National Park Service
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Natural Resource Stewardship and Science

Mojave Desert Network Inventory and Monitoring Streams and Lakes Protocol

2014 Monitoring Data

Natural Resource Data Series NPS/MOJN/NRDS—2015/973

ON THE COVER
Stella Lake in GRBA, September 2014.
Photograph courtesy of MOJN

Mojave Desert Network Inventory and Monitoring Streams and Lakes Protocol

2014 Monitoring Data

Natural Resource Data Series NPS/MOJN/NRDS—2015/973

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Executive Summary

The Mojave Desert Network Inventory and Monitoring Program (MOJN I&M) is a National Park Service (NPS) program that monitors ecological vital signs in eight parks located in Southern California, Nevada, and Arizona. The MOJN I&M Streams and Lakes protocol focuses on monitoring water quality and water quantity in headwater streams and sub-alpine lakes in Great Basin National Park (GRBA), located in eastern Nevada. Pilot testing of the protocol was completed in the summer of 2009, and the protocol was formally approved in 2012. This report presents Streams and Lakes protocol data collected in the 2014 field season.

The report includes water quality and benthic macroinvertebrate assemblage data for GRBA streams, and water quality, water level, clarity, and ice-free period data for GRBA lakes. Stream discharge data will be published in a separate report, as the processing, analysis, and review of discharge records can delay their availability for reporting.

The water quality in GRBA streams and lakes is generally excellent, with the measured water quality and chemistry parameters in compliance with regulatory limits. The benthic macroinvertebrate assemblages observed in the streams are consistent with healthy ecosystems.

Water year 2014 had greater-than-average precipitation, with the weather station at Lehman Caves recording the wettest July and August on record. The largest summer storms resulted in brief periods of high stream discharge, but no major changes to stream chemistry were observed. Five of the six lakes exhibited water level increases of less than 0.1 m in response to the summer storms. The level of Baker Lake, however, rose by more than 0.5 m. No major changes in water chemistry were observed in any of the lakes.

Acknowledgments

The data in this report was collected thanks to the efforts of numerous GRBA and MOJN I&M staff. In particular, Mark Pepper, Jonathan Reynolds, and Rebecca Cook collected the bulk of the water quality data.

Analytical data were provided by the Cooperative Chemical Laboratory established by Memorandum of Understanding no. PNW-82 between the U.S. Forest Service Pacific Northwest Research Station and the Department of Forest Ecosystems and Society, Oregon State University.

Benthic macroinvertebrate data were provided by the Utah State University National Aquatic Monitoring Center (the BugLab).

The Lehman Creek discharge data were collected, processed, and published by the U.S. Geological Survey.

List of Acronyms

AMS+: Alternative Measurement Sensitivity Plus
ANC: Acid Neutralization Capacity
BCT: Bonneville Cutthroat Trout (*Oncorhynchus clarki* Utah)
BLM: Bureau of Land Management
BMI: Benthic Macroinvertebrates
CWA: Clean Water Act
DEVA: Death Valley National Park
DO: Dissolved Oxygen
DOC: Dissolved Organic Carbon
EMAP: Environmental Monitoring and Assessment Program
EPT: Ephemeroptera, Plecoptera, and Trichoptera
GRBA: Great Basin National Park
I&M: Inventory and Monitoring Program
JOTR: Joshua Tree National Park
LAKE: Lake Mead National Recreation Area
MANZ: Manzanar National Historic Site
MDL: Method Detection Limit
MOJA: Mojave National Preserve
MOJN: Mojave Desert Network
MQO: Method Quality Objective
NAC: Nevada Administrative Code
NRCS: Natural Resources Conservation Service
NPS: National Park Service
NWS COOP: National Weather Service Cooperative Observers Program
ONRW: Outstanding Natural Resource Water
PARA: Grand Canyon-Parashant National Monument
QAPP: Quality Assurance Project Plan
QA/QC: Quality Assurance and Quality Control
RAWS: Remote Automated Weather Stations program
RL: Reporting Limit
RPD: Relative Percent Difference
SOP: Standard Operating Procedure
TDN: Total Dissolved Nitrogen
TDP: Total Dissolved Phosphorus
TN: Total Nitrogen
TP: Total Phosphorus
US EPA: United States Environmental Protection Agency
USGS: United States Geological Survey

Introduction

The Mojave Desert Network (MOJN) includes eight units of the National Park system: Death Valley National Park (DEVA), Great Basin National Park (GRBA), Joshua Tree National Park (JOTR), Lake Mead National Recreation Area (LAKE), Manzanar National Historic Site (MANZ), Mojave National Preserve (MOJA), Grand Canyon-Parashant National Monument (PARA), and Tule Springs Fossil Beds National Monument (TUSK). Collectively, these parks comprise 3.3 million hectares or 9.7% of the total land area managed by the NPS.

The MOJN I&M Streams and Lakes protocol (Caudill et al 2012) is focused on monitoring the water quality and quantity at streams and lakes in GRBA. The protocol is only implemented in GRBA because the water bodies in LAKE are monitored by other agencies, and stream and lake habitats are limited or absent in the other parks.

GRBA lies within the South Snake Range of east-central Nevada, and receives the most precipitation of the MOJN parks. GRBA contains ten perennial streams and six small subalpine lakes (Figure 1). These streams and lakes are fed primarily by snowmelt, so they are vulnerable to changes in precipitation patterns due to climate change. This report includes water quality and benthic macroinvertebrate assemblage data for GRBA streams, and water quality, water level, clarity, and ice-free period data for GRBA lakes from Water Year 2014. Stream discharge data will be published in a separate report, as the processing, analysis, and review of discharge records can delay their availability for reporting.

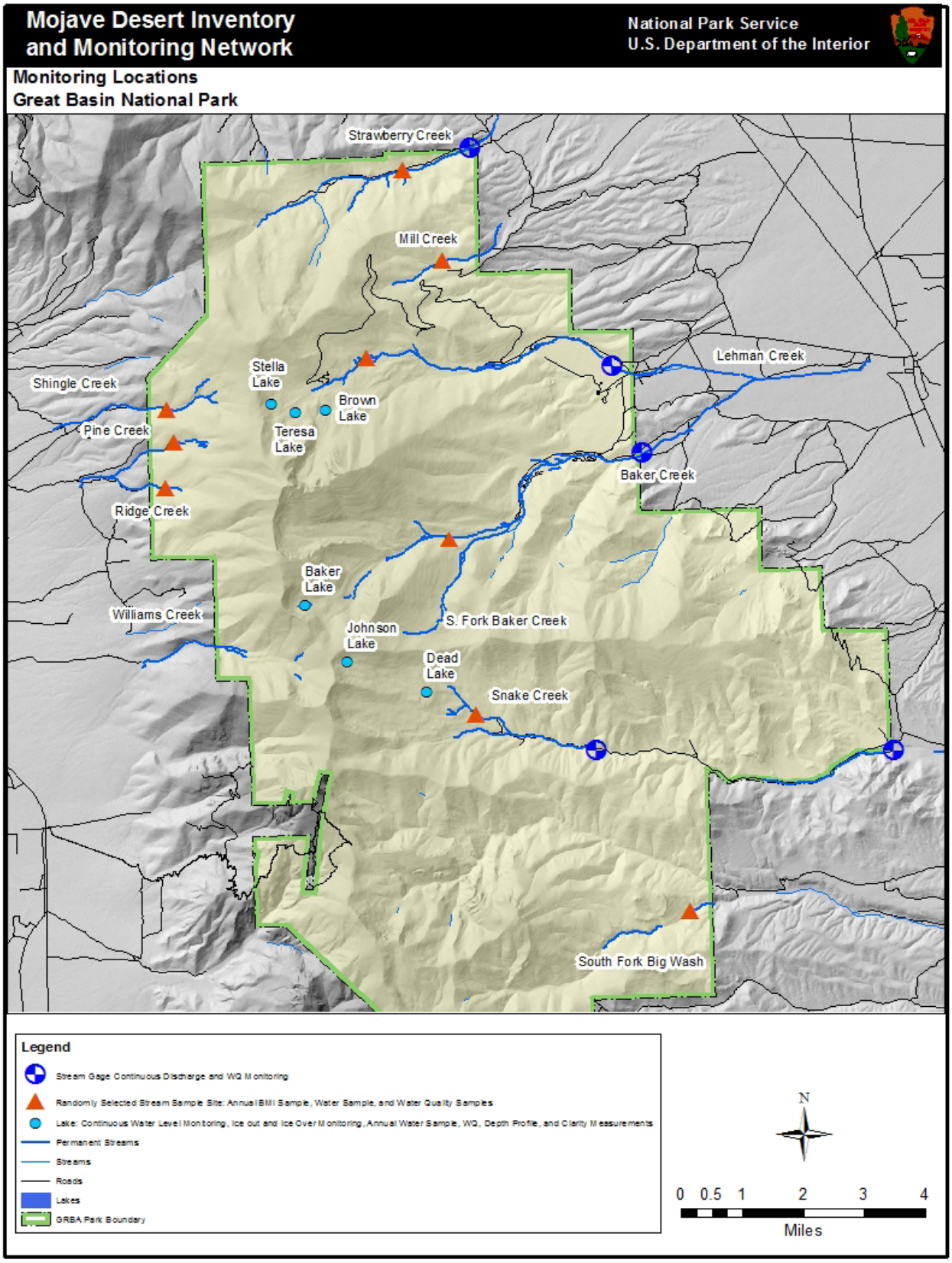

Figure 1. Map of sampling locations in GRBA.

Methods

The methods used to collect the data presented in this report are fully described in the MOJN Streams and Lakes protocol narrative and SOPs (Caudill et al. 2012, Moret et al. 2012). The methods are briefly summarized here.

Streams

The MOJN I&M Streams and Lakes protocol contains four stream monitoring components: stream discharge, continuous water quality monitoring, stream water chemistry, and benthic macroinvertebrate sampling. All monitoring locations are shown on Figure 1.

Stream discharge is continuously monitored by GRBA staff at four gage sites (Strawberry Creek, Baker Creek, upper Snake Creek, and lower Snake Creek) and by the USGS at one gage site (Lehman Creek). These sites are shown on Figure 1. No discharge data are included in this report other than USGS data for Lehman Creek, which is included to provide context for the water quality data.

Continuous water quality data are collected from early June to late September at the five sites (Strawberry Creek, Baker Creek, Lehman Creek, upper Snake Creek, and lower Snake Creek) shown on Figure 1. The records are collected using sondes (data-logging instruments deployed in the streams) that are recalibrated approximately every two weeks. The sondes record hourly measurements of temperature, specific conductance, dissolved oxygen, and pH. The data from the two week deployments are processed, graded, and joined using the Aquarius software package. With the exception of the upper Snake Creek site, the water quality sondes are located adjacent to the stream gages.

Stream water chemistry is determined through laboratory analysis of water samples. Annual samples were collected in late summer of 2014 from nine of GRBA's ten permanent streams (the tenth stream, Williams Canyon, was determined to be too inaccessible for annual monitoring) and analyzed for nutrients, major ions, and acid neutralization capacity. A handheld multimeter was used to measure temperature, dissolved oxygen, specific conductance, and pH at the time of sampling. The water samples were collected from initially randomly-selected sites that are visited each year (Figure 1).

Benthic macroinvertebrate (BMI) samples are collected at the same time and location as the water samples. Samples are collected using the EPA's Environmental Monitoring and Assessment Program (EMAP) method (Peck et al. 2006), which involves collecting samples from 11 evenly-spaced reaches and compositing them.

Lakes

The MOJN I&M Streams and Lakes protocol contains three lake monitoring components: lake level and ice-free period, lake water chemistry, and lake clarity. All lakes are visited annually in a late-September index period.

Lake level and ice-free period are monitored using data-logging pressure transducers and temperature sensors. At each annual visit, the lake level is compared to the elevation of fixed benchmarks using the line level method (e.g. Hoffman et al. 2005). The lake-bottom pressure transducer record is converted to a lake level record using the measured elevations and an atmospheric pressure record collected using a separate transducer. The lake level record and the temperature record are then used to infer the dates of ice-over and ice-out.

Lake water chemistry is monitored by laboratory analysis of water samples and depth profiles of water chemistry. Each year, a single water sample is collected by hand-dipping from the deepest area of each lake and analyzed for nutrients, major ions, and acid neutralization capacity. At the same time, a handheld multimeter is used to measure temperature, dissolved oxygen, specific conductance, and pH at several depths from the lake surface to the lake bed.

Lake clarity is assessed by lowering a Secchi disk until it is no longer visible, then recording the depth. The disk is then raised until it becomes visible, and a second depth is recorded. This process is repeated three times, and the average of the six depths is the Secchi depth. In practice, the lakes of GRBA are shallow and clear, so the disk is often visible on the bottom.

Precipitation, Snowpack, and Discharge

Year-to year variations in precipitation, snowpack, and stream discharge are expected to cause variations in many of the monitored parameters. This section discusses the precipitation measured at National Weather Service Cooperative Observers Program (NWS COOP) Station Number 263340 (located behind the Lehman Caves Visitor Center), the snowpack measured at Baker Creek Snowcourse # 3 (Natural Resources Conservation Service (NRCS) Station 14L03), and the stream discharge measured at the Lehman Creek gage (USGS site 10243260). These index sites were chosen so that the results in a given year could be compared to the longest possible historical record. The intent of this section is not to provide a complete discussion of the year's precipitation, snowpack, and stream discharge in GRBA, but to provide context for the monitoring data presented in this report.

Water Year 2014 Precipitation

NWS Coop Station 263340 recorded 19.26 inches of precipitation in WY2014 (Figure 2), greater than the 1951-2014 average of 13.44 inches. Precipitation events were distributed throughout the year, with unusually high precipitation in July and August (Figure 3).

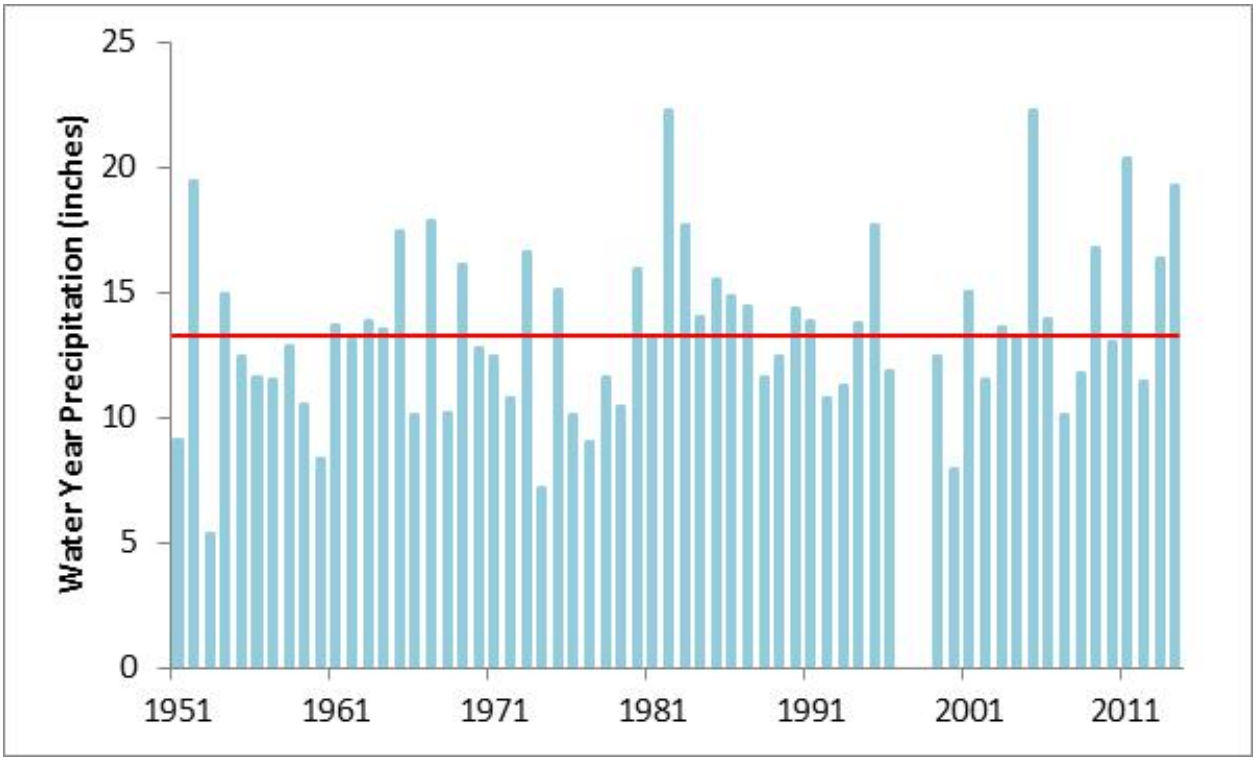

Figure 2. Annual precipitation by water year (October 1 to September 30) recorded at the NWS COOP weather station at Lehman Caves Visitor Center. The average annual precipitation at the site is represented by the horizontal red line.

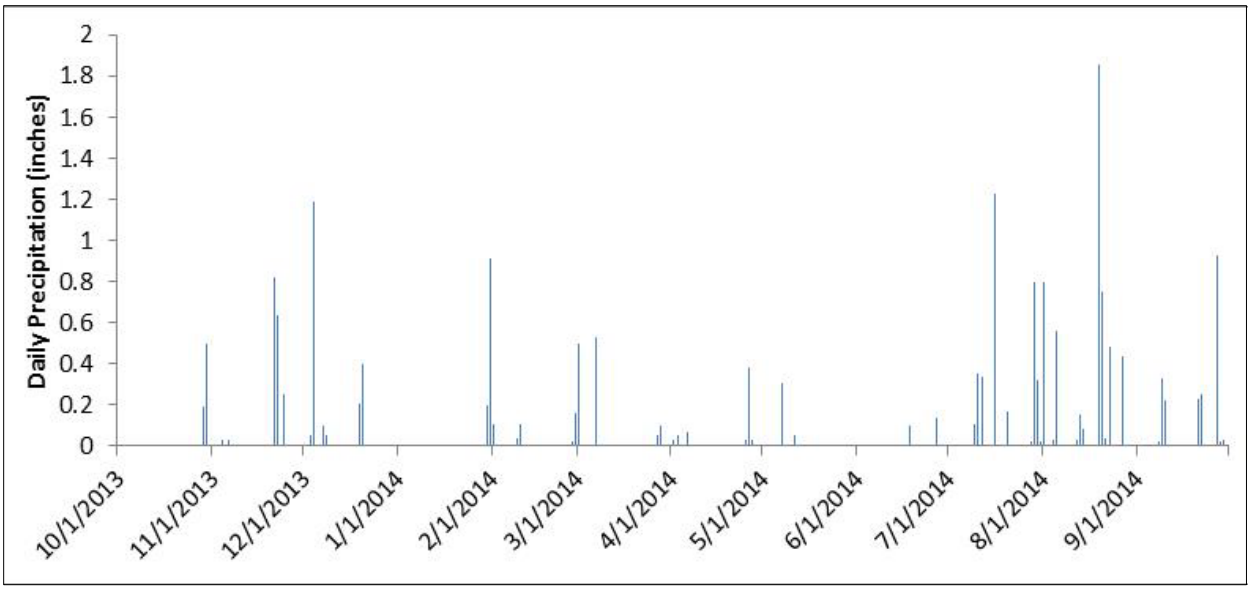

Figure 3. Daily precipitation recorded at the NWS COOP weather station at Lehman Caves Visitor Center in WY2014.

The total July and August precipitation for 2014 at Coop Station 263340 was 8.72 inches, the highest on record for these two months (Figure 4). Monsoonal precipitation, which occurs during July and August in the Southwestern United States, tends to be extremely localized (Barry and Chorley 2010), so record precipitation at this weather station does not necessarily indicate record precipitation across the park. However, all weather stations at GRBA received unusually high precipitation in July and August of 2014.

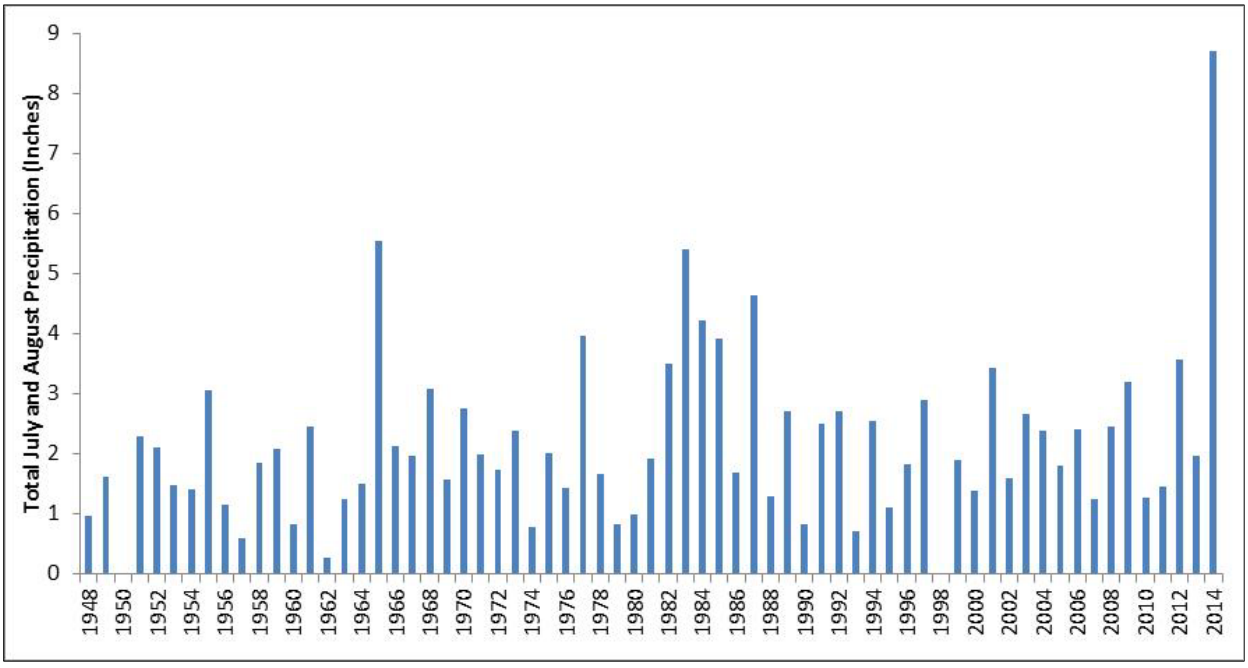

Figure 4. July and August precipitation recorded at the NWS COOP weather station at Lehman Caves Visitor Center.

Water Year 2014 Snowpack

The April 1 depth of the snowpack at the snow course site for 2014 (actually measured on April 1) was 58 inches (Figure 5), slightly greater than the 1942-2014 average of 55.1 inches.

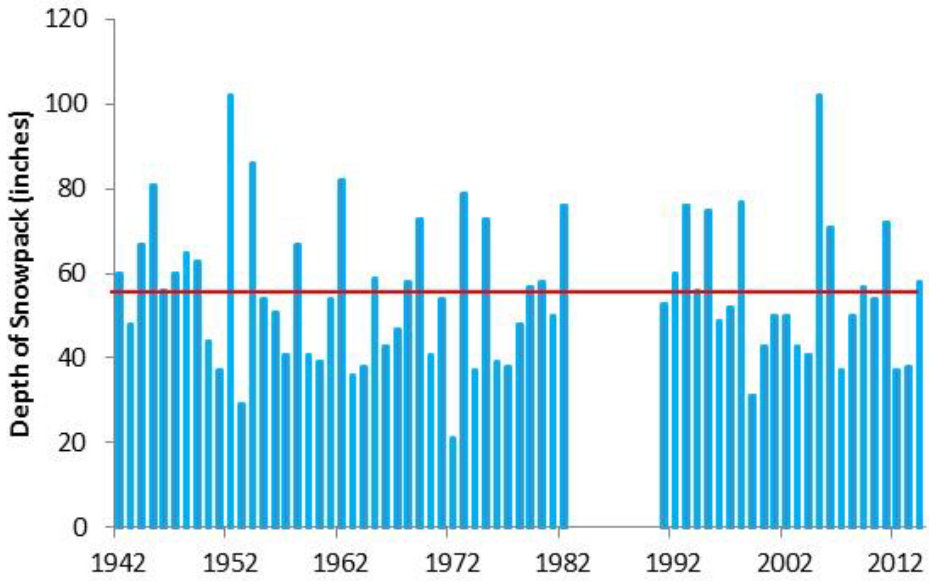

Figure 5. NRDS depth-of-snowpack data collected at Baker Creek Snowcourse #3 near April 1 of each year. The average April 1 snowpack for the site is represented by the horizontal red line.

Water Year 2014 Stream Discharge

The USGS Lehman Creek gage was out of operation due to lack of funding from the end of WY2012 until May 29, 2014. Thus, data are only available for the latter half of WY2014 (Figure 6). No data are available for the peak annual discharge. Interestingly, discharge increased rapidly in response to summer storms. The daily mean discharges on August 19 and August 26 (16 cfs and 15 cfs, respectively) were greater than the annual peak discharge recorded in some years (Table 1).

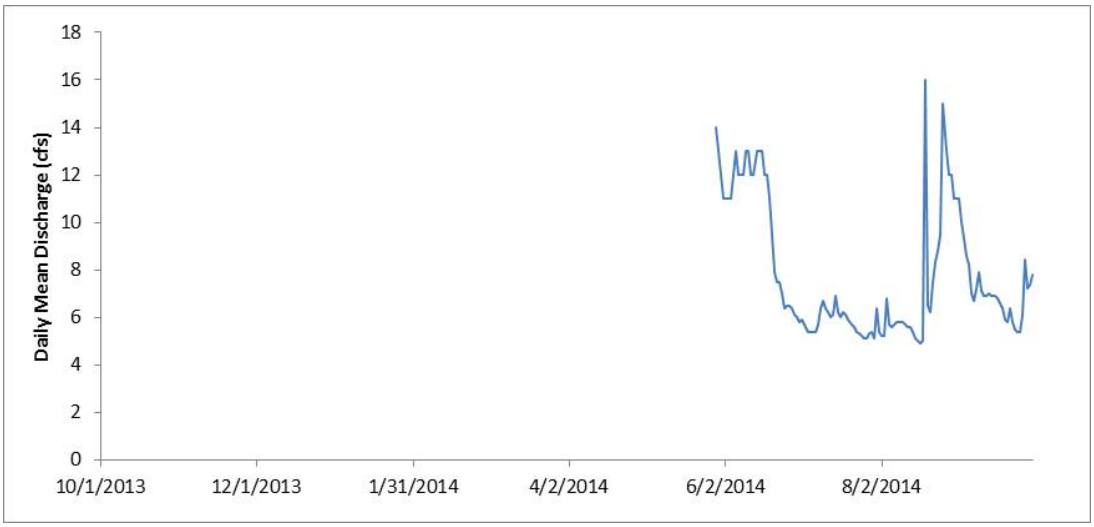

Figure 6. USGS discharge record for Lehman Creek in WY2014. Data collection began on May 29, 2014.

Table 1. USGS measurements of mean annual discharge, date of peak discharge, and peak discharge for Lehman Creek gage.

Water Year	Mean Annual Discharge (cfs)	Date of Peak Discharge	Peak Discharge (cfs)
1948	4.31	date not recorded	15
1949	5.98	19-Jun	34
1950	3.67	7-Jun	16
1951	3.90	29-May	16
1952	9.06	2-Jun	45
1953	2.51	25-Jun	7
1954	4.55	22-May	21
1955	5.50	13-Jun	27
1993	5.64	27-May	57
1994	4.17	31-May	24
1995	11.0	29-Jun	80
1996	4.11	15-Jun	15
1997	5.07	24-Jun	24
2003	4.02	30-May	32
2004	3.47	3-Jun	12
2005	13.7	29-May	227
2006	5.70	20-May	30
2007	2.77	22-May	7.5
2008	2.98	21-Jun	12
2009	5.10	21-May	25
2010	4.05	11-Jun	43
2011	8.52	27-Jun	64
2012	3.26	4-Oct*	13*
2013		----gage not in operation----	
2014		----insufficient data----	
Average	5.35	7-Jun	36.8

*Spring/Summer peak discharge for 2012 was 5.5 cfs on May 27.

Monitoring Results from Streams

The results of stream continuous water quality monitoring, stream water chemistry monitoring, and benthic macroinvertebrate sampling activities are summarized below. More detailed information regarding these data may be obtained by contacting the Mojave Desert Network.

Continuous Water Quality

Continuous water quality data were collected near the stream-gages on Baker Creek, Lehman Creek, Strawberry Creek, and Upper Snake Creek (gage locations are shown in Figure 1 and given in Table 2). Only four sondes were available for the 2014 field season, so no sonde was placed at the Lower Snake Creek gage.

Table 2. UTM coordinates (NAD 83, Zone 11S) for continuous water quality monitoring locations.

Gaged Stream	Easting (m)	Northing (m)
Baker Creek	742,027	4,319,535
Lehman Creek	741,152	4,321,829
Upper Snake Creek	740,625	4,311,740
Strawberry Creek	733,483	4,327,499

Baker Creek

In 2014, a sonde was deployed in Baker Creek from May 29 to October 30. The pH probe was not functional upon deployment and was replaced on June 18. The average values for each parameter in five index periods are provided in Table 3. The daily average, minimum, and maximum values of each parameter are plotted in Figure 7.

Table 3. Average water quality parameter values in Baker Creek, 2009-2014.

Parameter	Year	July 1-15	July 16-31	August 1-15	August 16-31	September 1-15
Mean Temp	2009	-	11.7[b]	-	-	-
°C	2010	-	12.5	13.4	13.2	10.5
	2011	-	9.6	10.3	11.6	10.1
	2012	-	13.3[a]	13.9[a]	13.6	11.6
	2013	13.9	14.7[b]	-	13.7	11.7
	2014	13.2	13.7[a]	12.8	11.1	10.1[a]
Median pH	2009	-	7.47[b]	-	-	-
Standard	2010	-	7.70	7.68[b]	7.59[a]	7.57
Units	2011	-	7.22	7.39	7.40[a]	-
	2012	-	-	7.52[a]	7.46	7.41
	2013	7.19	-	-	7.29	7.17
	2014	7.56	7.58	7.55	7.47	7.40
Mean SpCond	2009	-	32[b]	-	-	-
µS/cm	2010	-	40	46[a]	40[a]	41
	2011	-	34	43	49	57
	2012	-	34[a]	35[a]	37	39
	2013	36	-	-	42	38
	2014	34	37[a]	39	39	37[a]
Mean DO	2009	-	81.0[b]	-	-	-
% Saturation	2010	-	82.9	80.9[a]	79.0[a]	77.9
	2011	-	79.3	79.3	79.3	79.3
	2012	-	81.1[a]	80.6[a]	80.2	80.3
	2013	78.5	-	-	79.2	79.2
	2014	77.8	78.3[a]	79.2	79.1	79.5[a]

a. Average calculated with 1-2 days of data missing

b. Average calculated with 3-5 days of data missing

Water temperature (Figure 7A) in Baker Creek increased steadily from early June until mid-July, when it reached a maximum of 14.6 °C on July 14. It then decreased in August and fluctuated around 10.0 °C throughout September, before decreasing again rapidly to a minimum of 3.1 °C on October 28.

The dissolved oxygen saturation (Figure 7B) ranged from 76.0 to 80.5%.

The pH (Figure 7C) decreased steadily over the summer from a maximum of 7.65 on August 1 and decreased more rapidly in early October to a minimum of 6.88 on October 16.

The specific conductance (Figure 7D) increased slightly throughout the deployment from a minimum of 27.7 µS/cm on May 30 to around 41 µS/cm in late October. The sharp peak of 48 µS/cm on August 19 and the smaller peaks in mid-July and late September occurred shortly after rain events.

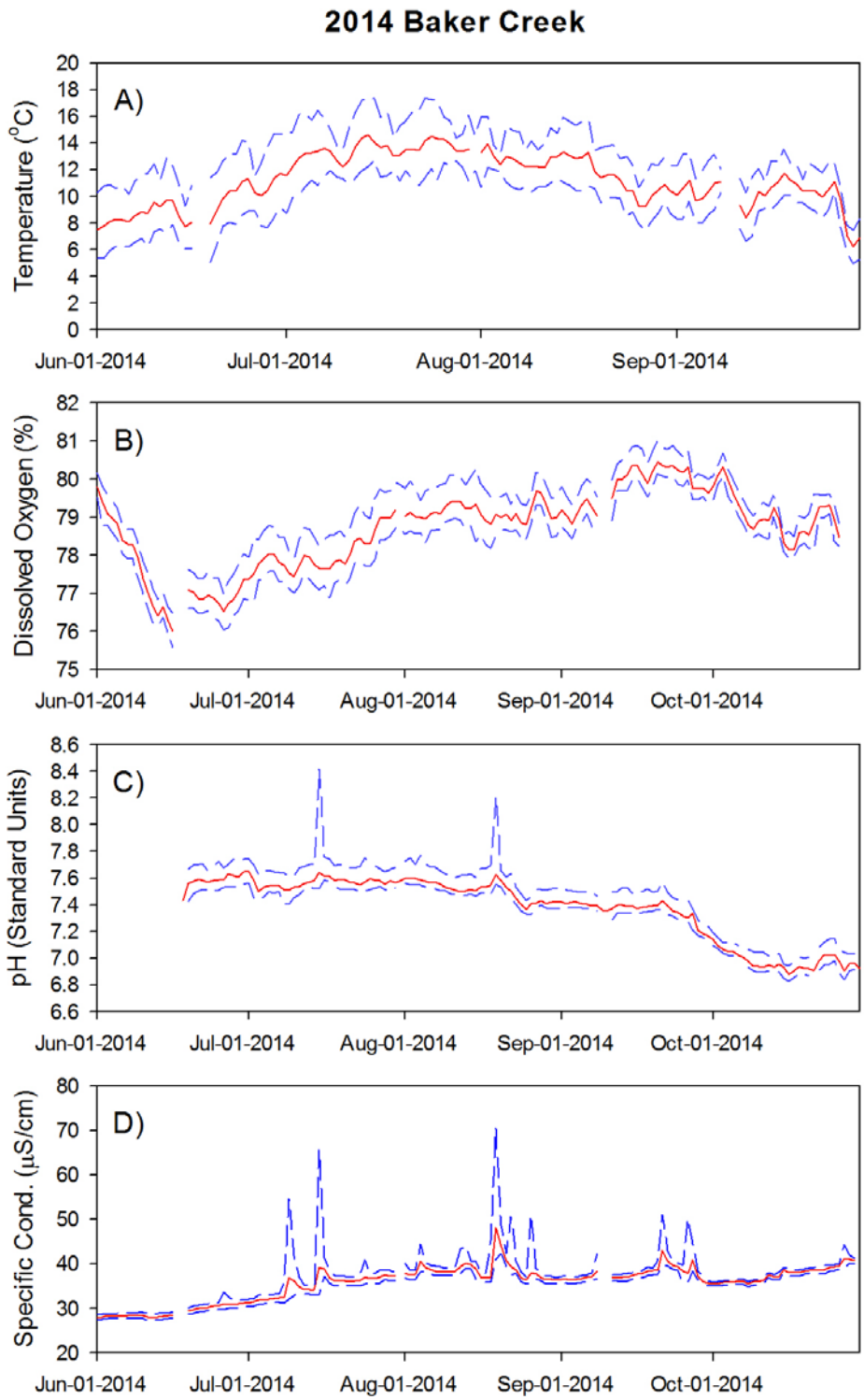

Figure 7. Baker Creek water quality data from the 2014 field season. A. Daily mean, minimum, and maximum temperature values. B. Daily mean, minimum, and maximum dissolved oxygen saturation values. C. Daily median, minimum, and maximum pH values. D. Daily mean, minimum, and maximum specific conductance values.

Lehman Creek

In 2014, a sonde was deployed in Lehman Creek from May 30 to October 30. The sonde was removed from the stream on June 16 for repairs, and a new sonde was deployed on August 19. The pH probe was not functional upon initial deployment and was replaced when the new sonde was deployed. The average values for each parameter in five index periods are provided in Table 4. The daily average, minimum, and maximum values of each parameter are plotted in Figure 8.

Table 4. Average water quality parameter values in Lehman Creek, 2009-2014.

Parameter	Year	July 1-15	July 16-31	August 1-15	August 16-31	September 1-15
Mean Temp	2009	-	-	-	10.9[a]	-
°C	2010	-	-	-	11.7[a]	9.8
	2011	8.9	9.5	9.7	10.6	9.2
	2012	-	12.7	13.2	12.7	11.2
	2013	-	-	13.2	13.2	11.4
	2014	-	-	-	10.1[b]	9.7
Median pH	2009	-	-	-	7.53[a]	-
Standard	2010	-	-	-	7.53[a]	7.55
Units	2011	-	-	7.46[a]	7.45	7.45
	2012	-	7.37[a]	7.44	7.44	7.47
	2013	-	-	7.45	7.46	7.33
	2014	-	-	-	7.50[b]	7.50
Mean SpCond	2009	-	-	-	35[a]	-
µS/cm	2010				36[a]	36
	2011	32[a]	-	-	-	-
	2012	-	36	36	37	39
	2013	-	-	40[a]	42	41
	2014	-	-	-	39[b]	38
Mean DO	2009	-	-	-	79.9[a]	-
% Saturation	2010	-	-	-	79.3[a]	79.5
	2011	80.8[b]	-	80.0[a]	80.3	80.5
	2012	-	77.2	77.5	78.0	77.9
	2013	-	-	79.2	79.5	79.6
	2014	-	-	-	80.0[b]	79.7

a. Average calculated with 1-2 days of data missing

b. Average calculated with 3-5 days of data missing

Water temperature (Figure 8A) in Lehman Creek reached a maximum of 11.3 °C on August 20 and a minimum of 8.2 °C on September 12.

The dissolved oxygen saturation (Figure 8B) ranged from 79.3% to 81.1%.

The pH (Figure 8C) reached a maximum of 7.57 on August 20 and a minimum of 7.46 on September 1.

The specific conductance (Figure 8D) reached a maximum of 45 µS/cm on August 20 and a minimum of 35 µS/cm on June 16. The peak on August 20 occurred shortly after a rain event.

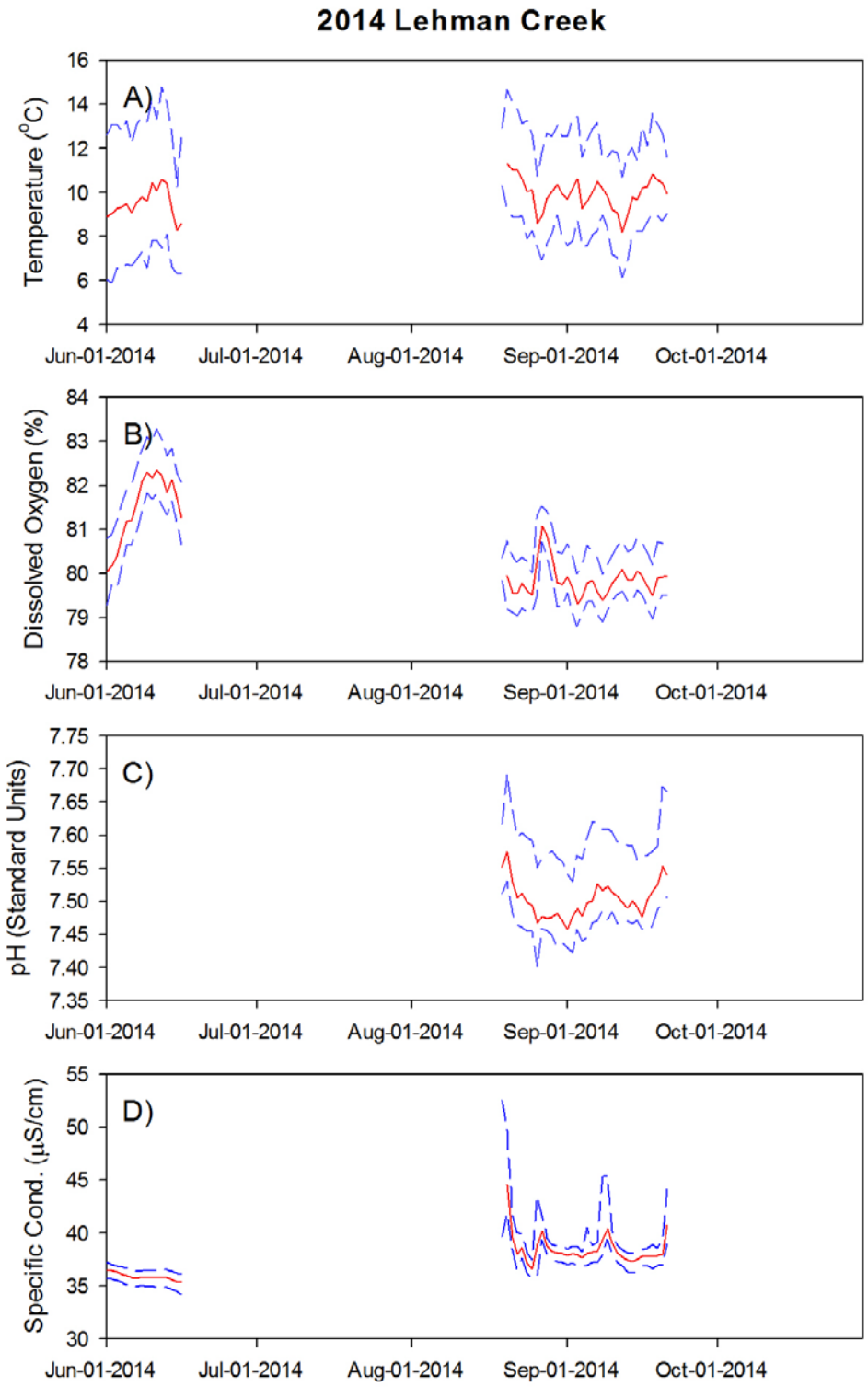

Figure 8. Lehman Creek water quality data from the 2014 field season. A. Daily mean, minimum, and maximum temperature values. B. Daily mean, minimum, and maximum dissolved oxygen saturation values. C. Daily median, minimum, and maximum pH values. D. Daily mean, minimum, and maximum specific conductance values.

Upper Snake Creek

In 2014, a sonde was deployed in Upper Snake Creek from June 11 to October 30. The average values for each parameter in five index periods are provided in Table 5. The daily average, minimum, and maximum values of each parameter are plotted in Figure 9.

Table 5. Average water quality parameter values in Upper Snake Creek, 2009-2014.

Parameter	Year	July 1-15	July 16-31	August 1-15	August 16-31	September 1-15
Mean Temp	2009	-	-	-	-	-
°C	2010	7.6	9.5	9.5	-	-
	2011	-	-	-	-	-
	2012	-	10.7[a]	11.4[a]	11.3	9.6
	2013	-	11.4[a]	10.4	11.1	10.5
	2014	10.2	10.9[a]	10.5[a]	9.7	9.2
Median pH	2009	-	-	-	-	-
Standard	2010	7.57	7.60	7.57	-	-
Units	2011	-	-	-	-	-
	2012	-	-	8.05	8.08	8.12
	2013	-	7.90[a]	7.90	7.87	7.87
	2014	8.01	7.95	8.02	7.93	7.80
Mean SpCond	2009	-	-	-	-	-
µS/cm	2010	48	47	-	-	-
	2011	-	112[a]	111	114	119
	2012	-	113[a]	118	119	117
	2013	102	105	110	112	113
	2014	101	107[a]	110[a]	111	113
Mean DO	2009	-	-	-	-	-
% Saturation	2010	75.8	75.9	73.2	-	-
	2011	-	-	-	-	-
	2012	-	-	76.5[a]	74.3	74.9
	2013	-	73.6[b]	74.8	74.9	75.1
	2014	74.8	74.9[a]	74.3[a]	73.3	73.4

a. Average calculated with 1-2 days of data missing

b. Average calculated with 3-5 days of data missing

Water temperature (Figure 9A) in Upper Snake Creek increased from mid-June to late July and reached a maximum of 11.6 °C on July 24. It decreased gradually throughout the remainder of the summer and then rapidly in late September. It reached a minimum of 2.3 °C on October 28.

The dissolved oxygen saturation (Figure 9B) ranged from 72.5% to 76.7%.

The pH (Figure 9C) decreased throughout June and then rose abruptly on July 2. It remained fairly steady during July and early August, reaching a peak of 8.15 on August 13. It decreased steadily from late August to mid-October, reaching a minimum of 7.23 on October 17.

The specific conductance (Figure 9D) increased from a minimum of 90 µS/cm on June 17 to mid-August and leveled off until late September. It reached a maximum of 115 µS/cm on September 25 and then decreased slightly in October. The sharp decreases in August and September occurred shortly after rain events.

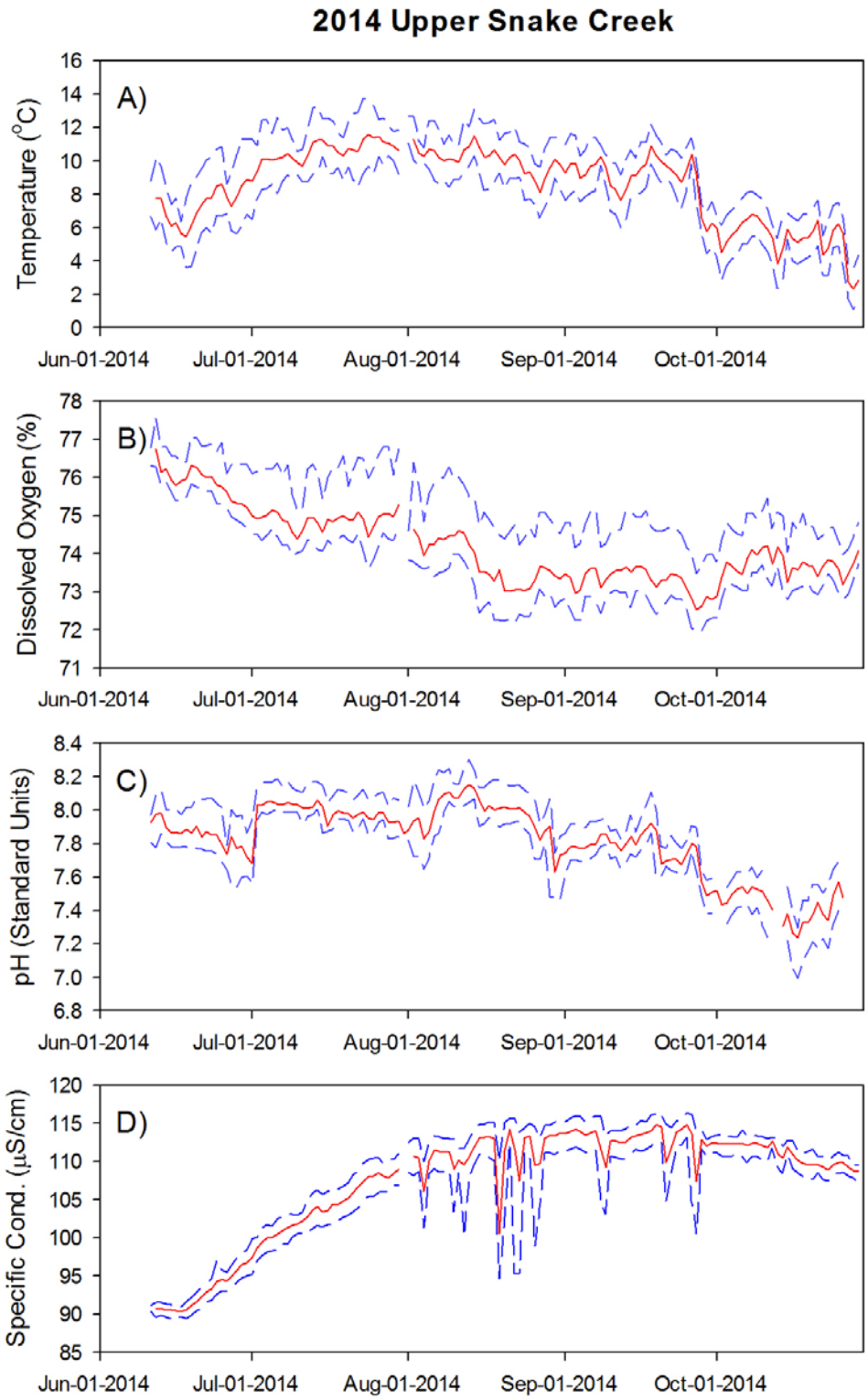

Figure 9. Upper Snake Creek water quality data from the 2014 field season. A. Daily mean, minimum, and maximum temperature values. B. Daily mean, minimum, and maximum dissolved oxygen saturation values. C. Daily median, minimum, and maximum pH values. D. Daily mean, minimum, and maximum specific conductance values.

Strawberry Creek

In 2014, a sonde was deployed in Strawberry Creek from May 29 to October 30. After continuous problems with the specific conductance record, the sonde was removed from the creek on June 19 and replaced on July 25 after being repaired. Other gaps in the data are due to calibration errors. The average values for each parameter in five index periods are presented in Table 6. The daily average, minimum, and maximum values of each parameter are plotted in Figure 10.

Table 6. Average water quality parameter values in Strawberry Creek, 2009-2014.

Parameter	Year	July 1-15	July 16-31	August 1-15	August 16-31	September 1-15
Mean Temp	2009	-	-	11.97[a]	-	-
°C	2010	10.79	13.19	13.02	12.38	10.10[a]
	2011	9.3	10.6	11.3	12.3	10.2
	2012	-	14.0[a]	14.9	14.3	12.2
	2013	15.0	15.5	14.0[b]	-	-
	2014	-	-	12.6	11.4	10.6
Median pH	2009	-	-	8.05[a]	-	-
Standard	2010	8.00[a]	8.02	7.93	8.07	8.06
Units	2011	-	8.25[b]	8.26	8.25	8.26
	2012	-	7.90[a]	7.81	7.88	7.88
	2013	7.88	7.96	7.90[b]	-	-
	2014	-	-	-	-	7.84
Mean SpCond	2009	-	-	120[a]	-	-
µS/cm	2010	94	108	177	131	124
	2011	73[b]	93[b]	-	114[b]	122[b]
	2012	-	156[a]	157	157	163
	2013	163	168	176[b]	-	-
	2014	-	-	146[a]	-	153
Mean DO	2009	-	-	78.2[a]	-	-
% Saturation	2010	79.1[b]	80.7	78.1	78.9	78.9
	2011	78.8	79.2	78.6	79.2	80.0
	2012	-	75.7[a]	78.1	80.5	77.5
	2013	72.4	73.2	73.0[b]	-	-
	2014	-	-	-	-	-

a. Average calculated with 1-2 days of data missing

b. Average calculated with 3-5 days of data missing

Water temperature (Figure 10A) in Strawberry Creek appears to have increased throughout June and July, reaching a maximum of 14.6 °C on July 27. It then decreased until the end of October, with a rapid decrease in late September. It reached a minimum of 2.6 °C on October 28.

The dissolved oxygen saturation (Figure 10B) ranged from 73.8 to 78.8%.

The pH (Figure 10C) decreased from a maximum of 7.98 on May 29 to a minimum of 7.64 on June 19, when the sonde was removed. It decreased again gradually after the sonde was re-deployed from approximately 7.88 to 7.72.

The specific conductance (Figure 10D) decreased from approximately 155 µS/cm in late July to 140 µS/cm in early August, with greater decreases occurring in response to rain events. The specific conductance remained fairly constant throughout September and October.

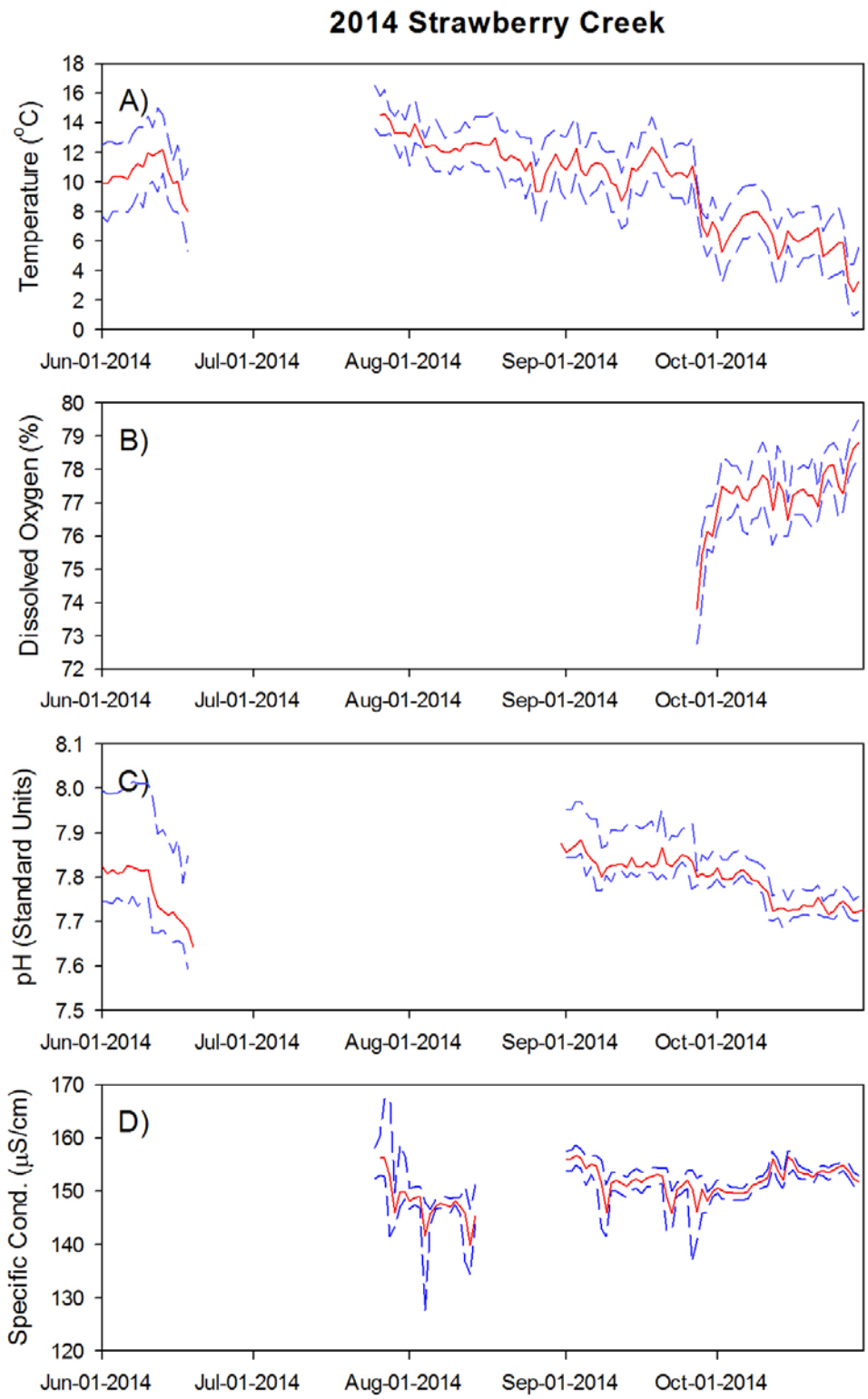

Figure 10. Strawberry Creek water quality data from the 2014 field season. A. Daily mean, minimum, and maximum temperature values. B. Daily mean, minimum, and maximum dissolved oxygen saturation values. C. Daily median, minimum, and maximum pH values. D. Daily mean, minimum, and maximum specific conductance values.

Stream Water Chemistry

Stream water samples were collected from nine streams at the locations given in Table 2 and shown in Figure 1. The sites were chosen randomly in 2009 to ensure that the results were representative of aquatic habitat condition across the park. Care should be taken in comparing values between streams, as some samples were collected at higher elevations in tributaries while other samples were collected at lower elevations on the main channel (Figure 1).

The water samples were analyzed for basic chemistry and nutrient concentrations at the Cooperative Chemical Analysis Facility (CCAL) in Corvallis, Oregon. The results of these analyses and the water quality data measured at the time of sampling are described in this section.

Water Quality Parameters

Four water quality parameters were measured at each stream: temperature, dissolved oxygen (DO), pH, and specific conductance (SpCond). In order to assess mixing, these parameters were measured near each bank and at the center of the channel. All of the streams were found to be well mixed each year, and the medians of the four measurements are reported here.

The state of Nevada has established water quality standards for Class A Waters for pH (between 6.5 and 9.0), DO (greater than or equal to 6.0 mg/L), and temperature (less than or equal to 20^0C). All of the measured values meet these standards (Table 7).

Table 7. Water quality parameters in GRBA streams. Each value is the median of three measurements.

Stream	UTM Coords NAD83 11S m	Visit Date	Temperature °C	Dissolved Oxygen mg/L	pH	Specific Conductance µS/cm
Snake	E 737569	8/1/2009	8.3	9.52	8.40	45.5
	N 4326941	9/7/2010	6.8	9.31	8.08	55.0
		8/31/2011	9.8	7.59	7.80	50.5
		8/30/2012	10.1	8.09	8.18	42.2
		8/27/2013	8.9	8.70	7.89	68.1
		8/29/2014	10.2	8.42	-	63.3
Baker	E 736781	8/31/2010	4.9	9.20	7.59	41.9
	N 4315879	9/1/2011	7.2	9.90	7.10	20.5
		8/31/2012	8.4	8.33	7.42	27.4
		8/28/2013	8.5	8.58	7.27	28.0
		8/27/2014	6.2	8.71	7.00	28.1
Lehman	E 734703	8/30/2010	4.4	8.33	7.92	30.3
	N 4322017	8/30/2011	8.0	8.66	7.90	27.7
		8/31/2012	7.4	8.46	7.79	29.6
		8/29/2013	6.8	9.06	7.49	34.5
		9/3/2014	7.6	8.25	-	34.6

Table 7. Water quality parameters in GRBA streams. Each value is the median of three measurements (continued).

Stream	UTM Coords NAD83 11S m	Visit Date	Temperature °C	Dissolved Oxygen mg/L	pH	Specific Conductance µS/cm
Pine	E 729600	8/26/2010	7.9	9.25	7.60	29.8
	N 4319780	9/2/2011	6.7	11.76	7.80	31.2
		9/6/2012	9.5	8.23	7.61	31.6
		8/30/2013	8.7	8.23	7.48	34.1
		8/28/2014	7.5	8.63	7.12	35.8
Ridge	E 729383	8/26/2010	6.8	9.95	7.57	36.9
	N 4318560	9/2/2011	6.5	9.34	7.60	38.8
		9/6/2012	8.2	8.53	7.73	42.9
		8/30/2013	7.1	8.51	7.50	46.3
		8/28/2014	6.7	9.01	7.30	43.6
South Fork	E 743243	9/2/2010	8.8	9.45	7.99	398.2
Big Wash	N 4307414	8/31/2011	8.9	8.66	8.00	381.7
		8/29/2012	9.8	8.88	8.14	439.3
		8/28/2013	9.2	7.92	8.10	455.2
		8/26/2014	9.7	8.47	7.84	468.6
Mill	E 736689	9/7/2010	8.3	8.92	7.91	49.7
	N 4324562	9/1/2011	9.0	8.28	7.70	60.6
		8/31/2012	11.8	7.76	8.16	73.3
		8/29/2013	11.4	7.07	7.84	72.5
		9/3/2014	10.8	7.76	-	59.1
Shingle	E 729424	8/18/2009	7.0	-	8.00	66.2
	N 4320644	9/1/2010	6.7	9.71	8.01	70.0
		9/2/2011	6.1	9.01	7.80	74.7
		9/6/2012	9.1	8.20	8.10	80.8
		8/30/2013	11.7	7.37	7.94	80.3
		8/28/2014	10.0	8.42	7.65	79.3
Strawberry	E 735651	7/31/2009	12.9	7.08	7.90	103.0
	N 4326941	8/24/2010	12.2	8.58	8.13	112.0
		8/30/2011	11.3	8.40	8.00	123.5
		8/30/2012	14.3	7.31	8.43	152.8
		8/27/2013	13.1	7.76	8.17	166.8
		9/4/2014	9.7	8.98	-	155.0

Nutrients

The nutrient concentrations measured in the stream water samples are all very low (Table 8). The highest Total Nitrogen (TN) and total Phosphorus (TP) values from 2014 were 0.55 mg/L and 0.027 mg/L, respectively. All TP values were less than 0.10 mg/L and met the Nevada water quality standard for Class A Waters.

In 2014, the Total Dissolved Nitrogen (TDN) value was greater than the TN value in one of the stream samples. As discussed in Appendix 1, the analytical results fall within precision limits, and the two values are analytically equal in concentration. The Total Dissolved Phosphorus (TDP) value was greater than the TP value for the same stream sample. Again, the values fall within the range of expected variability.

Table 8. Nutrient concentrations in GRBA streams.

Stream	Sampling Date	Total N mg/L	Total Dissolved N mg/L	Nitrate + Nitrite mg/L as N	Total P mg/L	Total Dissolved P mg/L
Snake	9/2/2009	0.05	0.06[b]	0.002	0.013	0.011
	9/7/2010	0.05	0.06[b]	0.003	0.007	0.005
	8/31/2011	0.06	0.04	0.004	0.007	0.004
	8/30/2012	0.11	0.08	0.008	0.017	0.012
	8/27/2013	0.07	0.07	0.004	0.009	0.006
	8/29/2014	0.07	0.07	0.001[d]	0.008	0.005
Baker	8/27/2009[a]	0.15	0.15	0.051	0.017	0.016
	8/31/2010	0.13	0.15[b]	0.091	0.008	0.009[b]
	9/1/2011	0.22	0.23[b]	0.173	0.011	0.010
	8/31/2012	0.64	0.48	0.393	0.032	0.011
	8/28/2013	0.53	0.53	0.458	0.016	0.012
	8/27/2014	0.52	0.52	0.415	0.011	0.009
Lehman	8/27/2009[a]	0.20	0.24[b]	0.158	0.020	0.015
	8/30/2010	0.24	0.24	0.191	0.010	0.007
	8/30/2011	0.19	0.18	0.130	0.015	0.007
	8/31/2012	0.42	0.40	0.354	0.009	0.006
	8/29/2013	0.54	0.55	0.495	0.010	0.007
	9/3/2014	0.55	0.58[b]	0.464	0.008	0.010[b]
Pine	8/28/2009	0.12	0.17[c]	0.092	0.013	0.012
	8/26/2010	0.21	0.19	0.130	0.015	0.012
	9/2/2011	0.17	0.20[c]	0.111	0.012	0.011
	9/6/2012	0.16	0.11	0.044	0.018	0.010
	8/30/2013	0.16	0.14	0.077	0.012	0.009
	8/28/2014	0.14	0.14	0.061	0.012	0.010
Ridge	8/28/2009	0.44	0.33	0.264	0.027	0.019
	8/26/2010	0.31	0.38[c]	0.248	0.020	0.016
	9/2/2011	0.37	0.29	0.225	0.025	0.017
	9/6/2012	0.37	0.35	0.304	0.018	0.015
	8/30/2013	0.40	0.38	0.350	0.017	0.014
	8/28/2014	0.42	0.42	0.323	0.018	0.016

Table 8. Nutrient concentrations in GRBA streams (continued).

Stream	Sampling Date	Total N mg/L	Total Dissolved N mg/L	Nitrate + Nitrite mg/L as N	Total P mg/L	Total Dissolved P mg/L
South Fork	9/2/2009	0.12	0.13[b]	0.080	0.005	0.004
Big Wash	9/2/2010	0.10	0.12[b]	0.070	0.002[d]	0.003[b]
	8/31/2011	0.09	0.08	0.059	0.002[d]	0.001[d]
	8/29/2012	0.24	0.15	0.106	0.011	0.001[d]
	8/28/2013	0.14	0.17[c]	0.100	0.003	0.001[d]
	8/26/2014	0.17	0.15	0.076	0.005	0.002[d]
Mill	7/31/2009	0.45	-	-	0.074	-
	9/7/2010	0.18	0.12	0.003	0.024	0.019
	9/1/2011	0.17	0.14	0.004	0.022	0.015
	8/31/2012	0.25	0.11	0.007	0.036	0.015
	8/29/2013	0.26	0.15	0.006	0.041	0.018
	9/3/2014	0.18	0.13	0.001[d]	0.027	0.018
Shingle	8/18/2009	0.22	-	-	0.030	-
	9/1/2010	0.08	0.11[b]	0.008	0.010	0.009
	9/2/2011	0.07	0.05	0.015	0.009	0.006
	9/6/2012	0.09	0.06	0.007	0.014	0.009
	8/30/2013	0.10	0.06	0.011	0.013	0.008
	8/28/2014	0.12	0.06	0.006	0.015	0.008
Strawberry	9/28/2009	0.16	0.13	0.005	0.031	0.020
	8/24/2010	0.10	0.06	0.004	0.020	0.013
	8/30/2011	0.11	0.11	0.006	0.018	0.014
	8/30/2012	0.06	0.06	0.005	0.008	0.006
	8/27/2013	0.11	0.10	0.008	0.017	0.010
	9/4/2014	0.12	0.08	0.004	0.021	0.012

a. Sample collected at stream gage.

b. TDN (or TDP) value greater than TN (or TP) value with the difference within precision limits, indicating that the samples are analytically equal in concentration.

c. TDN (or TDP) value greater than TN (or TP) value with the difference outside the expected range of variability, indicating contamination of the sample.

d. Concentration below the method detection limit (MDL).

Major Ions and Acid Neutralization Capacity

Water samples were analyzed for sodium, potassium, calcium, magnesium, sulfate, and chloride (Table 9). Systematic changes in the concentrations of these ions over time may be useful in determining changes in the source of water to the streams.

In addition, the acid neutralization capacity (ANC) of each stream was measured. ANC is expressed in milliequivalents per liter (meq/L), that is, the number of millimoles of H^+ ions (acid) that can be neutralized by a liter of the water sample without a change in pH. As ANC decreases, the sensitivity of the stream to acidification increases. A decrease in ANC may be an indication of acid deposition.

Table 9. Major ion concentrations and acid neutralization capacity in GRBA streams.

Stream	Sampling Date	Sodium mg/L	Potassium mg/L	Calcium mg/L	Magnesium mg/L	Sulfate mg/L as S	Chloride mg/L	ANC µeq/L
Snake	9/2/2009	3.21	0.52	6.29	0.74	0.66	0.82	485
	9/7/2010	3.32	0.50	6.29	0.75	0.68	0.69	496
	9/1/2011	3.06	0.47	5.74	0.84	0.67	0.67	452
	8/30/2012	6.00	0.84	19.26	4.19	1.49	3.79	1166
	8/27/2013	3.90	0.53	7.08	1.04	0.66	0.74	524
	8/29/2014	3.82	0.54	6.98	1.03	0.71	0.74	551
Baker	8/27/2009[a]	1.78	0.43	4.42	0.78	0.67	0.71	296
	8/31/2010	2.60	0.41	4.32	0.67	0.52	0.64	362
	9/1/2011	0.82	0.27	2.08	0.47	0.57	0.34	157
	8/31/2012	0.88	0.53	2.79	0.61	0.80	0.65	170
	8/28/2013	0.91	0.36	2.75	0.61	0.75	0.49	161
	8/27/2014	0.87	0.31	2.84	0.61	0.83	0.43	160
Lehman	8/27/2009[a]	1.46	0.33	3.96	0.76	0.40	0.60	314
	8/30/2010	1.08	0.27	3.71	0.78	0.36	0.39	268
	8/30/2011	0.97	0.26	3.36	0.66	0.29	0.31	296
	8/31/2012	0.87	0.27	3.51	0.70	0.37	0.39	243
	8/29/2013	0.92	0.28	3.85	0.77	0.42	0.42	247
	9/3/2014	0.94	0.3	3.93	0.74	0.45	0.45	255
Pine	8/28/2009	1.82	0.22	3.43	0.70	0.49	0.65	270
	8/26/2010	1.16	0.23	3.42	0.74	0.51	0.40	254
	9/2/2011	1.28	0.27	3.66	0.84	0.51	0.52	276
	9/6/2012	1.18	0.23	3.68	0.85	0.46	0.41	291
	8/30/2013	1.19	0.22	3.78	0.87	0.46	0.39	292
	8/28/2014	1.23	0.2	3.98	0.92	0.45	0.42	307
Ridge	8/28/2009	1.65	0.43	4.10	0.88	0.61	0.66	124
	8/26/2010	1.33	0.49	4.25	0.95	0.62	0.69	308
	9/2/2011	1.31	0.43	4.37	1.08	0.62	0.54	329
	9/6/2012	1.34	0.45	5.00	1.14	0.67	0.54	346
	8/30/2013	1.32	0.52	5.11	1.17	0.65	0.56	359
	8/28/2014	1.26	0.47	4.78	1.11	0.63	0.48	337
South Fork	9/2/2009	3.21	0.49	58.70	16.26	2.45	2.93	3771
Big Wash	9/2/2010	3.08	0.45	62.57	14.55	3.11	2.76	3583
	9/1/2011	3.50	0.48	58.03	14.43	2.90	2.96	2573
	8/29/2012	3.74	0.48	45.36	17.93	3.97	3.61	2863
	8/28/2013	3.48	0.45	64.05	17.37	4.23	3.07	2935
	8/26/2014	3.37	0.48	68.27	17.89	4.04	2.96	3256

Table 9. Major ion concentrations and acid neutralization capacity in GRBA streams (continued).

Stream	Sampling Date	Sodium mg/L	Potassium mg/L	Calcium mg/L	Magnesium mg/L	Sulfate mg/L as S	Chloride mg/L	ANC µeq/L
Mill	7/31/2009	-	-	-	-	-	-	395
	9/7/2010	2.54	0.50	5.18	1.29	0.73	1.37	416
	9/1/2011	3.18	0.59	6.41	1.87	0.72	1.77	509
	8/31/2012	3.66	0.63	8.33	2.25	0.81	2.24	648
	8/29/2013	3.21	0.66	7.39	2.01	0.74	1.89	557
	9/3/2014	2.72	0.57	6.02	1.66	0.70	1.46	479
Shingle	8/18/2009	-	-	-	-	-	-	615
	9/1/2010	2.07	0.32	9.84	1.85	0.66	0.65	657
	9/2/2011	2.01	0.31	10.23	1.83	0.67	0.59	637
	9/6/2012	1.95	0.31	11.39	2.03	0.72	0.59	729
	8/30/2013	1.90	0.32	10.84	1.89	0.66	0.57	606
	8/28/2014	1.90	0.30	10.67	1.85	0.67	0.55	644
Strawberry	9/28/2009	4.73	0.77	12.37	3.15	1.19	2.42	963
	8/24/2010	4.44	0.66	15.29	3.33	1.16	2.10	952
	8/30/2011	5.17	0.67	14.82	3.49	1.31	2.65	1011
	8/30/2012	3.65	0.53	6.93	1.03	0.65	0.76	530
	8/27/2013	6.18	0.82	19.39	4.06	1.55	3.70	1099
	9/4/2014	5.95	0.83	18.49	4.03	1.58	3.69	1188

a. Sample collected at stream gage.

Stream Benthic Macroinvertebrates

Benthic macroinvertebrate (BMI) samples were collected from nine streams at the locations given in Table 2 at the same time that water samples were collected. The sampled macroinvertebrates were identified and enumerated by the Utah State University National Aquatic Monitoring Center (BugLab) in Logan, Utah. The complete results of the analysis are available from MOJN. Four common population metrics are reported in Table 10.

Abundance (the total number of specimens in each sample), taxa richness (the total number of taxa in each sample), and percent dominant taxon (the percentage of counted specimens in the most abundant taxon) are measures of the diversity of BMI communities in streams. In general, BMI communities in impaired streams are less diverse than those in healthy streams. EPT taxa richness is the number of taxa in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These insects are more sensitive to ecosystem stressors, so EPT taxa richness would be expected to decrease in response to any degradation of water quality.

Of particular note in these data are the decrease in the number of EPT taxa and the increase in the % Dominant Taxon observed in South Fork Big Wash in 2013 and 2014 relative to earlier years. If these changes continue in future years, they may be indicative of a change in the ecosystem.

Table 10. Population metrics for BMI samples collected in GRBA streams.

Stream	Sampling Date	Abundance (per m2)	# of Taxa (Richness)	# of EPT Taxa (EPT Richness)	% Dominant Taxon
Snake	9/2/2009	1039	55	19	24
	9/7/2010	858	61	24	12
	9/1/2011	823	26	13	11
	8/30/2012	2924	29	17	14
	8/27/2013	2938	34	20	12
	8/29/2014	2082	30	15	15
Baker	8/27/2009[a]	820	60	24	24
	8/31/2010[a]	3563	41	18	38
	9/1/2011	861	18	11	18
	8/31/2012	1727	19	12	13
	8/28/2013	2550	24	16	17
	8/27/2014	2125	18	11	15
Lehman	8/27/2009[a]	566	54	26	32
	8/30/2010	870	39	18	19
	8/30/2011	738	18	9	17
	8/31/2012	2116	19	12	14
	8/29/2013	4119	19	12	11
	9/3/2014	4222	19	12	18
Pine	8/28/2009	1090	51	22	9
	8/26/2010	1973	55	19	14
	9/2/2011	1338	18	10	23
	9/6/2012	2424	21	10	11
	8/30/2013	3655	25	11	11
	8/28/2014	4817	23	12	13
Ridge	8/28/2009	1891	45	20	12
	8/26/2010	4840	50	19	16
	9/2/2011	981	16	8	17
	9/6/2012	11647	15	6	18
	8/30/2013	7975	23	11	9
	8/28/2014	3043	20	10	12
South Fork Big Wash	9/2/2009	506	35	11	16
	9/2/2010	1467	41	13	19
	9/1/2011	1039	23	11	16
	8/29/2012	746	19	9	18
	8/28/2013	2802	18	7	28
	8/26/2014	1845	12	6	31
Mill	7/31/2009	1252	53	26	27
	9/7/2010	4502	62	26	18
	9/1/2011	1016	23	11	12
	8/31/2012	2446	36	19	9
	8/29/2013	2506	30	17	14
	9/3/2014	1521	34	16	29

Table 10. Population metrics for BMI samples collected in GRBA streams (continued).

Stream	Sampling Date	Abundance (per m2)	# of Taxa (Richness)	# of EPT Taxa (EPT Richness)	% Dominant Taxon
Shingle	8/18/2009	614	57	21	12
	9/1/2010	1062	65	24	11
	9/2/2011	915	27	13	18
	9/6/2012	1842	29	17	12
	8/30/2013	4836	27	15	11
	8/28/2014	2595	29	18	7
Strawberry	9/28/2009	311	46	20	12
	8/24/2010	1477	57	23	19
	8/30/2011	518	15	7	40
	8/30/2012	2570	33	16	12
	8/27/2013	3448	29	17	21
	9/4/2014	6648	31	16	27

a. Sample collected at a different site—not comparable to later data.

Monitoring Results from Lakes

The results of lake level and temperature monitoring, water quality depth profile collection, lake water chemistry monitoring, and lake water clarity monitoring activities are summarized below. All of the lakes were visited in 2014.

Lake Level and Ice-Free Period

The relative water levels measured at the lakes near the end of September each year are given in Table 11. Each lake's water level measurements are reported relative to a lake-specific benchmark (assigned a relative elevation of 100 m), so water levels cannot be compared between lakes.

Table 11 also includes ice-on dates (the date of the first ice formation as determined from the temperature and water level records) and ice-off dates (the date that the ice begins melting as determined from the temperature and water level records). The ice-on dates are relatively imprecise (perhaps ±5 days), as the first ice of the season often melts quickly. The ice-off dates are more accurate, perhaps ±1 day.

Teresa Lake was too deep to recover the pressure transducer in September 2014, so no ice-on or ice-off dates are available. The water level in Dead Lake fell below the pressure transducer in fall of 2013 (the lake was not visited in fall of 2013 due to the government shutdown and weather), so no ice-on date is available.

Table 11. Measured water levels in GRBA lakes.

Lake	Sampling Date	Relative Lake Level (m) Benchmark = 100 m	Ice-On Date	Ice-Off Date
Stella	8/27/2009[a]	97.76	-	-
	9/21/2010	98.51	11/5/09	-
	9/27/2011	98.76	-	-
	9/25/2012	97.87	-	4/20/12
	9/24/2013	98.52	10/10/12	5/7/13
	9/30/2014	98.72	10/09/13	5/14/14
Teresa	8/27/2009[a]	97.25	-	-
	9/21/2010	98.10	11/13/09	-
	9/27/2011	98.67	10/19/10	6/12/11
	9/25/2012	98.64	10/4/11	4/28/12
	9/23/2013	99.18	10/22/12	5/10/13
	9/30/2014	100.17	-	-
Brown	9/21/2010	99.27	-	-
	9/27/2011	99.27	10/4/10	5/5/11
	9/25/2012	99.33	10/5/11	3/31/12
	9/24/2013	99.35	10/12/12	4/30/13
	9/30/2014	99.57	10/9/13	4/18/14

Table 11. Measured water levels in GRBA lakes (continued).

Lake	Sampling Date	Relative Lake Level (m) Benchmark = 100 m	Ice-On Date	Ice-Off Date
Baker	9/25/2009	98.98	-	-
	9/22/2010	99.37	11/13/09	6/2/10
	9/29/2011	99.08	10/4/10	6/11/11
	9/27/2012	99.06	-	-
	9/25/2013	99.36	10/11/12	5/15/13
	10/1/2014	99.46	10/05/13	5/21/14
Johnson	9/24/2009	98.81	-	-
	9/23/2010	98.98	11/13/09	5/31/10
	9/28/2011	99.09	-	-
	9/26/2012	99.06	-	-
	2013	-	10/6/12	4/28/13
	10/2/2014	99.10	10/3/13	4/9/14
Dead	9/23/2010	99.02	-	-
	9/28/2011	101.33	-	-
	9/26/2012	98.10	-	-
	2013	-	10/12/12	5/1/13
	10/2/2014	97.76	-	4/23/14

a. Lake level measured outside of the index period.

Stella Lake

In WY2014, the water level in Stella Lake reached a maximum value on May 28, 2014 (Figure 11). Summer rain storms appear to have raised the lake level by less than 0.1 m.

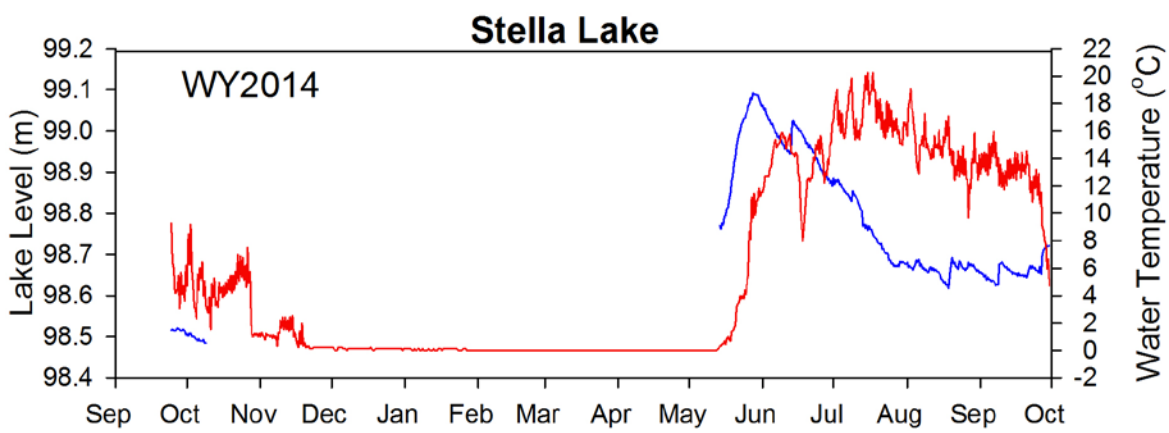

Figure 11. WY2014 water level record (blue line) and temperature record (red line) for Stella Lake.

Teresa Lake

The September 2014 water level in Teresa Lake was too high for the data logger to be recovered.

Brown Lake

In WY2014, the water level in Johnson Lake reached a maximum value on May 29, 2014, more than a month after ice-out (Figure 12). The temperature sensor malfunctioned on August 14, 2014. Summer rain storms appear to have raised the lake level by less than 0.1 m.

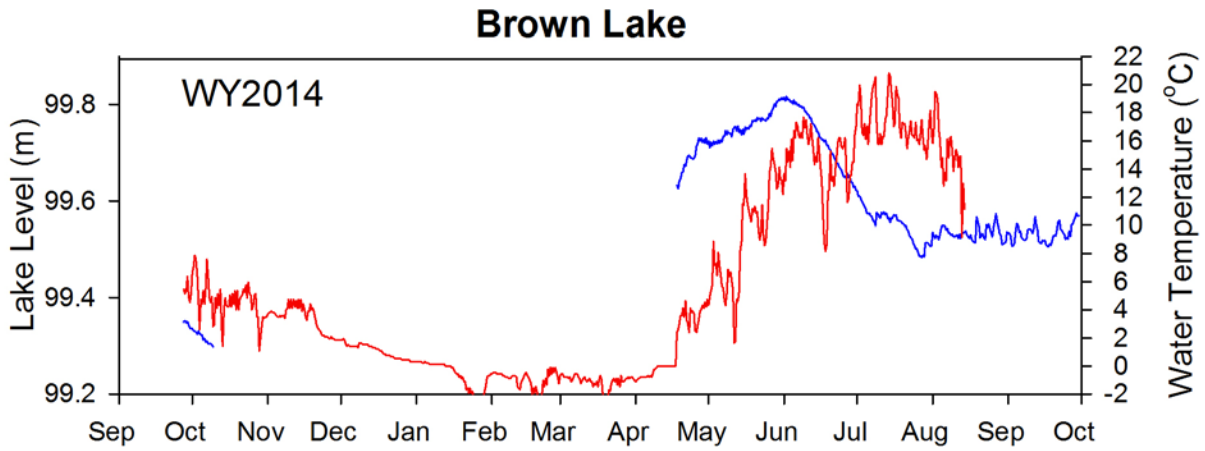

Figure 12. Water level record (blue line) and temperature record (red line) for Brown Lake.

Baker Lake

In WY2014, the water level in Baker Lake reached a maximum value of 100.10 m on May 31, 2014 (Figure 13). Rain storms appear to have raised the lake level by 0.38 m in August and a further 0.15 m in late September.

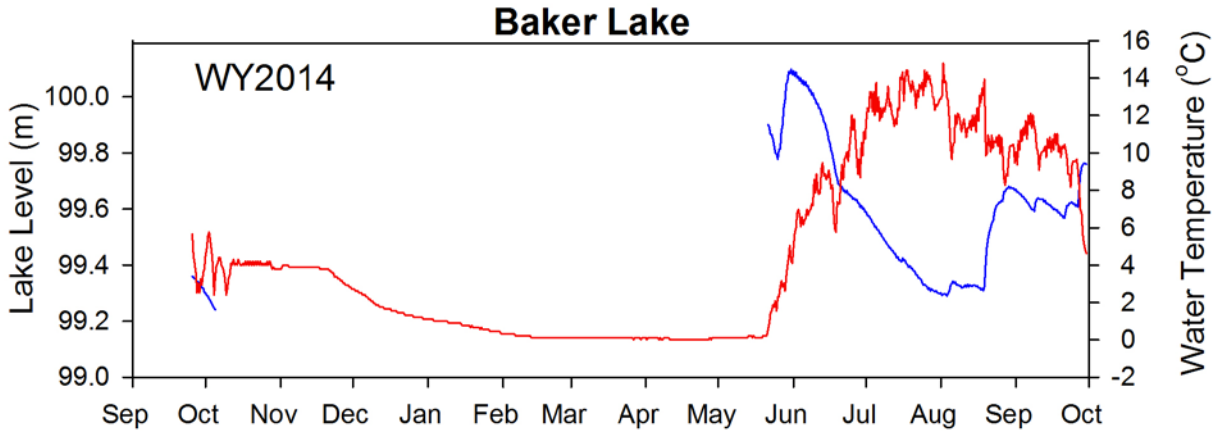

Figure 13. WY2104 water level record (blue line) and temperature record (red line) for Baker Lake.

Johnson Lake

Johnson Lake was not visited in 2013 due to the government shutdown, but the pressure transducer was recovered in September 2014 with data from WY2013 and WY2014 (Figure 14). The fall 2013 data are not tied to a lake level measured during a field visit, so they cannot be used quantitatively. The post-WY2014 ice-out data are tied to the September 2014 lake measurement.

In WY2014, the water level in Johnson Lake reached a maximum value on May 29, 2014, more than a month after ice-out. Summer rain storms appear to have raised the lake level by less than 0.1 m.

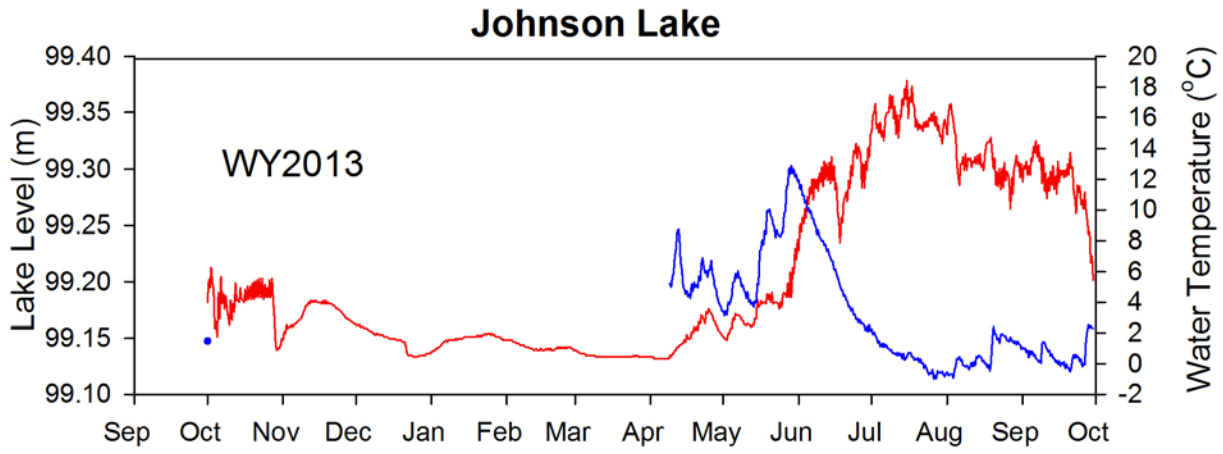

Figure 14. WY 2014 water level record (blue line) and temperature record (red line) for Johnson Lake. The Fall 2013 water level record is not tied to a lake level reading.

Dead Lake

Dead Lake was not visited in 2013 due to the government shutdown, but the pressure transducer was recovered in September 2014 with data from WY2013 and WY2014. In addition, the lake level fell below the elevation of the data logger in Fall 2013 and after July 15, 2014, so the record cannot be tied to measured lake levels. The recovered data have been graphed in Figure 15 for the purposes of qualitative interpretation.

In WY2014, The water level in Dead Lake reached a maximum value on May 11, 2014.

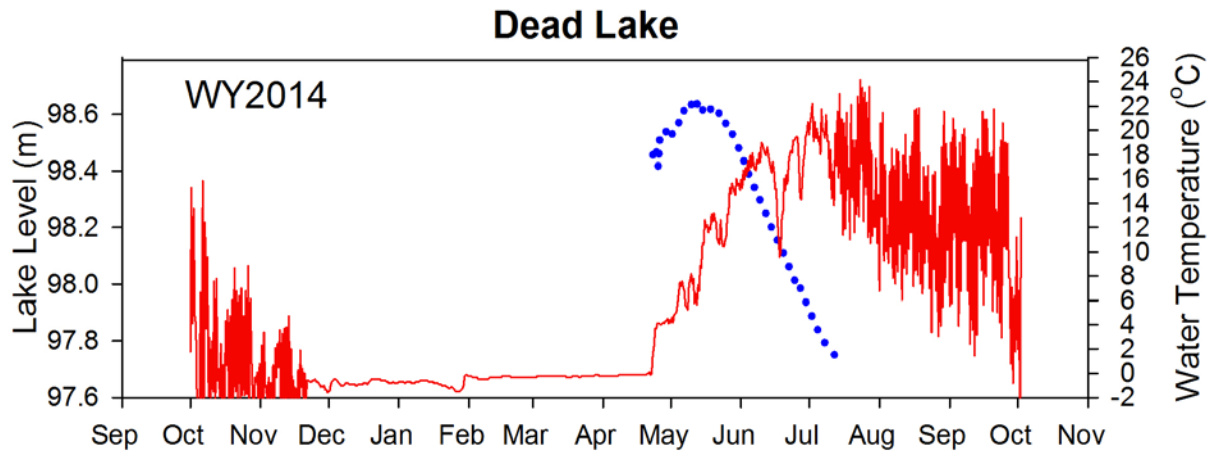

Figure 15. WY 2014 water level record (blue line) and temperature record (red line) for Dead Lake. The water level record is not tied to a lake level reading.

Lake Water Clarity

Lake water clarity was assessed in the field by measuring Secchi depth. In all 2014 visits, the Secchi disk was visible on the bottom of the lake (Table 12). While the lakes at GRBA are likely too shallow to detect small changes in water clarity using this method, these data allow any major decrease in water clarity (i.e. the 2011 and 2012 algal blooms in Dead Lake) to be documented.

Table 12. Secchi depth in GRBA lakes.

Lake	Visit Date	Secchi Depth
Stella	8/27/2009[a]	visible on bottom (0.9 m)
	9/21/2010	visible on bottom (0.7 m)
	9/27/2011	visible on bottom (1.0 m)
	9/25/2012	visible on bottom (0.7 m)
	9/24/2013	visible on bottom (0.8 m)
	9/30/2014	visible on bottom (1.0 m)
Teresa	8/27/2009[a]	visible on bottom (1.3 m)
	9/21/2010	visible on bottom (0.8 m)
	9/27/2011	visible on bottom (1.5 m)
	9/25/2012	visible on bottom (1.4 m)
	9/23/2013	visible on bottom (1.9 m)
	9/30/2014	visible on bottom (2.4 m)
Brown	9/21/2010	visible on bottom (0.5 m)
	9/27/2011	visible on bottom (0.9 m)
	9/25/2012	visible on bottom (0.5 m)
	9/24/2013	visible on bottom (0.7 m)
	9/30/2014	visible on bottom (0.9 m)
Baker	9/25/2009	visible on bottom (2.1 m)
	9/22/2010	visible on bottom (2.0 m)
	9/29/2011	visible on bottom (2.2 m)
	9/27/2012	visible on bottom (2.1 m)
	9/25/2013	visible on bottom (2.3 m)
	10/7/2014	visible on bottom (2.3 m)
Johnson	9/24/2009	visible on bottom (4.4 m)
	9/23/2010	visible on bottom (4.2 m)
	9/28/2011	visible on bottom (4.9 m)
	9/26/2012	visible on bottom (3.4 m)
	2013	-
	10/2/2014	visible on bottom (4.0 m)
Dead	9/23/2010	visible on bottom (1.4 m)
	9/28/2011	**bottom not visible** (3.7 m)
	9/26/2012	**bottom not visible** (0.3 m)
	2013	-
	10/2/2014	visible on bottom (0.2 m)

a. Lake monitored outside of index period.

Lake Water Chemistry

Lake water samples were collected by hand-dipping near the deepest point in each lake. These samples were analyzed for basic chemistry and nutrient concentrations at the Cooperative Chemical Analysis Facility (CCAL) in Corvallis, Oregon. The results of these analyses and the water quality data measured at the time of sampling are described in this section.

Water Quality Parameters

Depth profiles of four water quality parameters (temperature, DO, pH, and SpCond) were measured at six lakes. Measurements were made at the lake surface, the bottom, and several points in between.

The 2014 depth profiles are given in Table 13. No stratification is apparent in any of the depth profiles. This observation, combined with the variations in temperature recorded at depth (Figures 11 to 15), likely indicate that the lakes are frequently mixed.

Table 13. Water quality depth profiles for 2014 collected in GRBA lakes.

Lake and Sampling Date	Depth m	pH	DO mg/L	SpCond µS/cm	Temperature °C
Stella	0.00	7.36	7.90	33	3.90
9/30/2014	0.30	7.39	8.05	34	3.94
	0.61	7.34	8.16	33	3.95
	0.98	6.86	7.36	36	4.46
Teresa	0.00	7.64	10.16	22	2.81
9/30/2014	0.61	7.52	9.14	22	2.76
	1.22	7.45	8.94	22	2.81
	1.83	7.34	9.74	21	4.20
	2.44	7.32	9.13	21	3.50
Brown	0.00	7.52	8.33	20	6.55
9/30/2014	0.30	7.5	8.31	19	6.53
	0.61	7.47	8.40	19	6.47
	0.91	7.19	7.71	19	6.63
Baker	0.00	7.24	8.82	16	4.68
10/7/2014	0.61	7.25	8.62	16	4.67
	1.22	7.24	8.59	16	4.68
	1.68	7.22	8.59	17	4.76
	2.13	7.21	8.55	17	4.71
Johnson	0.00	7.60	8.55	34	6.60
10/2/2014	0.91	7.41	8.47	34	6.26
	1.83	7.05	8.61	34	5.17
	2.74	7.07	8.83	34	5.07
	3.66	7.07	8.81	33	5.00
Dead	0.00	7.25	7.90	33	16.88
10/2/2014					

Nutrients

Nutrient concentrations measured in the lake water samples (Table 14) are generally similar to the concentrations measured in the stream water samples. In 2014, the highest total nitrogen (TN) value was 0.81 mg/L, and the highest total phosphorus (TP) value was 0.160 mg/L. This TP value from Dead Lake exceeds the 0.10 mg/L Nevada water quality standard for Class A Waters.

Total dissolved nitrogen (TDN) values were close to TN values, but nitrate + nitrite values were more variable depending on the lake. This suggests that the dominant form of N in late summer may be dissolved organic nitrogen or that dissolved organic nitrogen may be present with nitrate + nitrite. Total dissolved phosphorus (TDP) values were usually less than TP values in many of the samples, suggesting that both particulate and dissolved phosphorus are present in the lakes.

In 2014, the Total Dissolved Nitrogen (TDN) value was greater than the TN value in three of the lake samples. As discussed in Appendix 1, the analytical results fall within precision limits, and the values for each sample are analytically equal in concentration. The Total Dissolved Phosphorus (TDP) value was greater than the TP value for one of the lake samples. Again, the values fall within the range of expected variability.

Table 14. Nutrient concentrations in GRBA lakes.

Lake	Sampling Date	Total N mg/L	Total Dissolved N mg/L	Nitrate + Nitrite mg/L as N	Total P mg/L	Total Dissolved P mg/L
Stella	8/27/2009[a]	0.25	0.25	0.002[d]	0.012	0.007
	9/21/2010	0.27	0.26	0.001[d]	0.011	0.007
	9/27/2011	0.28	0.28	0.002[d]	0.016	0.009
	9/25/2012	0.43	0.31	0.005	0.019	0.007
	9/24/2013	0.45	0.35	0.001[d]	0.011	0.007
	9/30/2014	0.22	0.24[b]	0.009	0.008	0.005
Teresa	8/27/2009[a]	0.21	0.39[c]	0.252[c]	0.012	0.010
	9/21/2010	0.68	0.64	0.014	0.054	0.035
	9/27/2011	0.48	0.47	0.360	0.012	0.010
	9/25/2012	0.77	0.69	0.599	0.012	0.006
	9/23/2013	0.89	0.84	0.789	0.010	0.006
	9/30/2014	0.79	0.81[b]	0.724	0.014	0.015[b]
Brown	2009	-	-	-	-	-
	9/21/2010	0.69	0.63	0.025	0.015	0.009
	9/27/2011	0.49	0.46	0.011	0.016	0.008
	9/25/2012	0.57	0.52	0.076	0.009	0.004
	9/24/2013	0.41	0.35	0.011	0.009	0.004
	9/30/2014	0.33	0.34[b]	0.040	0.008	0.006

Table 14. Nutrient concentrations in GRBA lakes (continued).

Lake	Sampling Date	Total N mg/L	Total Dissolved N mg/L	Nitrate + Nitrite mg/L as N	Total P mg/L	Total Dissolved P mg/L
Baker	9/25/2009	0.26	0.24	0.052	0.025	0.019
	9/22/2010	0.28	0.29[b]	0.068	0.033	0.026
	9/29/2011	0.27	0.37[c]	0.107	0.020	0.013
	9/27/2012	0.43	0.42	0.307	0.017	0.010
	9/25/2013	0.52	0.48	0.403	0.014	0.005
	10/7/2014	0.54	0.46	0.384	0.015	0.009
Johnson	9/24/2009	0.20	0.21	0.004	0.008	0.006
	9/23/2010	0.21	0.23[b]	0.004	0.009	0.008
	9/28/2011	0.14	0.13	0.003	0.006	0.005
	9/26/2012	0.16	0.14	0.011	0.006	0.003
	2013	-	-	-	-	-
	10/2/2014	0.19	0.19	0.024	0.009	0.009
Dead	2009	-	-	-	-	-
	9/23/2010	0.82	0.95[c]	0.001[d]	0.051	0.039
	9/28/2011	0.54	0.45	0.001[d]	0.029	0.018
	9/26/2012	1.08	0.88	0.001[d]	0.218	0.044
	2013	-	-	-	-	-
	10/2/2014	0.81	0.77	0.002	0.160	0.029

a. Lake sampled outside of index period.

b. TDN (or TDP) value greater than TN (or TP) value with the difference within precision limits, indicating that the samples are analytically equal in concentration.

c. TDN (or TDP) value greater than TN (or TP) value with the difference outside the expected range of variability, indicating contamination of the sample.

d. Concentration is below the method detection limit (MDL).

Major Ions and Acid Neutralization Capacity

Water samples were analyzed for sodium, potassium, calcium, magnesium, sulfate, and chloride (Table 15). Systematic changes in the concentrations of these ions over time may be useful in determining whether the lake is being affected by atmospheric deposition. The relatively minor year-to-year variations of these concentrations suggest that any future changes will be detectable.

In addition, the acid neutralizing capacity (ANC) of each lake was measured. Lakes with ANC values of less than 100 μeq/L are often considered to be sensitive to acidification (e.g., Campbell et al 2004, Stoddard et al. 2008, Burns et al. 2011). By this measure, none of the lakes sampled in 2014 would be classified as sensitive to acidic deposition during the index period.

Table 15. Major ion concentrations and acid neutralization capacity in GRBA lakes.

Lake	Sampling Date	Sodium mg/L	Potassium mg/L	Calcium mg/L	Magnesium mg/L	Sulfate mg/L as S	Chloride mg/L	ANC µeq/L
Stella	8/27/2009[a]	1.25	0.51	3.87	0.71	0.19	0.50	241
	9/21/2010	1.62	0.57	4.35	0.84	0.23	0.62	335
	9/27/2011	1.21	0.60	3.64	0.61	0.20	0.46	283
	9/25/2012	1.35	0.69	4.03	0.75	0.19	0.60	320
	9/24/2013	1.39	0.43	3.85	0.68	0.15	0.61	300
	9/30/2014	1.19	0.52	4.47	0.72	0.16	0.48	312
Teresa	8/27/2009[a]	0.69	0.34	1.96	0.43	0.34	0.45	92
	9/21/2010	0.87	0.59	2.44	0.64	0.36	0.67	192
	9/27/2011	0.55	0.28	1.80	0.46	0.33	0.32	129
	9/25/2012	0.58	0.33	2.01	0.52	0.40	0.45	127
	9/23/2013	0.74	0.32	2.35	0.58	0.44	0.53	135
	9/30/2014	0.67	0.37	2.32	0.57	0.41	0.48	117
Brown	2009	-	-	-	-	-	-	-
	9/21/2010	2.05	1.19	4.08	1.13	0.57	1.76	306
	9/27/2011	0.98	0.63	1.95	0.55	0.25	0.67	168
	9/25/2012	1.19	0.78	2.12	0.66	0.56	1.12	176
	9/24/2013	0.96	0.56	1.88	0.57	0.60	0.72	161
	9/30/2014	0.85	0.46	1.97	0.53	0.40	0.65	137
Baker	9/25/2009	0.73	0.33	1.94	0.37	0.41	0.55	144
	9/22/2010	0.70	0.40	1.77	0.43	0.43	0.44	140
	9/29/2011	0.72	0.36	1.63	0.37	0.39	0.57	129
	9/27/2012	0.53	0.27	1.77	0.39	0.41	0.37	121
	9/25/2013	0.62	0.26	1.80	0.39	0.39	0.37	118
	10/7/2014	0.53	0.25	1.83	0.39	0.41	0.32	103
Johnson	9/24/2009	1.06	0.29	5.76	0.38	1.15	0.42	293
	9/23/2010	0.96	0.30	5.30	0.40	1.12	0.24	258
	9/28/2011	0.79	0.21	4.16	0.30	0.91	0.18	238
	9/26/2012	0.55	0.06	6.08	0.36	1.18	0.10	301
	2013	-	-	-	-	-	-	-
	10/2/2014	0.65	0.13	5.69	0.34	1.08	0.14	264
Dead	2009	-	-	-	-	-	-	-
	9/23/2010	1.52	0.89	1.80	0.41	0.34	1.04	152
	9/28/2011	1.25	0.73	2.50	0.52	0.27	0.58	214
	9/26/2012	1.62	0.52	1.61	0.39	0.24	0.92	154
	2013	-	-	-	-	-	-	-
	10/2/2014	1.75	1.02	3.24	0.73	1.85	0.65	137

a. Lake sampled outside of index period.

Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) are discussed in Appendix A. The major QA/QC issues encountered with 2014 data was missing continuous water quality data.

As described in Appendix A, many days of water quality data were not collected due to calibration errors, sensor malfunction, and downtime for repairs. In the future, more care will be taken in training inexperienced crew members assigned to calibrate the sondes. MOJN will also attempt to reduce the amount of lost data by instituting a set of post-season instrument tests so that any necessary repairs and replacements can be carried out between field seasons.

Discussion

Water year 2014 had greater-than-average precipitation, with the Coop station at Lehman Caves recording the wettest July and August on record. The largest summer storms resulted in brief periods of high stream discharge, but no major changes to stream chemistry were observed. Most of the lakes exhibited water level increases of less than 0.1 m in response to the summer storms. The level of Baker Lake, however, rose by more than 0.5 m. No major changes in water chemistry were observed in any of the lakes.

The overall water quality of the streams and lakes in GRBA is high. Both the streams and the lakes have low nutrient concentrations, high pH values, low temperatures, and high levels of oxygen saturation. The observed BMI communities in the streams are consistent with unimpaired water quality.

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Appendix A: QA/QC Measurements

This appendix reports on the results of all QA/QC measurements made in the field and the laboratory during the 2014 field season.

Instrument Testing

QA/QC testing of the instruments was performed at the beginning of the field season in accordance with the protocol SOPs (Moret et al. 2012). The tested instruments are listed in Table A-1, below.

Table A-1. Instruments included in QA/QC testing.

Instrument	Owner	Type	Parameters	Manufacturer	Model #
A	GRBA	sonde	All 4	YSI	6920 V2
B	MOJN	sonde	All 4	YSI	6920 V2
C	MOJN	sonde	All 4	YSI	6920 V2
D	MOJN	sonde	All 4	YSI	6920 V2
E	MOJN	sonde	All 4	YSI	6920

Temperature Sensor Comparison

Temperature sensors are not calibrated. Instead, temperature sensors are compared to each other once a year in water baths of different temperatures to detect problematic performance. In previous years an ice water bath was used, but it was difficult to keep the water temperature constant (Moret and others 2013). In 2014, tap water of three different temperatures was used in the laboratory sink. The standard is that the measurements should be within 0.2 °C of each other. As Table A-2 shows, the test was not successful. Because one sensor was not consistently reading differently in the different water baths, the differences in the readings are likely due to spatial variability in water temperature within the sink. In future years, all tests should be carried out in a large cooler, and the water should be mixed continuously.

Table A-2. Temperature sensor comparison results.

Bath	Hot	Warm	Cold
A	24.7 °C	18.25 °C	10.60 °C
B	24.38 °C	19.04 °C	10.70 °C
C	-	19.10 °C	11.58 °C
E	-	19.18 °C	11.38 °C

Head-to-Head Testing and AMS+ Calculation

The head-to-head instrument comparison was carried out in Baker Creek near Upper Baker Creek Campground. As Table A-3 shows, major problems were encountered with the pH probes (sonde D's pH probe was completely non-functional). MOJN is in the process of replacing all of the pH probes.

Table A-3. Head-to-head comparison of water quality measurements made using different instruments.

Instrument	Temperature (°C)	SpCond (µS/cm)	pH	DO (%)
A	9.14	28.9	7.24	74.0
B	9.88	22.9	8.30	76.5
C	9.94	19.8	7.82	75.6
D	9.99	22.7	n/a	77.0
E	10.00	27.3	7.25	74.5

AMS+ is a metric of measurement sensitivity in an ambient condition such as a well-mixed flowing stream. It is affected by instrument noise and natural heterogeneity. Seven repeated measurements are made in rapid succession in situ. AMS+ is then calculated as:

$$AMS+ = t \times s \quad ,$$

where:

s = sample standard deviation of the 7 in-situ measurement values, and
t = 3.708, the 99% confidence middle (two-sided) t-value for a sample size of 7.

The AMS+ values for the instruments are given in Table A-4. The data quality objectives (DQOs) for AMS+ are 0.3 °C for temperature, 5 µS/cm for specific conductivity, 0.3 for pH, and 0.4 mg/L for dissolved oxygen. These targets were met for all sensors except the sonde A DO sensor (Table A-4). This sensor was subsequently replaced.

Table A-4. AMS+ values for water quality instruments used during the field season. Bolded values exceed DQOs.

Instrument	Temperature (°C)	SpCond (µS/cm)	pH	DO (%)
A	0.03	0.02	0.06	7.08
B	0.01	0.09	0.16	0.37
C	0.025	0.018	0.018	0.221
D	0.02	0.03	n/a	0.23
E	0.01	0.36	0.03	0.28

Stream Cross-Section Data

Over five years of stream cross-section testing in GRBA streams (2009-2013), no spatial variation in water quality was observed in any stream at any time. This observation is consistent with the observation that small, fast-moving, turbulent mountain streams are well-mixed. MOJN did not conduct stream cross-section tests in 2014, and does not plan to in the future unless flow conditions suggests the possibility of spatial variation in water quality.

Laboratory QA/QC

The discussion below summarizes QA/QC checks and procedures for laboratory analytical data collected during 2011, 2012, and 2013. All analyses were performed by the Cooperative Chemical Analytical Laboratory (CCAL).

Laboratory Detection Limits and Quantitation Limits

CCAL met the desired measurement quality objectives (MQOs) for detection limits. Several analytical results were between the detection limit (MDL) and the quantitation limit (ML), meaning that the analytes were detected, but their concentrations could not be quantified. These data have been flagged, and they should not be used in long term trend analyses without careful consideration.

Dissolved Concentrations Exceeding Total Concentrations

One observed problem with the laboratory data was that four of the total dissolved nitrogen (TDN) values were greater than their corresponding total nitrogen (TN) values, and two of the total dissolved phosphorus (TDP) values were greater than their corresponding total phosphorus (TP) values. The laboratory concluded that all of the discrepancies were within the range of normal variability, and that the values were "analytically equal in concentration." Unlike previous years, none of the samples failed to conform to analytical expectations, suggesting that field techniques have improved over time.

Table A-5. Summary of 2014 laboratory analyses with TDN > TN.

	Total Nitrogen (mg/L)	Total Dissolved Nitrogen (mg/L)
Lehman Creek	0.55	0.58
Lab Report: "analytical results fall within precision limits, and are analytically equal in concentration"		
Brown Lake	0.33	0.34
Duplicate Analysis	0.33	-
Lab Report: "analytical results fall within precision limits, and are analytically equal in concentration"		
Stella Lake	0.22	0.24
Lab Report: "analytical results fall within precision limits, and are analytically equal in concentration"		
Teresa Lake	0.79	0.81
Lab Report: "analytical results fall within precision limits, and are analytically equal in concentration"		

Table A-6. Summary of 2014 laboratory analyses with TDP > TP.

	Total Phosphorus (mg/L)	Total Dissolved Phosphorus (mg/L)
Lehman Creek	0.008	0.010
Lab Report: "analytical results fall within precision limits, and are analytically equal in concentration"		
Teresa Lake	0.014	0.015
Lab Report: "analytical results fall within precision limits, and are analytically equal in concentration"		

Duplicate Analyses

In 2014, CCAL performed 46 duplicate analyses on 13 samples. At least one duplicate analysis was performed for each of the measured parameters.

The analytical results for the duplicate samples are compared using Relative Percent Difference (RPD). The RPD for each pair of measurements is calculated as:

$$\text{RPD} = \left[\frac{S_1 - S_2}{(S_1 + S_2)/2} \right] \times 100 \quad ,$$

where:

S_1 = the larger test result value, and
S_2 = the smaller test result value.

The results of the duplicate analyses and RPD calculations are given in Table A-7. None of the calculated RPD values exceed the laboratory precision MQO of 30% specified in the QAPP.

Table A-7. 2014 duplicate laboratory analyses and relative percent difference (RPD) values.

Sample	Analysis	Original Result	Duplicate Result	RPD
Baker Creek	Cl (mg/L)	0.43	0.43	0%
Baker Creek	SO4-S (mg/L)	0.83	0.83	0%
Baker Lake	TDN (mg/L)	0.46	0.47	2%
Baker Lake	TDP (mg/L)	0.009	0.010	11%
Baker Lake	Na (mg/L)	0.53	0.54	2%
Baker Lake	K (mg/L)	0.25	0.25	0%
Brown Lake	TN (mg/L)	0.33	0.33	0%
Brown Lake	TP (mg/L)	0.008	0.008	0%
Johnson Lake	pH	7.2	7.3	1%
Johnson Lake	Alk CaCO3 (mg/L)	13.21	13.31	1%
Johnson Lake	TDN (mg/L)	0.19	0.18	5%
Johnson Lake	TDP (mg/L)	0.009	0.008	12%
Lehman Creek	pH	7.4	7.4	0%
Lehman Creek	Alk CaCO3 (mg/L)	12.77	12.67	1%
Lehman Creek	Cl (mg/L)	0.45	0.45	0%
Lehman Creek	SO4-S (mg/L)	0.45	0.45	0%
Lehman Creek	Na (mg/L)	0.94	0.94	0%
Lehman Creek	K (mg/L)	0.30	0.30	0%
Mill Creek	TN (mg/L)	0.18	0.18	0%
Mill Creek	TP (mg/L)	0.027	0.026	4%
Mill Creek	Cl (mg/L)	1.46	1.45	1%
Mill Creek	SO4-S (mg/L)	0.70	0.69	1%
Pine Creek	Cl (mg/L)	0.42	0.42	0%
Pine Creek	SO4-S (mg/L)	0.45	0.46	2%
Ridge Creek	Cl (mg/L)	0.48	0.48	0%
Ridge Creek	SO4-S (mg/L)	0.63	0.64	2%
Ridge Creek	Ca (mg/L)	4.78	4.83	1%
Ridge Creek	Mg (mg/L)	1.11	1.11	0%

Table A-7. 2014 duplicate laboratory analyses and relative percent difference (RPD) values (continued).

Sample	Analysis	Original Result	Duplicate Result	RPD
Shingle Creek	TDN (mg/L)	0.06	0.07	15%
Shingle Creek	TDP (mg/L)	0.008	0.009	12%
Shingle Creek	Cl (mg/L)	0.55	0.54	2%
Shingle Creek	SO4-S (mg/L)	0.67	0.68	1%
Snake Creek	NO3 + NO2-N (mg/L)	0.001	0.001	0%
Snake Creek	TN (mg/L)	0.07	0.07	0%
Snake Creek	TP (mg/L)	0.008	0.008	0%
Snake Creek	Cl (mg/L)	0.74	0.73	1%
Snake Creek	SO4-S (mg/L)	0.71	0.71	0%
S. Fork Big Wash	TN (mg/L)	0.17	0.16	6%
S. Fork Big Wash	TP (mg/L)	0.005	0.005	0%
Stella Lake	NO3 + NO2-N (mg/L)	0.009	0.008	12%
Stella Lake	Ca (mg/L)	4.47	4.50	1%
Stella Lake	Mg (mg/L)	0.72	0.73	1%
Strawberry Creek	TDN (mg/L)	0.08	0.09	12%
Strawberry Creek	TDP (mg/L)	0.012	0.012	0%
Strawberry Creek	Cl (mg/L)	3.69	3.69	0%
Strawberry Creek	SO4-S (mg/L)	1.58	1.59	1%

Effectiveness and Completeness

Effectiveness, E, is calculated as:

$$E = (U / N) \times 100 \quad ,$$

where:

U = number of usable parameter values, and
N = number of parameter values collected, including low-quality data that cannot be used in future analyses.

Completeness, C, is calculated as:

$$C = (U / P) \times 100 \quad ,$$

where:

P = number of potential parameter values that would have been collected had the field season proceeded as envisioned in the sampling plan.

Annual Stream Visits

All of the streams were visited in 2014, and all of the visits resulted in usable chemistry, BMI, and water quality data. Overall completeness for 2014 (4 stream visits out of 4 planned stream visits) was 100%.

Annual Lake Visits

All of the lakes were visited in 2014. Usable chemistry and water quality data were generated at each visit (E = 100%), so the overall completeness for 2014 (6 lake visits out of 6 planned lake visits) was 100%.

Lake Level Records

As described in the "Lake Level and Ice-Free Period", 4 of the 5 lake level records are usable (C = 80%). The Teresa Lake pressure transducer could not be recovered due to unusually high water levels.

Continuous Water Quality

The effectiveness and completeness statistics for the continuous water quality monitoring are summarized in Table A-8. Many of the periods of missing or unusable data are due to sonde malfunction. MOJN is working to develop procedures for timely sensor replacement that should increase the C and E of the monitoring program. Some of the gaps are due to high flows in the early part of the season or low flows in the later part of the season, and are therefore unavoidable.

Table A-8. Effectiveness and completeness of continuous water quality monitoring for the 77-day index period in 2014.

Stream	Parameter	Days of Data (N)	Days of Usable Data (U)	% Effectiveness (E)	% Completeness (C), P = 77
Baker	Temperature	77	75	97.4	97.4
	DO	77	75	97.4	97.4
	pH	77	77	100.0	100.0
	SpCond	77	74	96.1	96.1
	Average	77	75.25	97.7	97.7
Lehman	Temperature	28	28	100.0	36.4
	DO	28	28	100.0	36.4
	pH	28	28	100.0	36.4
	SpCond	28	28	100.0	36.4
	Average	28	28	100.0	36.4
Upper Snake	Temperature	77	76	98.7	98.7
	DO	77	76	98.7	98.7
	pH	77	76	98.7	98.7
	SpCond	77	76	98.7	98.7
	Average	77	76	98.7	98.7
Lower Snake	Temperature	0	0	-	0
	DO	0	0	-	0
	pH	0	0	-	0
	SpCond	0	0	-	0
	Average	0	0	-	0

Table A-8. Effectiveness and completeness of continuous water quality monitoring for the 77-day index period in 2014 (continued).

Stream	Parameter	Days of Data (N)	Days of Usable Data (U)	% Effectiveness (E)	% Completeness (C), P = 77
Strawberry	Temperature	53	53	100.0	68.8
	DO	53	0	0.0	0.0
	pH	53	16	30.2	20.8
	SpCond	53	15	28.3	19.5
	Average	53	21	39.6	27.3

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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