. Lakes in the park were generally at high elevations with small watersheds in areas with little soil development and sparse vegetation. Precipitation thus has relatively short retention times in the watersheds with resultant less opportunity for neutralization with base minerals. Karst geology is also not found at higher elevation in the park. Streams represent an integration of waters from larger and more complex watersheds than those of lakes in the park. Greater residence times in watersheds provide greater opportunity for reaction of precipitation with basic minerals, resulting in higher dissolved solids, conductivity, and ionic strength. Reflective of this are the average alkalinity values, 0.21 meq/l for lakes and 0.90 meq/l for streams. A greater variability in stream chemistry was also evidenced compared to that of lakes, as illustrated by the much greater relative standard deviation (standard deviation/mean) for ionic strength of 113% for streams compared to 31% for lakes.

In terms of the distributions of ions in lakes and streams, calcium and magnesium represent a greater fraction of base cations in streams than in lakes, while anion distributions were similar in lakes and streams. The higher relative importance of calcium and magnesium in streams than in lakes is consistent with a watershed geology more strongly influenced by limestone mineralogy.

Compared with Rocky Mountain lakes of Colorado, Wyoming, Utah, and Idaho (Turk and Spahr 1991), lakes in Great Basin National Park are higher in average alkalinity, cation sum, and anion sum by factors of about two (100% greater). Compared with Sierra Nevada lakes of California and western Nevada (Melack and Stoddard 1991), the park's lakes are higher in average alkalinity, cation sum, and anion sum by factors of about three (200% greater). Thus, lakes in the park are higher in dissolved mineral content and buffering capacity than those in mountain ranges in neighboring western states. However, lakes in the park are in the moderate sensitivity range in terms of susceptibility to acid deposition (Hendry et al. 1980, Nelson and Delwiche 1983). Empirical analysis of the park data using the methods of Munson and Gherini (1991)



indicated no detectable acidification of park lakes based on the data set in this report (results not presented).

Based on the August sampling, nutrient concentrations in streams and lakes of the park were generally low to moderate and may in some locations be indicative of contamination (Table 5). In streams, average nutrient concentrations were 70  $\mu\text{g}/\text{l}$  for Kjeldahl-nitrogen, 50  $\mu\text{g}/\text{l}$  for nitrate-N, and 22  $\mu\text{g}/\text{l}$  for total phosphorus. Nitrate concentrations in streams were highly variable, ranging from below detection (LLD = 1  $\mu\text{g}/\text{l}$ ) in Snake Creek to 242  $\mu\text{g}/\text{l}$  in Ridge Creek. Lehman Creek nitrate was also relatively elevated at 117  $\mu\text{g}/\text{l}$ . Kjeldahl-nitrogen concentrations were elevated in Mill Creek (160  $\mu\text{g}/\text{l}$ ) and Timber Creek (140  $\mu\text{g}/\text{l}$ ). Phosphorus concentration was elevated in Strawberry Creek (46  $\mu\text{g}/\text{l}$ ).

For the lakes, average nutrient concentrations were 280  $\mu\text{g}/\text{l}$  for Kjeldahl-nitrogen, 45  $\mu\text{g}/\text{l}$  for nitrate, and 22  $\mu\text{g}/\text{l}$  for total phosphorus. The average nitrate concentration was skewed by one high value for Teresa Lake (235  $\mu\text{g}/\text{l}$ ) (Table 6). The average nitrate-N concentration excluding Teresa Lake was 8  $\mu\text{g}/\text{l}$ . Phosphorus appears to be the limiting nutrient for the lakes. The mean molar ratio of total nitrogen (Kjeldahl plus nitrate-nitrogen) to total phosphorus was 40 to 1 (Table 8). This was well above the Redfield ratio of 16 to 1, indicating an excess of nitrogen relative to phosphorus required for algal growth. However, for Baker Lake this ratio was 11 to 1, and for Johnson Lake this ratio was nearly balanced at 15 to 1. Overall, more seasonal data and nutrient uptake studies are required to substantiate the limiting nutrient for the lakes.

Metals concentrations were generally low and below detection limits (Tables 9 and 10). For a few metals, moderately elevated concentrations were detected in some streams and lakes. Metals for which some elevated concentrations were detected included copper, chromium, and aluminum. In no cases were drinking water or aquatic toxicity criteria exceeded. Due to the uncertainty in the metals analyses by ICP reported in this study, further testing of park waters for metals at a future date is recommended, especially considering the possibility of contamination from past and present mining activities in the park.

Table 9. ICP analysis of trace metals (mg/l) in streams of Great Basin National Park.

Location	Ca	Mg	K	Na	S	P	Si	Fe	Mn	Zn	Al	
Strawberry	37.779	8.104	1.53	10.57	2.134	bd	0.352	0.284	0.008	0.12	bd	
Mill	16.022	4.407	1.38	6.509	1.609	bd	0.17	0.329	0.009	0.116	0.301	
Lehman	9.448	2.089	bd	2.828	0.904	bd	4.697	0.116	bd	0.221	bd	
Baker	11.488	2.505	0.93	4.207	1.633	bd	0.298	0.148	0.003	0.146	bd	
S. Fork Baker	14.519	2.838	1.08	7.376	1.423	bd	0.261	0.140	bd	0.207	0.181	
Timber	48.879	8.346	1.88	18.026	3.754	bd	0.900	0.072	0.006	0.105	bd	
S. Fork Big Wash	136.97	39.795	1	7.107	8.843	bd	1.246	0.047	bd	0.104	bd	
Snake	102.22	10.463	1.64	15.714	4.429	bd	0.830	0.061	bd	0.147	bd	
Shingle	34.406	6.263	0.94	5.404	2.113	bd	1.527	0.056	0.003	0.169	bd	
Shingle (Dupl.)	16.332	3.002	bd	2.555	0.963	bd	0.468	0.034	bd	0.092	bd	
Pine	14.225	3.21	bd	3.389	1.591	bd	1.195	0.233	0.005	0.183	0.160	
Ridge	10.614	2.514	0.80	2.411	10255	bd	0.294	0.095	bd	0.119	bd	
Williams	14.003	2.124	0.88	3.74	0.578	bd	0.345	0.105	0.004	0.130	0.160	
	B	Cu	Cd	Cr	Ni	As	Sb	Pb	Mo	Ti	Sn	Sr
Strawberry	0.032	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.174
Mill	0.033	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.085
Lehman	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.045
Baker	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.068
S. Fork Baker	0.022	0.017	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.109
Timber	0.039	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.261
S. Fork Big Wash	0.037	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.691
Snake	0.033	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.319
Shingle	0.020	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.117
Shingle (Dupl.)	bd	bd	bd	0.022	bd	bd	bd	bd	bd	bd	bd	0.056
Pine	bd	0.026	bd	0.021	bd	bd	bd	bd	bd	bd	bd	0.062
Ridge	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.049
Williams	bd	0.016	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.071

1. These data are suspect based on cation/anion balance calculations and based on results of the duplicate sample collected at Shingle Creek.  
 2. bd signifies below detection.

Table 10. ICP analysis of trace metals (mg/l) in lakes of Great Basin National Park.

Location	Ca	Mg	K	Na	S	P	Si	Fe	Mn	Zn	Al
Brown Lake	7.347	2.019	1.89	2.631	1.164	bd	0.277	0.24	0.005	0.162	bd
Teresa Lake	3.708	0.882	bd	0.791	0.542	bd	0.366	0.077	0.004	0.131	bd
Stella Lake	17.469	2.934	1.44	3.884	0.938	bd	0.226	0.23	0.012	0.216	bd
Baker Lake	3.010	0.645	bd	0.909	0.635	bd	1.286	0.069	bd	0.093	bd
Johnson Lake	13.586	0.824	bd	1.632	2.853	bd	0.358	0.247	0.010	0.125	bd
Dead Lake	5.775	1.181	1.69	2.785	1.358	bd	0.245	0.252	0.021	0.220	0.169

B	Cu	Cd	Cr	Ni	As	Sb	Pb	Mo	Ti	Sn	Sr
Brown Lake	0.038	0.019	bd	0.036	bd	bd	bd	bd	bd	bd	0.042
Teresa Lake	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.019
Stella Lake	bd	0.026	bd	bd	bd	bd	bd	bd	bd	bd	0.063
Baker Lake	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.015
Johnson Lake	0.021	bd	bd	bd	bd	bd	bd	bd	bd	bd	0.071
Dead Lake	0.040	0.028	bd	bd	bd	bd	bd	bd	bd	bd	0.035

<sup>1</sup> These data are suspect based on cation/anion balance calculations and based on results of the duplicate sample collected at Shingle Creek.

<sup>2</sup> bd signifies below detection

## Changes Over Time

Based on the sampling from mid-July through mid-October, pH, alkalinity, and conductivity increased over time (Table 11). These changes were likely correlated with a decreasing influence of surface flow relative to groundwater flow.

Table 11. Comparison of pH, alkalinity, and conductivity over time.

Location and Date of Collection	pH	Alkalinity HCO <sub>3</sub> -C mg/l	Conductivity $\mu$ S/cm
Lehman Creek			
July 15	7.5	3.28	32.2
August 25	7.5	3.72	35.1
September 15	7.9	4.05	39.0
October 16	8.8	4.40	40.1
Baker Creek			
July 15	7.6	3.28	31.2
August 25	7.5	3.50	35.5
September 15	7.6	3.76	39.0
October 16	8.6	4.01	38.7

## Discharge

Discharge estimates for the streams sampled are reported in Table 12. Gaging stations were operated on Baker and Lehman creeks from December 1947 through September 1955, and the minimum discharges observed during that period were comparable to the estimates developed in this survey (Hood & Rush 1965). The minimum discharges recorded at the gaging station in July, August, September, and October on Lehman Creek were 6.40, 3.66, 2.43, and 2.20 cubic feet per second (cfs), respectively. For the same months, minimum discharge measurement recorded at the gaging station on Baker Creek were 6.4, 3.66, 2.43, and 2.40 cfs, respectively. The gaging



stations were at the "Narrows" on Baker Creek and near the town of Baker on Lehman Creek. Both of these sites are downstream from the sites sampled in this study.

Table 12. Rough estimates of stream discharge. Estimates are based on measurements made in late August 1992 unless indicated otherwise.

Location and sampling dates	Avg. Channel Depth (m) <sup>1</sup>	Wetted Width (m)	Time to float 1 m (min)	Time to float 1 m (sec)	Surface Velocity (m/sec)	Correction Factor	Estimated Discharge (m <sup>3</sup> /sec)	Estimated Discharge (ft <sup>3</sup> /sec)
Strawberry Creek	0.05 (7)	1.2	0.05	3	0.33	0.8	0.02	0.56
Mill Creek	0.07 (4)	0.6	0.16	9.6	0.10	0.8	0.00	0.12
Lehman Creek								
15 Jul.	0.12 (12)	4.1	0.04	2.4	0.42	0.8	0.16	5.79
25 Aug.	0.09 (8)	4.1	0.04	2.4	0.42	0.8	0.12	4.34
15 Sept.	0.12 (7)	3.7	0.08	4.8	0.21	0.8	0.07	2.61
16 Oct.	0.08 (9)	3.5	0.07	4.2	0.24	0.8	0.05	1.88
Baker Creek								
15 Jul.	0.31 (8)	2.6	0.09	5.1	0.20	0.8	0.13	4.46
25 Aug.	0.27 (7)	2.5	0.17	10.2	0.10	0.8	0.05	1.87
15 Sept.	0.28 (8)	2.6	0.19	11.4	0.09	0.8	0.05	1.80
16 Oct.	0.36 (8)	2.7	0.18	10.8	0.09	0.8	0.07	2.54
S. Fork Baker Creek	0.08 (6)	2.3	0.15	9	0.11	0.8	0.02	0.58
Timber Creek	0.14 (5)	0.8						
S. Fork Big Wash	0.05 (6)	1.0	0.14	8.4	0.12	0.8	0.00	0.17
Snake Creek	0.1 (10)	1.8	0.05	3	0.33	0.8	0.05	1.69
Shingle Creek	0.08 (8)	2.1	0.08	4.8	0.21	0.8	0.03	0.99
Pine Creek	0.03 (8)	1.4	0.03	1.8	0.56	0.8	0.02	0.66
Ridge Creek	0.09 (9)	1.5	0.05	3	0.33	0.8	0.04	1.27
Williams Creek	0.08 (6)	1.8	0.04	2.4	0.42	0.8	0.05	1.69

<sup>1</sup> The number in parentheses is the number of depths measured across the channel.

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Appendix I. Complete list of all data from lake and stream sampling conducted in Great Basin National Park from June through October 1992, excluding trace metals analyzed via ICPAES.<sup>1</sup> Blank spaces indicate the characteristic was not sampled.

Lab No. 2	Location	Coll. Date	Total Kjehl. N Mg/l	Unfilter Total-P mg/l	Dstvd PO4-P mg/l	NO3-N NO2-N mg/l	NH3-N mg/l	pH	Alkal HCO3-C mg/l	Cond umtho per cm	Dstvd NA mg/l	Dstvd K mg/l	Dstvd CA mg/l	Dstvd MG mg/l	Dstvd Cl mg/l	Dstvd SO4-S mg/l	Dstvd Solids mg/l
101	Baker Ck	Jun 15	0.11					7.5	3.45	33.4							
102 DF	Baker Ck	Jun 15	0.06					7.5	3.45	34.4							
103 DF	Baker Ck	Jun 15	0.05					7.5	3.47	32.1							
103 DC	Baker Ck	Jun 15						7.5	3.49	33.0							
104	Baker Ck	Jul 15						7.6	3.28	32.2							
105 DF	Baker Ck	Jul 15						7.5	3.28	32.2							
106	Lehman Ck	Jul 15						7.5	3.40	31.2							
107 DF	Lehman Ck	Jul 15						7.5	3.40	31.2							
108	S. Fk. Baker Ck.	Aug 18	0.04	0.025	0.007	0.006	0.005	8.3	4.73	44.9	2.58	0.46	4.82	0.847	0.77	0.63	46
109	Timber Ck	Aug 18	0.14	0.027	0.007	0.034	0.012	8.6	15.58	147.8	7.75	0.99	19.75	3.260	4.42	1.93	114
109 DC	Timber Ck	Aug 18						7.6	41.01	264.3	3.02	0.53	65.80	14.390	3.00	3.4	483
110	S. Fk Big Wash	Aug 19	0.03	0.015	bd	0.052	0.008										
110 DC	S. Fk Big Wash	Aug 19		0.012	bd												
111	Shingle Ck	Aug 20	0.05	0.020	0.007	0.007	0.006	8.2	8.00	71.0	1.82	0.36	10.02	1.748	0.67	0.88	56
111 DC	Shingle Ck	Aug 20					0.006										
112 DF	Shingle Ck	Aug 20	0.04	0.021	0.007	0.006	0.006	8.3	7.73	71.0	1.82	0.35	9.50	1.753	0.66	0.87	54
113	Williams Ck	Aug 21	0.09	0.018	0.007	0.053	0.007	7.5	3.72	40.6	1.46	0.36	4.84	0.701	0.47	1.25	31
114	Strawberry Ck	Aug 22	0.07	0.046	0.019	0.003	0.008	8.0	13.61	120.9	4.94	0.80	16.65	3.480	2.53	1.24	88
115 DF	Strawberry Ck	Aug 22	0.07	0.051	0.019	0.003	0.007	8.2	14.65	124.8	4.95	0.80	16.85	3.430			86
116	Brown Lk	Aug 23	0.39	0.012	0.002	0.025	0.019	7.6	2.34	26.1	1.01	0.76	2.41	0.629	0.82	0.51	25
117	Teresa Lk	Aug 23	0.25	0.019	0.009	0.235	0.051	7.7	1.87	19.9	0.55	0.31	2.09	0.449	0.31	0.44	20
118	Stella Lk	Aug 23	0.22	0.011	bd	0.003	0.014	7.7	3.79	34.4	1.16	0.50	4.02	0.643	0.49	0.32	20
119	Baker Ck	Aug 25	0.07	0.020	0.005	0.036	0.010	7.5	3.50	35.5	1.58	0.37	3.70	0.764	0.82	0.80	24
120	Lehman Ck	Aug 25	0.07	0.020	0.004	0.117	0.009	7.5	3.72	35.1	1.30	0.31	3.85	0.809	0.51	0.49	28
120 DC	Lehman Ck	Aug 25					0.009										
121	Baker Lk	Aug 26	0.07	0.034	0.003	bd	0.007	7.4	1.58	15.4	0.6	0.34	1.55	0.314	0.46	0.44	14



Appendix I  
(continued)

Lab No. <sup>2</sup>	Location	Coll. Date	Total Kjehl. N Mg/l	Unfilter Total-P mg/l	Dstvd PO4-P mg/l	NO3-N NO2-N mg/l	NH3-N mg/l	pH	Alkal HCO3-C mg/l	Cond umho per cm	Dstvd NA mg/l	Dstvd K mg/l	Dstvd CA mg/l	Dstvd MG mg/l	Dstvd Cl mg/l	Dstvd SO4-S mg/l	Dstvd Solids mg/l
122	Johnson Lk	Aug 27	0.14	0.022	bd	0.006	0.004	9	3.35	39.7	0.77	0.05	5.14	0.31	0.09	0.38	33
122 DC	Johnson Lk	Aug 27		0.022		0.003											
123	Dead Lk	Aug 27	0.52	0.031	0.002	0.003	0.012	7.2	1.87	20.1	0.96	0.63	1.85	0.349	0.4	0.54	25
124	Mill Ck	Aug 28	0.16	0.02	0.009	bd	0.005	7.8	6.25	62.4	2.83	0.69	6.2	1.645	1.78	0.9	55
124 DC	Mill Ck	Aug 28									2.85	0.69	6.36	1.689			
125	Pine Ck	Aug 29	0.05	0.02	0.006	0.046	0.004	7.7	3.69	35.1	1.14	0.24	4.07	0.864	0.43	0.67	31
126	Ridge Ck	Aug 29	0.03	0.019	0.014	0.242	bd	7.6	3.89	39.7	1.17	0.44	4.43	0.99	0.48	0.74	30
126 DC	Ridge Ck	Aug 29				0.003											
127	Snake Ck	Aug 30	0.03	0.011	0.002	bd	0.005	8.4	23.63	213.7	5.47	0.66	32.8	3.26	4.48	1.78	123
127 DC	Snake Ck	Aug 30			0.002												
128	Lehman Ck	Aug 30	0.08	0.007	0.003	0.144	0.010	7.5	3.89	36.6	1.36	0.40	4.13	0.884	0.60	0.51	24
129	Corvallis	Sept 1	0.06	0.147	0.115	0.011	0.010	7.6	15.26	161.6	33.8	0.07	0.06	0.009	4.28	4.49	139
129 DC	Corvallis	Sept 1															
131	Snake Ck	Aug 30	0.04	0.012	0.004	0	0.004	8.1	22.29	171.7	5.36	0.69	31.55	3.285	4.55	1.72	129
132	Lehman Ck	Aug 30	0.07	0.018	0.005	0.149	0.006	8.0	3.97	37.9	1.33	0.43	4.27	0.927	0.57	0.5	27
132 DC	Lehman Ck	Aug 30			0.005												
133	Corvallis	Sept 1	0.03	0.161	0.097	0.012	0.005	7.6	15.30	161.6	34.10	0.10	0.06	0.011	4.24	4.48	135
133 DC	Corvallis	Sept 1		0.156													
134	Baker Ck	Sept 15						7.6	3.76	39.0							
135	Lehman Ck	Sept 15						7.9	4.05	39.0							
136	Baker Ck	Oct 16						8.6	4.01	38.7							
136 DC	Baker Ck	Oct 16						8.7	4.01								
137	Lehman Ck	Oct 16						8.8	4.40	40.1							
137 DC	Lehman Ck	Oct 16						40.1									

<sup>1</sup> bd signifies a value below the detection limit of the analytical method used.

<sup>2</sup> DF indicates duplicate field sample and DC indicates a duplicate sample prepared by the processing laboratory using the sample collected in the field.





