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Natural Resource Stewardship and Science

Status of Climate and Water Resources at Gila Cliff Dwellings National Monument

Water Year 2016

Natural Resource Report NPS/SODN/NRR—2018/1615

ON THE COVER

Benthic macroinvertebrate collection on the West Fork Gila River, Gila Cliff Dwellings National Monument. NPS photo.

Status of Climate and Water Resources at Gila Cliff Dwellings National Monument

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Natural Resource Report NPS/SODN/NRR—2018/1615

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Executive Summary

Climate and hydrology are major drivers of ecosystems. They dramatically shape ecosystem structure and function, particularly in arid and semi-arid ecosystems. Understanding changes in climate, groundwater, streamflow, and water quality is central to assessing the condition of park biota and key cultural resources. This report combines data collected on climate, groundwater, and surface water at Gila Cliff Dwellings National Monument (NM) to provide an integrated look at climate and water conditions during water year 2016 (October 2015–September 2016).

Although 2016 was the hottest year on record globally (NASA 2017), local air-temperature patterns at Gila Cliff Dwellings NM were more mixed. Maximum air temperatures in February, March, June, and July were well above normal. Annual precipitation was 113% of normal, with the largest increases occurring in November, April, and September. Increased rainfall and mixed air temperatures reduced the reconnaissance drought index relative to recent years, indicating a degree of recovery from the drought of the early 2000s.

The available stream-gauge data at Gila Cliff Dwellings NM did not meet QA/QC requirements during water year 2016. Annual discharge for the region was interpreted from data from USGS gauge 09430500 in Gila, New Mexico, 40 kilometers downstream of the monument. Discharge was generally within the normal range, with high-flow events in late January, late July, and September. None of these flow events, if they did occur at the West Fork of the Gila River index site, overflowed the river banks. The flow event in late July was captured on the multi-parameter datalogger at the index site, but these data indicated a stream-elevation increase of less than five inches, and other parameters (temperature, specific conductivity, pH) rapidly returned to median values after this event.

There were 236 discrete analyses of water samples collected from the West Fork Gila River index site in water year 2016. Of these samples, 89 were associated with New Mexico surface water criteria. Of those 89 samples, there were five exceedances of state standards, meaning that 94% of samples were compliant with state standards. There were exceedances for *E. coli*, turbidity, and total aluminum (chronic fish and wildlife). The stream was flowing at a higher rate during several sampling visits, and an elevated level of total suspended sediments indicates that the aluminum exceedance was likely the result of precipitation flushing sediment into the stream. Higher concentrations of aluminum have been detected in the past; they are not the result of human activity.

Macroinvertebrates were collected to provide data for compliance with the New Mexico biological standards. In water year 2016, the index reach scored a 60.78 on the New Mexico integrated biological index, putting it in the “good” category. Habitat metrics collected with the macroinvertebrate samples indicated a system that continues to recover from the impact of fires in water years 2011–2012.

Acknowledgements

We thank former superintendent Hugh Hawthorne and the staff and volunteers of Gila Cliff Dwellings National Monument for their on-site support of the monitoring effort. Mark Hiller and Finnian Freeling assisted with data collection and processing. Kristen Bonebrake led the management and posting of all data products. Macroinvertebrate identifications were completed by the Utah State University BugLab, and TestAmerica (Arizona) processed the water-chemistry samples.

1 Introduction

Climate and hydrology are major drivers of ecosystems. They dramatically shape ecosystem structure and function, particularly in arid and semi-arid ecosystems. Understanding changes in climate, groundwater, streamflow, and water quality is central to assessing the condition of park biota and key cultural resources. This document summarizes climate and water resource conditions for water year (WY) 2016 (October 2015–September 2016) at Gila Cliff Dwellings National Monument (NM), a small (216-ha) National Park Service unit in southwestern New Mexico. Detailed analyses of trends will follow in subsequent reports as the period of record warrants such assessments. For details on the monitoring protocols, park setting and resources, and information on other resources of management focus, please see http://www.nps.gov/im/sodn/.

2 Climate

2.1 Background and methods

Climate is the suite of characteristic meteorological conditions of the near-surface atmosphere at a given place (Strahler 2013), and is the primary driver of ecological processes on earth. A broader temporal scale (seasons to years) is what distinguishes climate from the instantaneous conditions reflected by the term, "weather."

Climate mediates the fundamental properties of ecological systems, such as soil–water relationships, plant–soil interactions, net primary productivity, the cycling of nutrients and water, and the occurrence, extent, and intensity of disturbances—in short, the underpinnings of the natural resources that the National Park Service manages and protects.

Gila Cliff Dwellings NM has had a nearby National Oceanic and Atmospheric Administration (NOAA) Cooperative Observer Program (COOP) weather station since 1957 (GILA HOT SPRINGS #0293530). This station provides a reliable long-term climate dataset. We used this excellent data source for all subsequent analyses. The monument has also hosted a Remote Automated Weather Station (RAWS) since 1998. Both stations are accessible through www.climateanalyzer.org. See the SODN climate monitoring protocol (Hubbard et al. in prep) for details on methods and data handling.

An Aridity Index (UNEP 1992), based on the long-term average annual precipitation relative to the average annual potential evapotranspiration, can be a useful tool for contrasting the local climate of national parks (Figure 2-1). Used globally to classify climate zones, aridity index seeks to answer the question "How dry is dry?" (Tsakiris and Vengelis 2005). Using the period of record (1957–present), the climate of Gila Cliff Dwellings NM is classified as semi-arid.

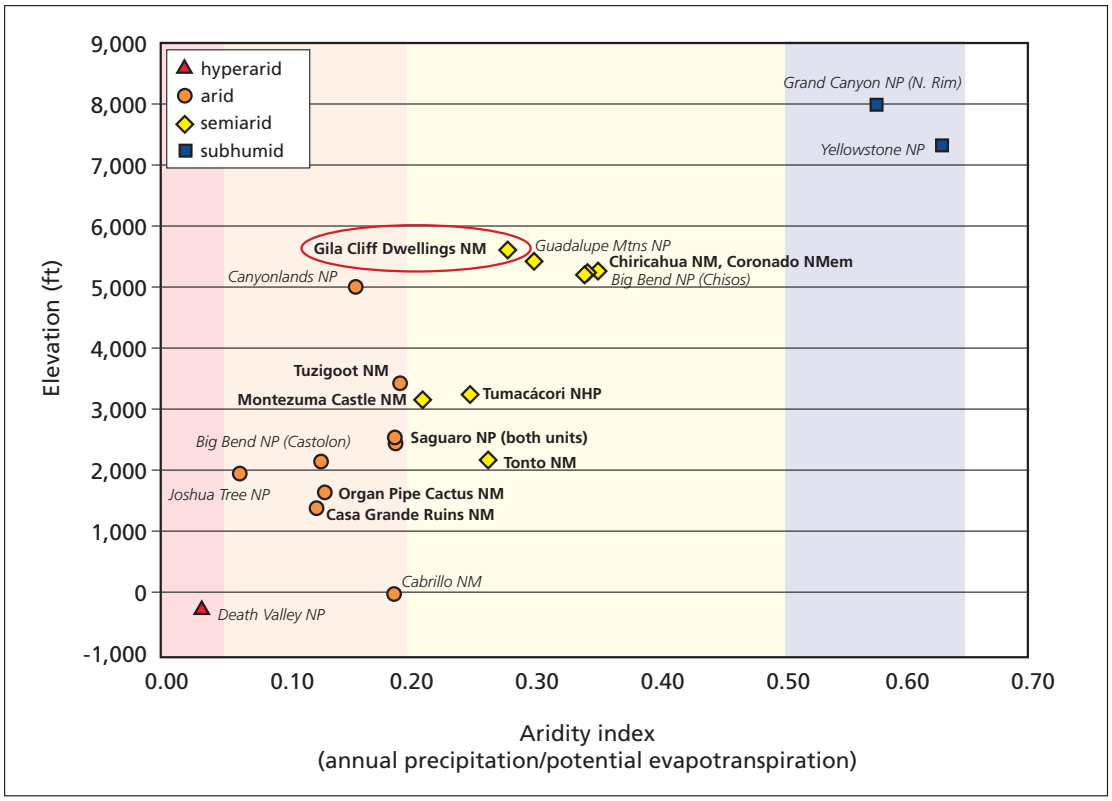

Figure 2-1. Aridity index vs. elevation of selected southwestern national parks, including Gila Cliff Dwellings National Monument. Figure from Hubbard and others (in prep).

2.2 Results and discussion

2.2.1 Departures from 30-year normals (1981–2010)

Data quality during WY2016 was excellent, with missing values on only five days, all in January. Overall annual precipitation was 113% of normal for Gila Cliff Dwellings NM (18.35" vs 16.26").

2.2.1.1 Cool season (October–March)

Overall precipitation was essentially normal (104% or +0.29") for the fall and winter of WY2016. Rainfall in February and April represented less than 20% of normal. November was dramatically wetter than normal, with 288% of the 1981–2010 normal rainfall levels (Figure 2-2). Fall and early winter air temperatures were generally close to normal (±2.5°F). The mean monthly maximum temperature was unusually high in February and March (+8.4°F) and +5.5°F, respectively). The mean monthly minimum temperature was lower than normal for both months, demonstrating a larger than normal diurnal temperature range (up to 59°F in a single day). As is usually the case, mean monthly low temperatures were below freezing from November to March.

2.2.1.2 Warm season (April–September)

Overall precipitation was above average (119%, 1.80") for the spring and summer months in WY2016. April and September were 200% wetter than normal. June rainfall was only 36% of normal. September had the highest monthly precipitation for the year, extending the duration of the monsoon season (Figure 2-3). Warm-season maximum and minimum air temperatures were close to normal (±2°F), except in June and July, which were warmer than normal.

2.2.2 Reconnaissance Drought Index

Reconnaissance drought index (Tsakiris and Vengelis 2005) provides a measure of drought severity and extent relative to the long-term climate based on the ratio of average precipitation to average potential evapotranspiration over shorter periods of time (seasons to years). The reconnaissance drought index for Gila Cliff Dwellings NM reflects the extended regional drought since 2000 (Figure 2-4), although conditions at the park began recovering in WY2015 and continued in WY2016, from the perspective of both precipitation and evaporative demand. However, the five-year moving mean of total annual precipitation from 1981 to 2016 (Figure 2-5) suggests that that the last two "wet" years have been insufficient to remedy the multi-year precipitation deficit.

2.2.3 Extreme weather events

Stochastic events, such as air-temperature extremes and unusually intense precipitation events, may be as important to understanding ecological patterns as long-term climate averages are. Although high air temperatures are a defining feature of warm deserts, extreme frost events also have important consequences for Arizona–New Mexico Mountains ecosystems. In particular, sustained low air temperatures can damage or even kill long-lived keystone plants (including the large deciduous trees that dominate the riparian woodlands of the park) (Turner et al. 2003), and the aquatic organisms that live in the river environment. Extreme precipitation events can also cause localized flooding and erosion events, spur or inhibit plant productivity and reproduction, and modify animal behavior.

Extremely cold days (<13°F, 5th percentile of 1981–2010 data) occurred only about 81% as often than normal in WY2016 (16 vs. 19.7 ± 1.9 days), and were of a similar duration (2.7 consecutive days vs. 2.1 ± 0.1 days). No days remained below 32°F all day.

The number of extreme precipitation events (>1") in WY2016 occurred twice the normal frequency (4 vs 2.3 days for 1981–2010). Large events occurred on November 26 (1.11"), July 29 (1.90"), September 8 (1.95"), and September 30 (1.94").

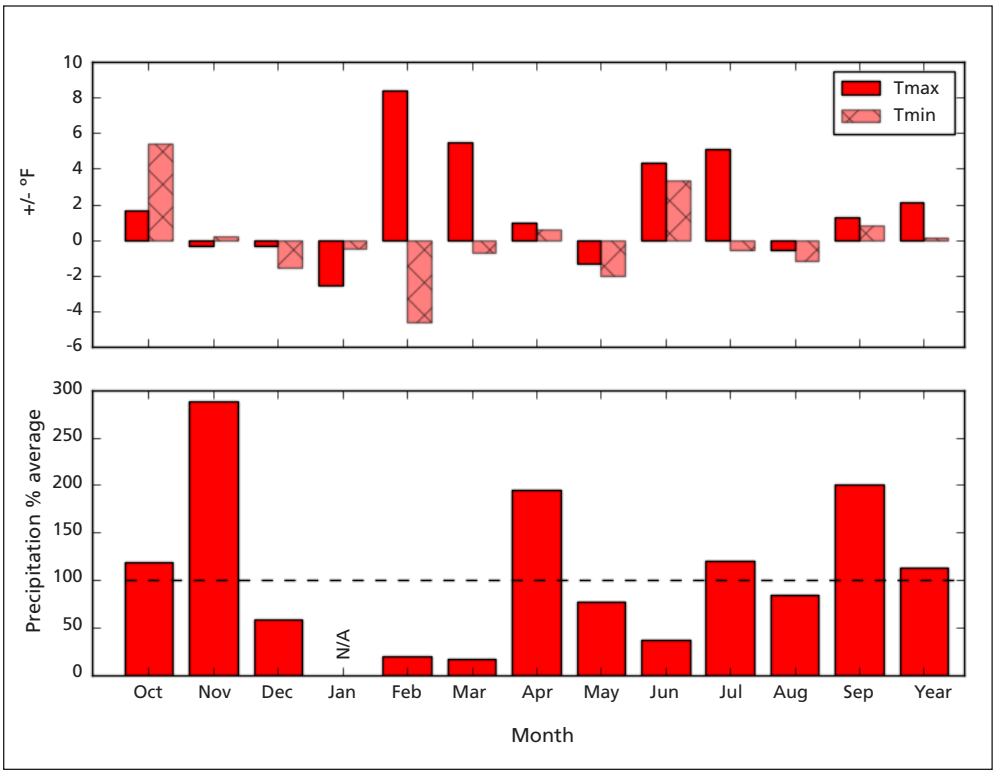

Figure 2-2. Departures from 30-year (1981–2010) normal minimum and maximum air temperature and precipitation, Gila Cliff Dwellings National Monument. Graphics generated by climateanalyzer.org.

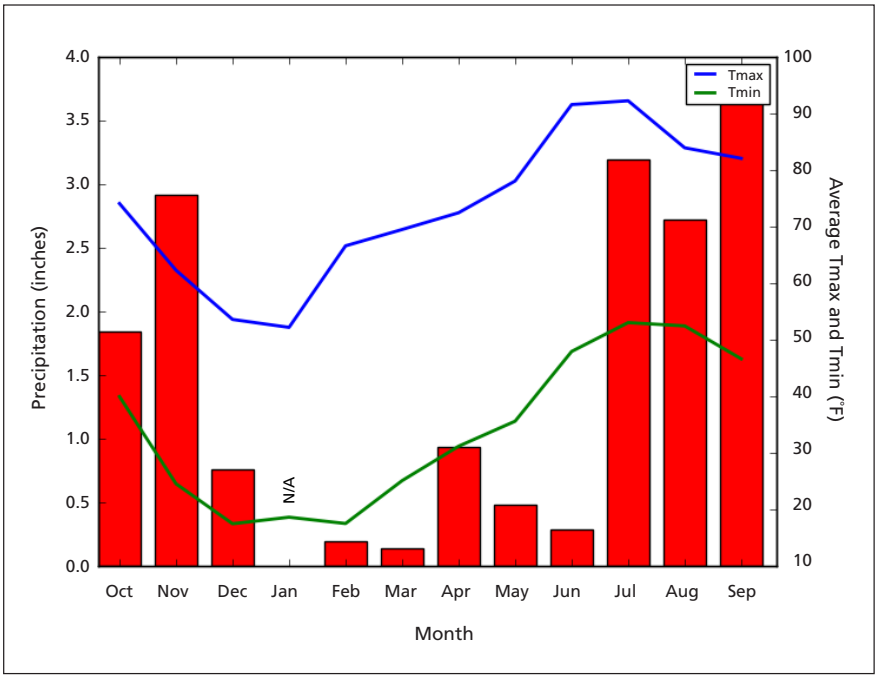

Figure 2-3. Climogram for water year 2016, Gila Cliff Dwellings National Monument. "n/a" = insufficient data to generate reliable precipitation totals. Graphics generated by climateanalyzer.org

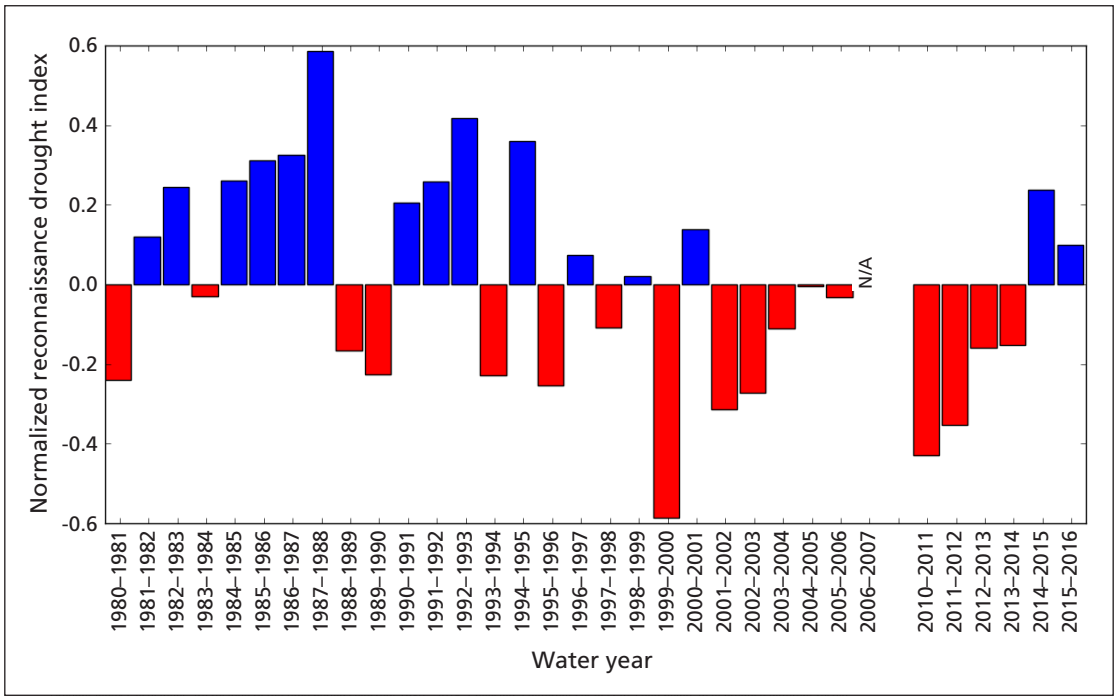

Figure 2-4. Reconnaissance drought index (RDI), Gila Cliff Dwellings National Monument, water years 1981–2016. "n/a" = insufficient data to generate reliable RDI estimates. The station was abandoned from 2007 to 2009. Graphics generated by climateanalyzer.org.

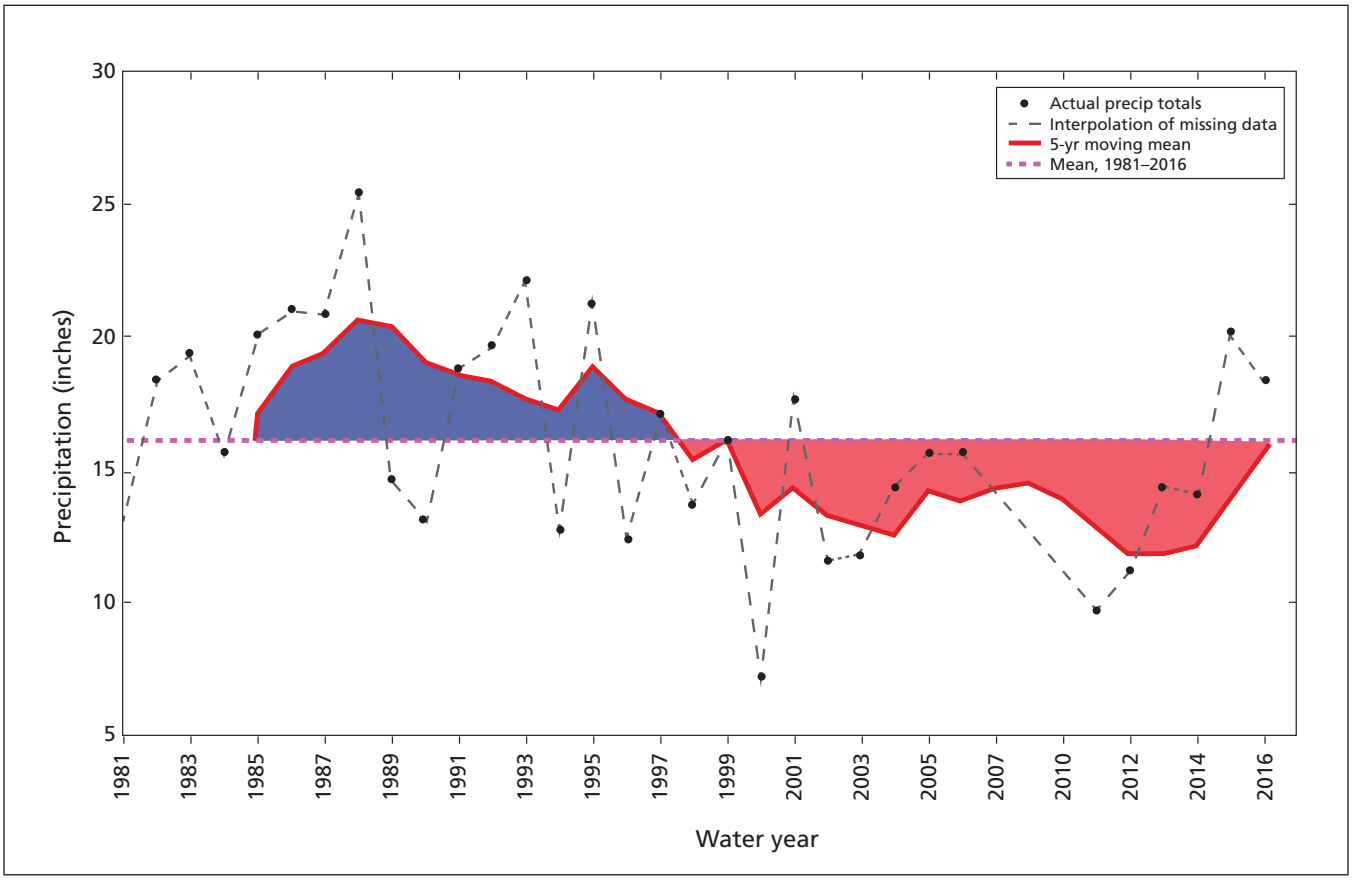

Figure 2-5. Five-year moving mean of annual precipitation, Gila Cliff Dwellings National Monument, 1981–2016. The moving mean (solid red line) is based on a timeseries with 11% (4 of 36) missing values, and includes the current year and previous four years. Blue and red fields represent water surplus and deficit. Missing years are linearly interpolated (dashed grey lines). The station was abandoned from WY2007–2010. Graphics generated by climateanalyzer.org.

3 Surface Water Monitoring

3.1 Background

The West Fork Gila River, which crosses the northeastern portion of Gila Cliff Dwellings NM, is a high-quality, mountainous stream. Located in the Gila Wilderness, its watershed is nearly devoid of residential, agricultural, and industrial land use. Visitor impacts are minimal. Consequently, this small (120-mi^2) watershed is more subject to natural stressors than anthropogenic disturbances.

The impacts of natural stressors vary temporally and spatially. The U.S. has been in a drought since approximately 2001. This has resulted in decreased streamflow in the West Fork Gila River, which sometimes runs dry near the park's eastern boundary. This area is also prone to flooding. Inside the park, the narrow floodplain is bounded by canyon walls that act as a bottleneck, increasing the destructive force of high flood waters. This was demonstrated in 2008, when a large rain-on-snow event carved a new stream channel. This event also caused economic damage when camp facilities and a bridge providing access to the monument were washed out, resulting in necessary repairs and reduced visitation.

In July 2012, the Whitewater–Baldy Fire burned in the watershed of the Gila Wilderness. Impacts of this fire have included aquatic habitat degradation, the establishment of invasive exotic plants, and potential future flooding and channel change.

In WY2016, Sonoran Desert Network (SODN) staff made four sampling visits to the West Fork Gila River at Gila Cliff Dwellings NM. Water quality monitoring occurred at the pedestrian bridge near the park's eastern boundary (Figure 3-1).

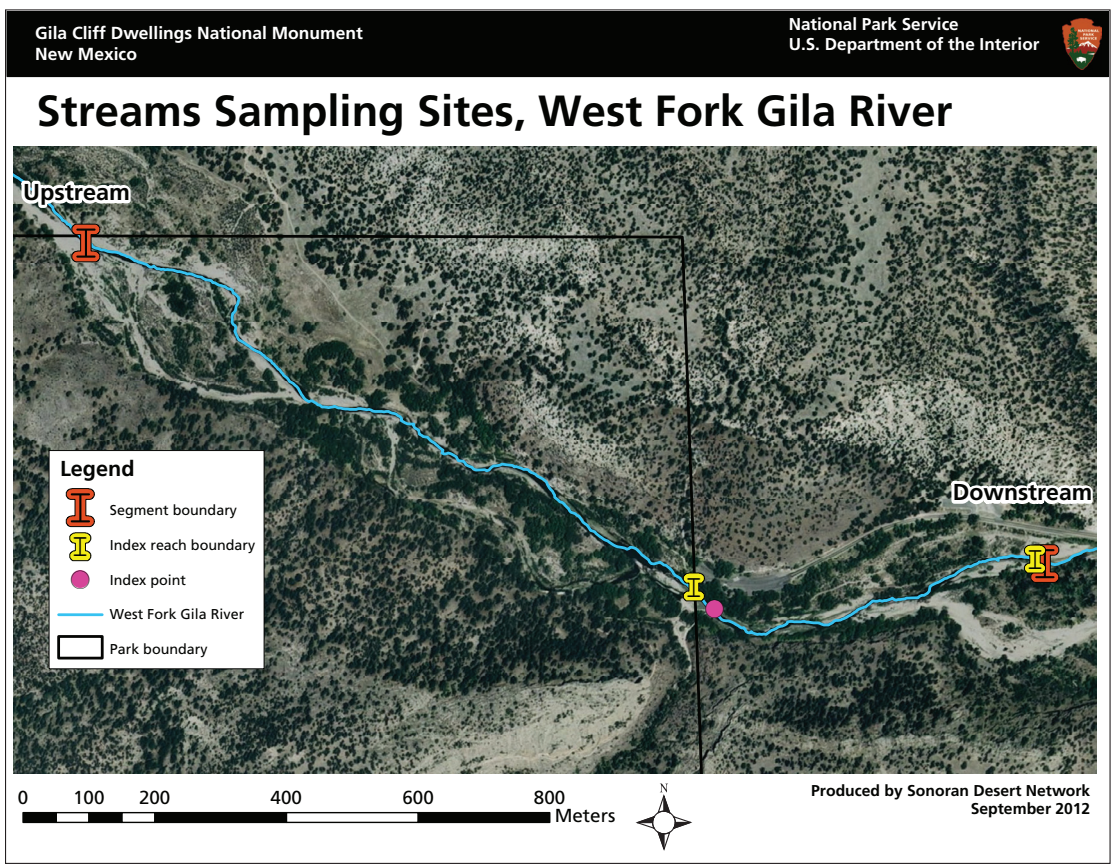

Figure 3-1. Index sampling location, Gila Cliff Dwellings National Monument.

3.2 Methods

A brief description of data collection and processing methodologies for stream sampling at Gila Cliff Dwellings NM during WY2016 is presented below. Detailed descriptions of these procedures will be available in the network's water quality monitoring protocol (Gwilliam et al. in review).

Sampling is conducted at the West Fork Gila River index site (for water quality, quantity, and discharge), and at the index reach (macroinvertebrates). The index site is located adjacent to the visitor contact station. The index reach is located downstream of the contact station (see Figure 3-1).

3.2.1 Water quality core parameters

Core water quality parameters are a group of ecologically important metrics that provide the most basic level of information about water quality (Irwin 2008). Water temperature, pH, specific conductivity, dissolved oxygen, turbidity, and discharge were sampled. During each visit, we noted the hydrologic conditions and sampled the core parameters using the following methods:

- On arrival at the site, a multi-parameter meter (YSI Professional Plus) was calibrated and deployed in a well-mixed part of the stream channel, logging temperature, pH, specific conductivity, and dissolved oxygen data at one-minute intervals. The meter was left in the stream for the entire visit.
- Turbidity samples were collected and analyzed within one hour using a portable turbidimeter (HACH 2100P).
- Discharge was measured using a FlowTracker Acoustic Doppler Velocimeter.

In addition to regular sampling, we used a logging multi-parameter instrument (YSI XLM600 V2) to collect data on temperature, pH, specific conductivity, and dissolved oxygen at 15-minute intervals for a minimum of two weeks during quarters 3 and 4. The sonde was not deployed during quarters 1 and 2 in WY2016 due to channel movement and the likelihood of the instrument being damaged by ice.

3.2.2 Water quality samples

During each site visit, water samples were collected in a three-liter Nalgene sample collection bottle, following non-isokinetic sampling methods as described in the National Field Manual for the Collection of Water Quality Data (USGS 2006). We transferred the sample water to bottles for analysis of bacteria, turbidity, metals, and other constituents. The sample water was filtered and/or treated as required, kept on ice, and dropped off at the contract laboratory. For WY2016, that lab was TestAmerica in Phoenix, Arizona.

3.2.3 Water quantity data

SODN uses a radar water-level telemetry system to measure water quantity at Gila Cliff Dwellings NM. A Waterlog radar gauge is mounted to the bottom of the footbridge across the West Fork Gila River (Figure 3-2). Every 15 minutes, the gauge sends a pulse of electromagnetic energy down toward the surface of the river and measures the reflected energy to determine the distance from the radar to the water surface (Sauer and Turnipseed 2010), thereby measuring the the elevation of the water. This instrument is attached to a Waterlog data recorder and a Sutron telemetry system using the National Weather Service GOES satellite system. This allows for remote real-time access and logging of water-level data (Sauer and Turnipseed 2010).

3.2.4 Aquatic macroinvertebrates and habitat

To ensure compatibility of monitoring samples, macroinvertebrate sample collection by SODN coincides with the index period used by the New Mexico Environment Department. The sampling period for warmwater streams is August 15–November 15 (Jacobi et al. 2006).

The index reach at Gila Cliff Dwellings NM is 570 meters long, starting upstream of the park's western boundary and continuing onto U.S. Forest Service land. The reach contains 11 equally spaced transects. At each transect, we measured wetted width, water depth, velocity, and canopy cover; estimated

Figure 3-2. Location of the radar gauge at Gila Cliff Dwellings National Monument. The radar emitter (center of white circle) is not stationed over the center of the stream due to channel movement.

substrate size, bank erosion (using the Rosgen Bank Erosion Hazard Index), and diversity of aquatic habitat; and completed a bank erosion hazard index. Two types of samples were collected:

- A quantitative sample was collected from four targeted riffle habitats to provide data on organism abundance. Using a kicknet with a 0.3-meter opening for one minute, a total of 12 replicate samples were collected from a 0.09-m^2 area. At each habitat, we also measured depth, velocity, particle size, and particle embeddedness. This method is effectively the same as the methods used by the State of New Mexico.
- A reach-wide qualitative sample was collected to develop a comprehensive list of species present in the reach. Using dip- and kicknets, samples were collected from all habitat types within the reach during a one-hour collection period, proportionally allocated by habitat type, and compiled into one composite sample.

Aquatic macroinvertebrate samples were sent to the National Aquatic Monitoring Center (BugLab), a Bureau of Land Management laboratory at Utah State University in Logan, Utah. There, a taxonomist certified by the North American Benthological Society identified all aquatic macroinvertebrates to the lowest taxonomic level possible.

3.2.5 Data handling and analysis

All water quality and quantity data are stored on the SODN server. This report includes all discrete water quality data collected except for turbidity, coliform, and *E. coli* samples, for which the mean of the triplicate samples are presented. For total coliforms and *E. coli* samples, most probable numbers (MPN/100 mL) are reported (IDEXX 2018). The continuous multi-parameter sonde measurements are presented with the minimum, first quartile, median, third quartile, and maximum to demonstrate variability. When applicable, this report compares SODN water quality data against the State of New Mexico water quality standards (NMAC 2013) and notes any exceedances.

3.3 Results and discussion

3.3.1 Water quantity

The USGS and SODN have partnered to operate a stream gauge at the West Fork Gila River index site (USGS 09430010). This gauge functioned only intermittently during WY2016. The active river channel under the footbridge moved closer to the left bank over the last year (see Figure 3-2). SODN staff repeatedly moved the radar emitter to accommodate this movement, but measurements still fell outside the QA/QC (quality assurance/quality control) proscription for the data. Technical issues with the radar emitter also resulted in missing data. We could not derive information from the existing dataset to generate an adequate stream stage-to-discharge relationship (Rantz et al. 1982). This gauge came back online in November 2016 and will provide data for WY2017 onward.

Therefore, water quantity data for WY2016 were inferred from USGS station 09430500 at Gila, New Mexico, approximately 40 kilometers downstream from the monument. Data from this gauge can only be used to indicate general status of the West Fork Gila River.

3.3.1.1 Mean daily discharge

Figure 3-3 represents the annual hydrograph from the USGS gauge at Gila, New Mexico, compared with flow from the record of that gauge. The ~40-kilometer distance between USGS gauge 09430500 and the Gila Cliff Dwellings NM sample site requires abundant caution during interpretation. However, the hydrograph indicates a generally average year. Flow in the late monsoon (October) and winter periods was higher than average. Flow in spring and summer was average to below average. The WY2016 monsoon was generally average.

This coarse interpretation matches the observations of SODN field crews and park staff: flow was generally unremarkable, and seemed to follow the typical pattern of being higher in winter, with a pulse of snowmelt in late winter/early spring, followed by a decrease during the late spring and summer, with higher flow events related to monsoon rain events. None of the flow events was likely beyond bankfull.

Insight into the relationship between the water stages at Gila Cliff Dwellings NM and USGS gauge 09430500 can be gained by comparing USGS gauge data with that of the SODN sonde, which collects stage when deployed. During the Q4 deployment, the sonde captured a flow event (red circle, Figure 3-3). The flow event fell in the green zone of the hydrograph, indicating an average flow event. At the monument, this was a near-bankfull event. Stream stage increased by about 0.8 meters (2.62 ft), but the elevation of the water, on average in the stream segment, did not exceed the bank.

This event was the result of intense precipitation in the West Fork Gila River watershed. The rain gauge at the monument recorded 1.9 inches of precipitation that day (http://www.climateanalyzer.org/). At the sonde (Figure 3-4), stage increased from 0.6 to 1.4 meters in less than 15 minutes (likely much faster). The stage decreased to approximately pre-event level within six hours.

There was a lag of approximately 1.5 days between when the peak of the water pulse was detected by the sonde (7/29/16 @14:15) and the USGS gauge at Gila, New Mexico (7/30/16 @22:15). It will be of interest in the future to measure the lag time of water pulses of varying intensity.

3.3.2 Water quality

In WY2016, SODN staff made a total of four sampling visits to the West Fork Gila River index site. Discrete samples were collected in each quarter. Continuous sampling occurred during deployment periods in each quarter.

A total of 236 discrete analyses were performed on water samples collected in WY2016. Of these, 89 were associated with state standards. There were five exceedances of state standards, meaning that 94% of samples were compliant with state standards. The exceedances for *E. coli* (1,328 MPN; Table 3-2) and turbidity (132 NTU; Table 3-1), both occurred during the Q4 sample. The three other exceedances were for total aluminum (see Section 3.3.2.4).

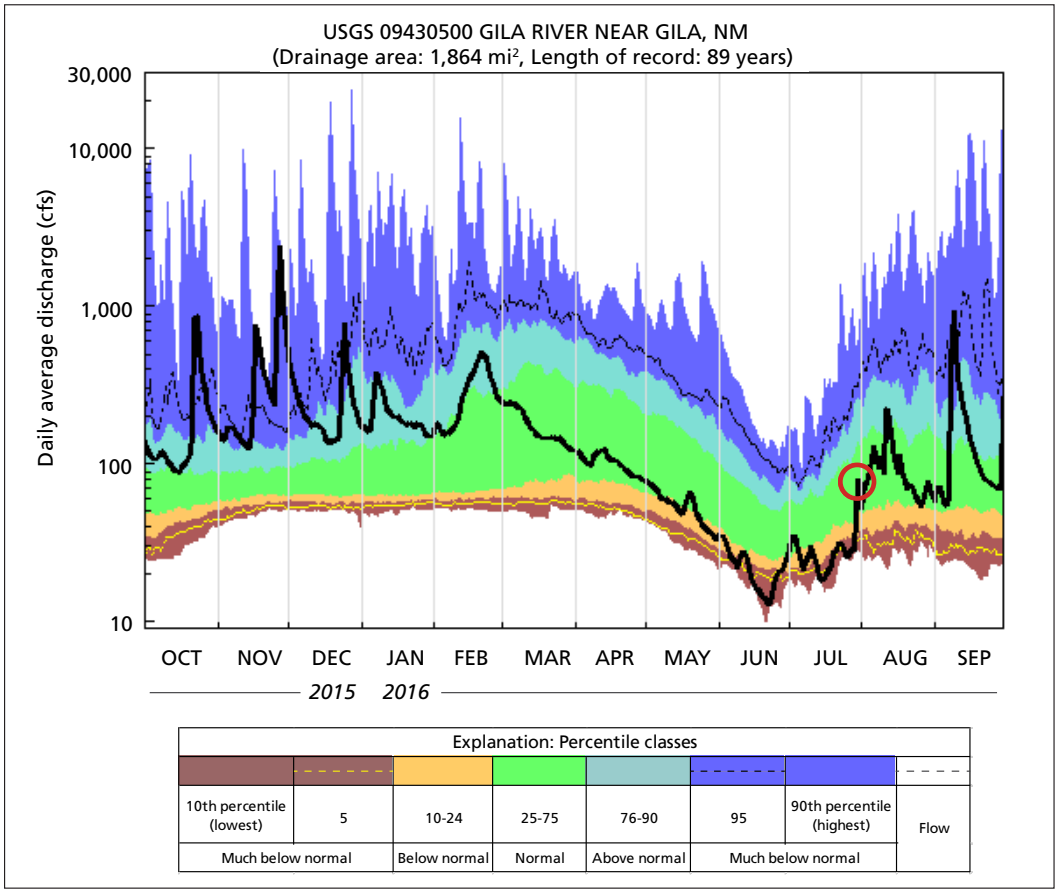

Figure 3-3. Hydrograph for Gila River near Gila, New Mexico, water year 2016. The solid black line represents mean daily discharge. The various colors represent the range of data, coded by percentile range. The red circle indicates the flow event discussed. This figure can be downloaded at http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=09430500.

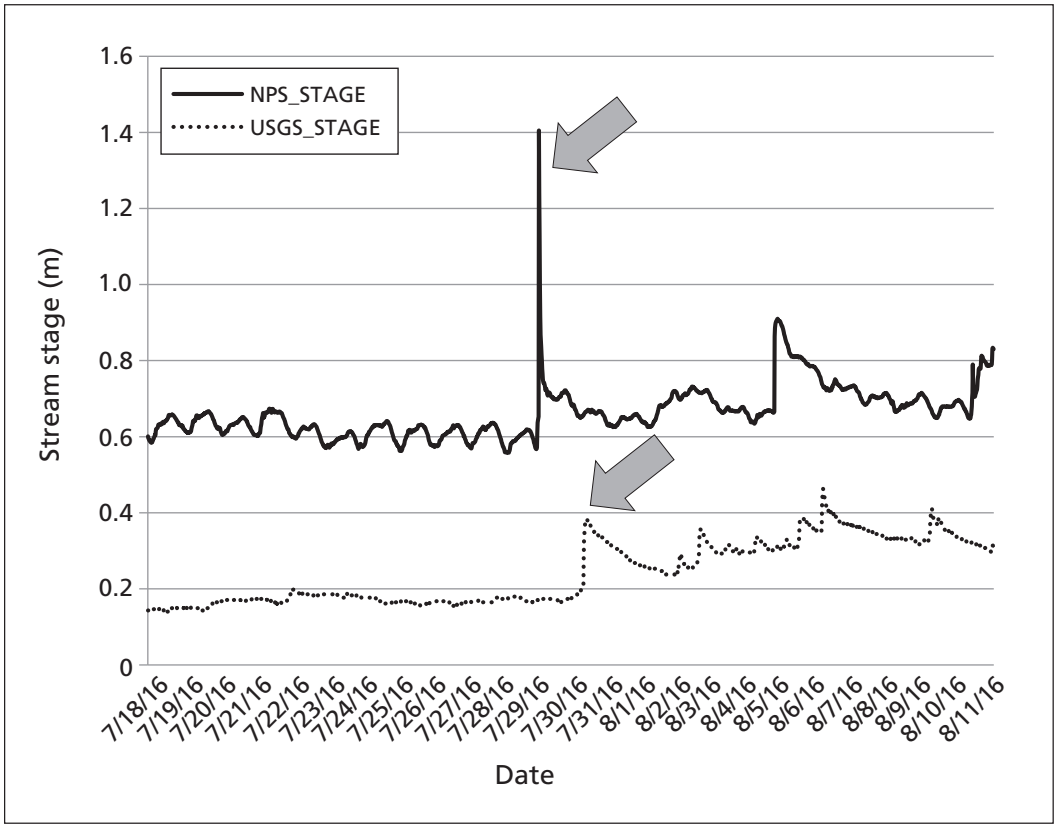

Figure 3-4. Stream stage, West Fork Gila River (black line, NPS sonde) and Gila River (dotted line, USGS gauge), July 18–August 11, 2016. The arrows identify the pulses of water discussed in this section.

3.3.2.1 Core parameters

***Discrete sampling*—.** The discrete measurements shown in Table 3-1, made in the field, represent conditions at the West Fork Gila River index site during site visits in WY2016. The results were all within the expected range for a mid-elevation stream in New Mexico, with the exception of turbidity during Q4.

Discharge data were collected during quarterly visits (Table 3-1) at the index site. Measurements fell within the expected range; there were no significant flow events during the deployment periods during WY2016.

***Continuous sampling*—.** A logging multiparameter sonde was deployed for approximately two weeks during quarters 3 and 4 to collect measurements of temperature, pH, specific conductivity, and dissolved oxygen data at 15-minute intervals. Over 5,600 measurements were collected (3,324 during Q3, May 5–June 9, and 2,277 in Q4, July 18–August 10). The sonde was not deployed during the first two quarters of WY2016 due to a change in streamflow that isolated the sonde mount from the active stream channel, and concern over possible damage to the sonde by ice.

The sonde sampling location has been moved to a secondary site, approximately 100 meters downstream from the footbridge. Flow events can greatly influence water qual-

Table 3-1. Discrete sampling results for core water quality parameters, West Fork Gila River, Gila Cliff Dwellings National Monument, WY2016.

Parameter	Quarter[a]				New Mexico state standard	
	Q1	Q2	Q3	Q4	Measure	Beneficial use
Temperature (°C)	7.8	-1.4	10.5	18.3	<23[b]	High Quality Coldwater Aquatic Life
Specific conductivity (µS/cm)	94.4	92.1	107	111	<400	[Segment-specific]
pH	7.08	8.29	7.83	6.87	6.6–8.8	High Quality Coldwater Aquatic Life
Oxygen concentration (mg/L)	10.32	13.63	8.77	7.34	>6	High Quality Coldwater Aquatic Life
Turbidity (NTU)	7.24	9.91	3	***132**	<10 over background[c]	General
Discharge (cfs)	ND	24.95	11.83	26.86	–	–

[a]Sampling dates: 11/5/2016 (Q1), 2/4/2016 (Q2), 5/5/2016 (Q3), 7/18/2016 (Q4).
[b]23°C, not to be exceeded for four or more consecutive hours on three or more consecutive days
[c]No more than 10 nephelometric turbidity units (NTU) over background (median value for site) when background is ≤50 NTU, or 20% increase when background is >50 NTU.
*Red bolded text indicates an exceedance of state water quality standards; ND=Data not collected due to equipment failure; cfs=cubic feet per second

Table 3-2. Sampling results for biological condition, West Fork Gila River index site, Gila Cliff Dwellings National Monument, WY2016.

Parameter	Quarter				Method	State standard	Beneficial use
	Q1	Q2	Q3	Q4			
Total organic carbon	NC	NC	NC	3.2	SM 5310B	No criterion	–
E. coli (MPN)	10.9	<DL	<DL	***1,328**	SM 9223B	575 cfu/mL	Park-specific

NC=sample was not collected for that parameter during the sampling event. <DL=result of analysis was below the detection limit of the analytical method. *Red bolded text indicates a value that exceeded a state standard. cfu=colony-forming units

ity values, and high discharge can damage the sonde and other sampling infrastructure. Sampling during high flow events is avoided.

Figure 3-5 summarizes the seasonal variability in water temperature, pH, specific conductivity, and dissolved oxygen. The results from continuous sampling of core water quality parameters in WY2016 were within what would be expected, with several considerations.

Although the segment of the West Fork Gila River at Gila Cliff Dwellings NM is in the "High Quality Cold Water" beneficial-use category, the park's elevation is at the bottom of the range for this group. This leads to possible exceedances of state water quality standards for core water quality parameters. For example, in Figure 3-5a, Q4, the 75% percentile statistic for temperature (20.94°C) approached the state temperature standard of 23°C. This indicates that commonly observed water temperatures at the index site frequently approach state standards due to the positioning of the index site (and the park unit) in the landscape. The main impetus behind the High Quality Cold Water Aquatic Life beneficial-use designation is fishery management, and trout fisheries in particular. Trout are encountered within the monument, but historically in low numbers because of lack of habitat and sub-optimal water temperature (NMAC 2013).

3.3.2.2 Nutrients

The results from nutrient sampling during WY2016 (nitrate, nitrate, total nitrogen, and Kjeldahl nitrogen) were all below the detection limit of the instrumentation used for analysis. Please see Appendix A for the detection limits and methods for nutrient analysis.

3.3.2.3 Biological condition

The *E. coli* result from the fourth quarter of WY2016 exceeded New Mexico state water quality standards (see Table 3-2). SODN data for total coliforms and *E. coli* are expressed as a most probable number (MPN) per 100 mL of stream water, a statistical estimate of the number of bacteria. Although water quality criteria are expressed as colony-forming units (cfu) per 100 mL (which, unlike MPN, does not assume estimation), the two units are comparable. The criterion for a single sample of *E. coli* is 575 cfu/100 mL.

Only parameters with results are reported. Please note that parameters not reported should not assumed to be zero, but rather below the detection limit of the analytical equipment. They may have been present in very low concentrations.

3.3.2.4 Metals and metalloids

There were three exceedances of state water quality standards for metals and metalloids in WY2016, all for total aluminum. Aluminum has been of interest in recent years due to increased concentrations detected after the 2011 and 2012 fires in and around the park. As in 2014, the amount of aluminum detected in winter exceeded the state standard (Gwilliam 2014). Exceedances for aluminum occur with relative frequency at the monument. The source is suspected to be found in the surrounding rocks and soil (Ratte et al. 2014).

Tables 3-3 and 3-4 display the results from analysis for total metals and dissolved metals. Because they are generally more easily absorbed by biologic systems, dissolved metals typically pose a greater threat to human health and wildlife. In several instances during WY2016, the total concentration of an analyte was less than the dissolved concentration for the same analyte. This was unexpected, because dissolved concentration is a component of total concentration. The lab's QA/QC procedures for this method indicate that if the results fall within the relative percent difference for that analysis, then the total and dissolved results should be considered statistically indistinguishable; that is, the analyte is in a dissolved state. Values where this was the case are indicated in bold in Tables 3-3 and 3-4.

3.3.2.5 Suspended and total sediment

During WY2016, results for total dissolved solids (Table 3-5) were within the range of results collected at the monument since WY2008. The Q4 measurement for total suspended solids was the second-highest TSS value recorded by SODN, and the highest value since WY2008 for a year not influenced by fire.

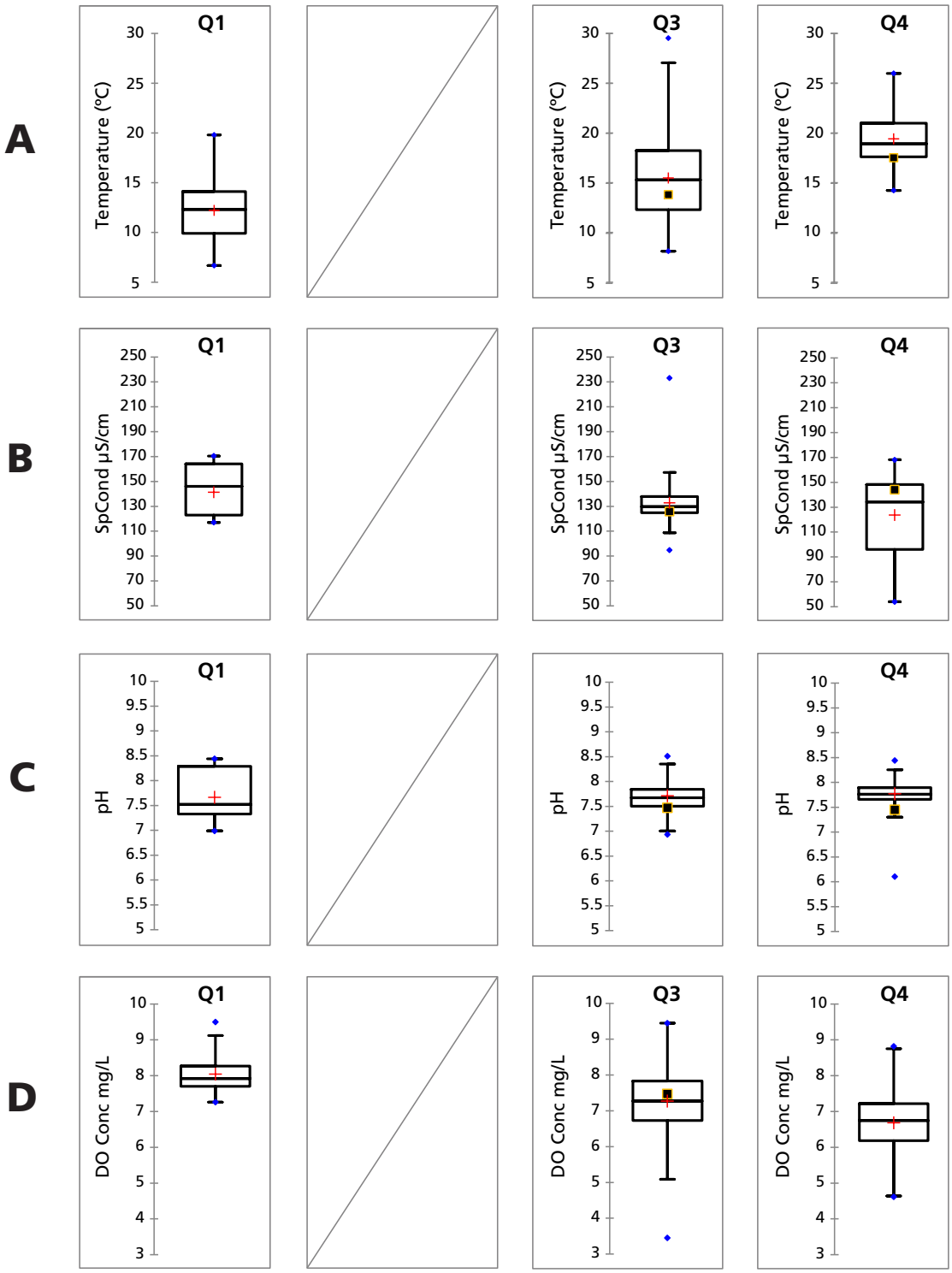

Figure 3-5. Data on (A) water temperature, (B) specific conductivity, (C) pH, and (D) dissolved oxygen concentration from the West Fork Gila River index site, Gila Cliff Dwellings National Monument, WY2011–2016. Dark squares indicate median values for WY2016. Blue dots indicate maximum and minimum, whiskers indicate limits, and the box indicates the bounds of the first and third quartiles. The line in the box indicates the median, while the red cross is the mean. *(Note that dark squares are absent for all Q1 values and for DO in Q4. Because the dissolved oxygen probe malfunctioned during the Q4 deployment, these data were not available or did not meet QA/QC standards. No data are available for Q2.)*

Table 3-3. Sampling results for total metals, West Fork Gila River index site, Gila Cliff Dwellings National Monument, WY2016.

Analyte (mg/L)	Quarter				Method	State standard (mg/L)
	Q1	Q2	Q3	Q4		
Aluminum	**0.72***	**2.2***	0.17	**4.8*[a]**	EPA 200.7/200.7 Rev 4.42	0.34–1.18[b]
Barium	NC	NC	NC	0.043	EPA 200.7/200.8	NS
Calcium	*10*	10	12	14	EPA 200.7/200.7 Rev 4.42	NS
Copper	<DL	<DL	<DL	0.004	EPA 200.7/200.7 Rev 4.42	NS
Iron	0.34	0.93	<DL	1.9*	EPA 200.7/200.8	NS
Lead	<DL	<DL	<DL	0.0035	EPA 200.7/200.7 Rev 4.42	NS
Magnesium	2.8	2.7	2.7	3.7	EPA 200.7/200.7 Rev 4.42	NS
Manganese	<DL	<DL	<DL	0.1	EPA 200.7/200.8	NS
Potassium	<DL	<DL	<DL	3.3	EPA 200.7/200.7 Rev 4.42	NS
Silica	30	34	28	50*	EPA 200.7/200.7 Rev 4.42	NS
Sodium	5.7	5.2	7.1	7.2	EPA 200.7/200.7 Rev 4.42	NS

[a]Sample was flagged by lab for QA/QC qualifiers.
[b]Standard calculated using total hardness of sample.
<DL=result was below the detection limit of the analytical equipment. NC=not collected. NS=no standard. Methods are from Eaton and others (2005).
Italicized results indicate when the result from analysis for total concentration was less than the dissolved concentration.
*Red bolded text indicates a value that exceeded a state standard.

Table 3-4. Sampling results for dissolved metals, West Fork Gila River index site, Gila Cliff Dwellings National Monument, WY2016.

Analyte (mg/L)	Quarter				Method	State standard (mg/L)
	Q1	Q2	Q3	Q4		
Aluminum	<DL	0.1	0.14	<DL	EPA 200.7	5
Barium	NC	NC	NC	0.0067	EPA 200.7/200.8	2
Calcium	*11*	9.3	12	12	EPA 200.7	NS
Magnesium	2.8*	2.4	2.6	2.9	EPA 200.7	NS
Manganese	<DL	<DL	<DL	0.0072	EPA 200.7/200.8	1.2–1.6[a]
Nickel	NC	NC	NC	0.0032	EPA 200.7/200.8	0.029[a]
Silica	28	24	28	27	EPA 200.7	NS
Sodium	5.9	<DL	6.7	7	EPA 200.7	NS

[a]Standard calculated using total hardness of sample.
*Sample was flagged by lab for QA/QC qualifiers.
<DL=result was below the detection limit of the analytical equipment; NC=not collected; NS=no standard; Methods are from Eaton and others (2005).
Italicized results indicate when the result from analysis for total concentration was less than the dissolved concentration.

Table 3-5. Sampling results for suspended and total sediment, West Fork Gila River index site, Gila Cliff Dwellings National Monument, WY2016.

Analyte (mg/L)	Quarter				Method
	Q1	Q2	Q3	Q4	
Total dissolved solids	94	90	89	89	SM 2540C
Total suspended solids	<DL	<DL	<DL	140	SM 2540D

<DL=result was below the detection limit of the analytical equipment. NS=no standard. SM=standard method (Eaton et al. 2005).

This elevated TSS value represents the impact of precipitation and streamflow on water quality parameters. The heavy precipitation event of July 29 washed particulate material from the land surface into the streams. The resulting higher flows carried these surface materials and entrained sediments from the river bed into the water column. The increased total suspended solids resulted in elevated levels of turbidity, *E. coli*, total aluminum, and specific conductivity.

To illustrate this relationship, Figure 3-6 displays the stream stage and specific conductivity data from the sonde deployed during flow events occurring in the Q4 sampling period.[1] There were several low-intensity flow events between the large flow event on July 29 and the end of the deployment on August 11. In addition, there was a beaver dam 30 meters upstream from the sampling point during the Q4 sample. During base flow, beaver dams can impound sediment and other material that is then washed out during high-flow events (Rosgen 1996). The larger event likely overtopped and breached the beaver dam. The smaller events would also have contained material washed into the stream during precipitation, entrained material during the increased flow (Rosgen 1996), and moved impounded material from behind the dam.

In Figure 3-6, flow event A increased specific conductivity from approximately 125 µS/cm to above 300 µS/cm. Flow event B showed an

[1] It should be noted that the relationship between increased flow rate is not always the same. A parameter may respond differently depending on the location and intensity of the precipitation event.

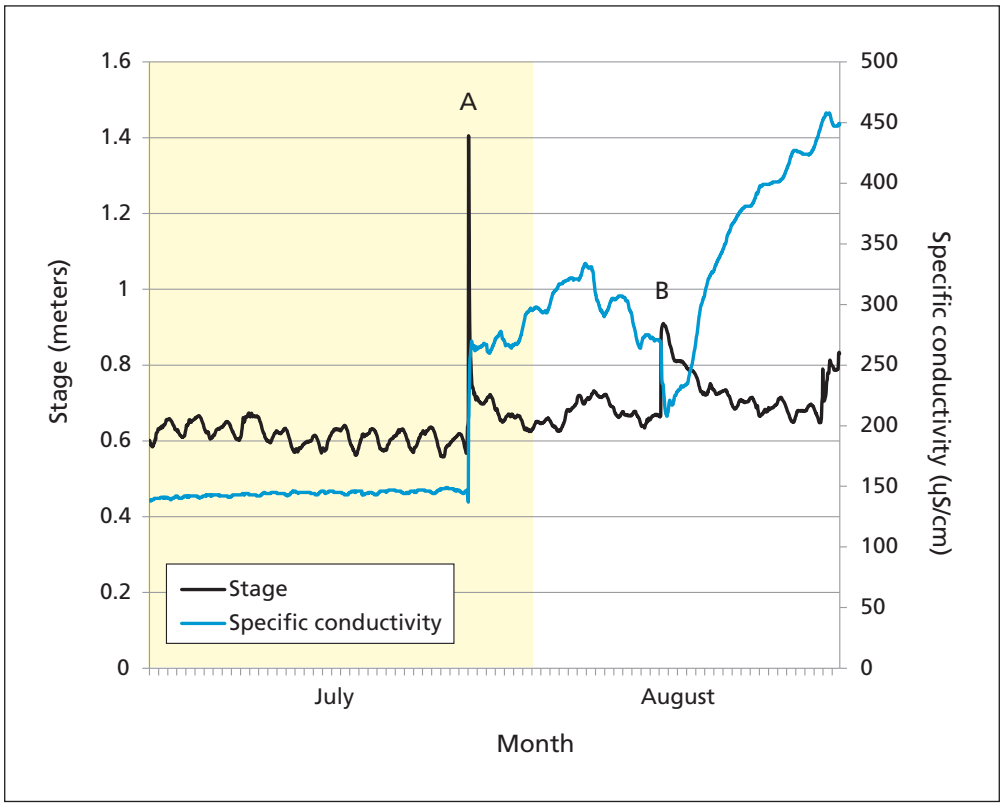

Figure 3-6. Stream stage and specific conductivity during sonde deployment, West Fork Gila River, Gila Cliff Dwellings National Monument, fourth quarter, water year 2016. Flow event A occurred on July 29. Flow event B occurred on August 4.

initial decrease in specific conductivity (SC), from 275 μS/cm to 200 μS/cm, possibly associated with water not originating from a sediment-rich source (e.g., areas with extensive exposed bedrock or vegetation that prevents easy entrainment of sediment). The flow following the initial pulse of water was likely high in sediment and salts, as demonstrated by the increase in specific conductivity—to a value above 450 μS/cm.

It is likely that the location of precipitation, coupled with duration and intensity, can impact the concentration of various analytes.

3.3.2.6 General water quality & inorganics

During WY2016, results for general water quality and inorganics (Table 3-6) remained within the range of expected values (Gwilliam 2014). However, the values for total hardness and cation/anion balance in Q2 were high, indicating that there was an analyte (likely an unidentified anion) in the sample.

3.3.3 Macroinvertebrates

Macroinvertebrate samples and associated habitat data were collected at the monument on November 10, 2015. The samples were received by the analytical lab on December 4, and the report from the lab was issued on September 20, 2016. A list of taxa collected from the index reach can be found in Appendix B.

The State of New Mexico uses the New Mexico Stream Condition Indices (NMSCI; Jacobi et. al 2006) to meet EPA mandates. In WY2016, the indices were measured at 60.78 (Figure 3-7). This placed Gila Cliff Dwellings NM in the "Good" category, falling in the top 25% of index sites in the "high-elevation small watershed" category.

This index reach has been sampled with the same methods since WY2012. The NMSCI value has been near the upper 25th percentile each year—even after major fires in the monument watershed (2011–2012). These results show the resilience of the macroinvertebrate community, and the ability of the stream reach to recover after postfire flows of debris and ash.

Table 3-6. Results from general and inorganic sampling, West Fork Gila River index site, Gila Cliff Dwellings National Monument, WY2016.

Analyte (mg/L)	Quarter				Method
	Q1	Q2	Q3	Q4	
Alkalinity as $CaCO_3$	40	37	48	54	SM 2320B
Bicarbonate Alkalinity as $CaCO_3$	40	37	48	54	SM 2320B
Fluoride	<DL	<DL	0.62	<DL	EPA 300.0
Sulfate	6	5.6	5.5	<DL	EPA 300.0
Total Hardness	38	90	41	51	SM 2340B
Anion/Cation Balance	7.6	**-12**	1.9	0.028	SM 1030E

<DL=result was below the detection limit of the analytical equipment; NS = no standard; SM = standard method (Eaton et al. 2005); other methods are from USEPA (1983).

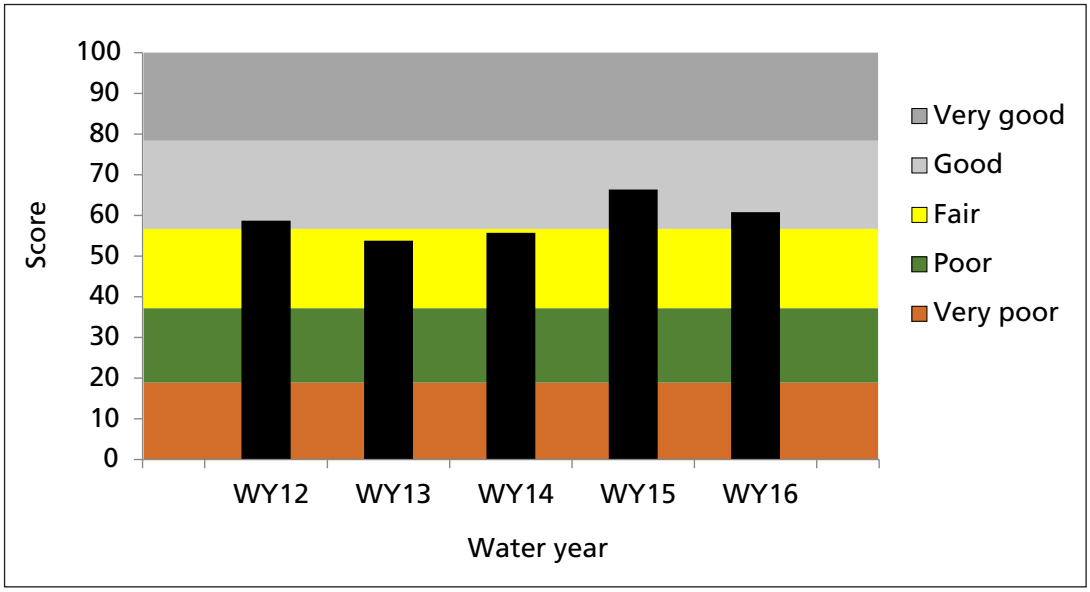

Figure 3-7. New Mexico Stream Condition Indices for Gila Cliff Dwellings National Monument, calculated from derived macroinvertebrate metrics, water years 2012–2016.

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Appendix A. Detection Limits and Methods for Nutrient Analysis

Analyte	RL	Units	Method
Acidity	10.00	mg/L	SM 2310B
Alkalinity as CaCO3	5.00	mg/L	SM 2320B
Aluminum	0.10	mg/L	200.7 Rev 4.4
Ammonia	0.10	mg/L	350.1
Anion/Cation Balance	N.A.	%	SM 1030E
Antimony	2.00	ug/L	200.8
Arsenic	5.00	ug/L	200.8
Barium	1.00	ug/L	200.8
Beryllium	1.00	ug/L	200.8
Bicarbonate Alkalinity as CaCO3	5.00	mg/L	SM 2320B
Biochemical Oxygen Demand	2.00	mg/L	SM5210B
Boron	0.10	mg/L	200.7 Rev 4.4
Cadmium	1.00	ug/L	200.8
Calcium	0.20	mg/L	200.7 Rev 4.4
Carbonate Alkalinity as CaCO3	5.00	mg/L	SM 2320B
Chloride	3.00	mg/L	300.0
Chromium	3.00	ug/L	200.8
Copper	2.00	ug/L	200.8
Cyanide, Total	0.01	mg/L	SM 4500 CN E
Dis Aluminum	0.10	mg/L	200.7
Dis Antimony	2.00	ug/L	200.8
Dis Arsenic	5.00	ug/L	200.8
Dis Barium	1.00	ug/L	200.8
Dis Beryllium	1.00	ug/L	200.8
Dis Boron	0.10	mg/L	200.7
Dis Cadmium	1.00	ug/L	200.8
Dis Calcium	0.20	mg/L	200.7
Dis Chromium	3.00	ug/L	200.8
Dis Copper	2.00	ug/L	200.8
Dis Iron	0.10	mg/L	200.7
Dis Lead	1.00	ug/L	200.8
Dis Magnesium	0.20	mg/L	200.7
Dis Manganese	2.00	ug/L	200.8
Dis Mercury	0.00	mg/L	245.1
Dis Molybdenum	2.00	ug/L	200.8
Dis Nickel	2.00	ug/L	200.8
Dis Phosphorus	3.00	mg/L	200.7
Dis Potassium	3.00	mg/L	200.7
Dis Selenium	5.00	ug/L	200.8
Dis Silver	1.00	ug/L	200.8
Dis SiO2, Silica	1.10	mg/L	200.7
Dis Sodium	5.00	mg/L	200.7

Appendix A. Detection Limits and Methods for Nutrient Analysis, cont.

Analyte	RL	Units	Method
Dis Thallium	1.00	ug/L	200.8
Dis Uranium	1.00	ug/L	200.8
Dis Zinc	10.00	ug/L	200.8
Fluoride	0.50	mg/L	300.0
Hardness, as CaCO3	1.30	mg/L	SM 2340B
Iron	0.10	mg/L	200.7 Rev 4.4
Lead	1.00	ug/L	200.8
Magnesium	0.20	mg/L	200.7 Rev 4.4
Manganese	2.00	ug/L	200.8
Mercury	0.00	mg/L	245.1
Molybdenum	2.00	ug/L	200.8
Nickel	2.00	ug/L	200.8
Nitrate Nitrite as N	0.10	mg/L	353.2
Nitrate, Dissolved	0.50	mg/L	300.0
Nitrite, dissolved	0.50	mg/L	300.0
Nitrogen, Kjeldahl	1.00	mg/L	351.2
Nitrogen, Total	0.10	mg/L	Computed
pH	0.10	SU	SM 4500 H+ B
Phosphorus	3.00	mg/L	200.7 Rev 4.4
Potassium	3.00	mg/L	200.7 Rev 4.4
Selenium	5.00	ug/L	200.8
Silver	1.00	ug/L	200.8
SiO2, Silica	1.10	mg/L	200.7 Rev 4.4
Sodium	5.00	mg/L	200.7 Rev 4.4
Specific Conductance	2.00	umhos/cm	SM 2510B
Sulfate	5.00	mg/L	300.0
Thallium	1.00	ug/L	200.8
Total Dissolved Solids	10.00	mg/L	SM 2540C
Total Organic Carbon	1.00	mg/L	SM 5310B
Total Suspended Solids	4.00	mg/L	SM 2540D
Uranium	1.00	ug/L	200.8
Zinc	10.00	ug/L	200.8

Appendix B. Macroinvertebrate Taxa List, Gila Cliff Dwellings National Monument, WY2016

Phylum	Class	Order	Family	Genus	Species
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	Helobdella	stagnalis
Annelida	Clitellata	Rhynchobdellida	Glossiphoniidae	–	–
Annelida	Clitellata	–	–	–	–
Arthropoda	Arachnida	Trombidiformes	Arrenuridae	Arrenurus	–
Arthropoda	Arachnida	Trombidiformes	Eylaidae	Eylais	–
Arthropoda	Arachnida	Trombidiformes	Hygrobatidae	–	–
Arthropoda	Arachnida	Trombidiformes	Lebertiidae	Lebertia	–
Arthropoda	Arachnida	Trombidiformes	Oxidae	Oxus	–
Arthropoda	Arachnida	Trombidiformes	Sperchonidae	Sperchon	–
Arthropoda	Arachnida	Trombidiformes	Sperchonidae	Sperchonopsis	–
Arthropoda	Arachnida	Trombidiformes	Sperchonidae	–	–
Arthropoda	Arachnida	Trombidiformes	Torrenticolidae	Testudacarus	–
Arthropoda	Arachnida	Trombidiformes	Torrenticolidae	Torrenticola	–
Arthropoda	Arachnida	Trombidiformes	Torrenticolidae	–	–
Arthropoda	Arachnida	Trombidiformes	–	–	–
Arthropoda	Entognatha	Collembola	–	–	–
Arthropoda	Insecta	Coleoptera	Curculionidae	–	–
Arthropoda	Insecta	Coleoptera	Dryopidae	Helichus	–
Arthropoda	Insecta	Coleoptera	Dryopidae	Postelichus	–
Arthropoda	Insecta	Coleoptera	Dytiscidae	Agabus	–
Arthropoda	Insecta	Coleoptera	Dytiscidae	Hygrotus	–
Arthropoda	Insecta	Coleoptera	Dytiscidae	Laccophilus	–
Arthropoda	Insecta	Coleoptera	Dytiscidae	Neoclypeodytes	–
Arthropoda	Insecta	Coleoptera	Dytiscidae	Rhantus	–
Arthropoda	Insecta	Coleoptera	Dytiscidae	Sanfilippodytes	–
Arthropoda	Insecta	Coleoptera	Dytiscidae	Stictotarsus	–
Arthropoda	Insecta	Coleoptera	Dytiscidae	Thermonectus	marmoratus
Arthropoda	Insecta	Coleoptera	Dytiscidae	–	–
Arthropoda	Insecta	Coleoptera	Elmidae	Dubiraphia	–
Arthropoda	Insecta	Coleoptera	Elmidae	Heterelmis	–
Arthropoda	Insecta	Coleoptera	Elmidae	Microcylloepus	pusillus
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	pecosensis
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	quadrimaculatus
Arthropoda	Insecta	Coleoptera	Elmidae	Optioservus	–
Arthropoda	Insecta	Coleoptera	Elmidae	Zaitzevia	parvulus
Arthropoda	Insecta	Coleoptera	Elmidae	–	–
Arthropoda	Insecta	Coleoptera	Haliplidae	Peltodytes	–
Arthropoda	Insecta	Coleoptera	Hydraenidae	Hydraena	–
Arthropoda	Insecta	Coleoptera	Hydrochidae	Hydrochus	–
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Berosus	–

Appendix B. Macroinvertebrate Taxa List, Gila Cliff Dwellings National Monument, WY2016, cont.

Phylum	Class	Order	Family	Genus	Species
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Enochrus	–
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Paracymus	–
Arthropoda	Insecta	Coleoptera	Hydrophilidae	Tropisternus	–
Arthropoda	Insecta	Coleoptera	Hydrophilidae	–	–
Arthropoda	Insecta	Coleoptera	Psephenidae	Psephenus	–
Arthropoda	Insecta	Coleoptera	Psephenidae	–	–
Arthropoda	Insecta	Coleoptera	Scirtidae	–	–
Arthropoda	Insecta	Diptera	Ceratopogonidae	Atrichopogon	–
Arthropoda	Insecta	Diptera	Ceratopogonidae	Bezzia	–
Arthropoda	Insecta	Diptera	Ceratopogonidae	Culicoides	–
Arthropoda	Insecta	Diptera	Ceratopogonidae	Dasyhelea	–
Arthropoda	Insecta	Diptera	Ceratopogonidae	Probezzia	–
Arthropoda	Insecta	Diptera	Ceratopogonidae	–	–
Arthropoda	Insecta	Diptera	Chironomidae	–	–
Arthropoda	Insecta	Diptera	Culicidae	Anopheles	–
Arthropoda	Insecta	Diptera	Culicidae	Culiseta	–
Arthropoda	Insecta	Diptera	Culicidae	–	–
Arthropoda	Insecta	Diptera	Dixidae	Dixella	–
Arthropoda	Insecta	Diptera	Dixidae	–	–
Arthropoda	Insecta	Diptera	Dolichopodidae	–	–
Arthropoda	Insecta	Diptera	Empididae	Chelifera	–
Arthropoda	Insecta	Diptera	Empididae	Neoplasta	–
Arthropoda	Insecta	Diptera	Empididae	Wiedemannia	–
Arthropoda	Insecta	Diptera	Empididae	–	–
Arthropoda	Insecta	Diptera	Ephydridae	–	–
Arthropoda	Insecta	Diptera	Muscidae	–	–
Arthropoda	Insecta	Diptera	Psychodidae	Maruina	–
Arthropoda	Insecta	Diptera	Psychodidae	Pericoma	–
Arthropoda	Insecta	Diptera	Psychodidae	–	–
Arthropoda	Insecta	Diptera	Simuliidae	Simulium	–
Arthropoda	Insecta	Diptera	Simuliidae	–	–
Arthropoda	Insecta	Diptera	Stratiomyidae	Caloparyphus	–
Arthropoda	Insecta	Diptera	Stratiomyidae	Odontomyia	–
Arthropoda	Insecta	Diptera	Stratiomyidae	–	–
Arthropoda	Insecta	Diptera	Tabanidae	Tabanus	–
Arthropoda	Insecta	Diptera	Tabanidae	–	–
Arthropoda	Insecta	Diptera	Tipulidae	Antocha	monticola
Arthropoda	Insecta	Diptera	Tipulidae	Limnophila	–
Arthropoda	Insecta	Diptera	Tipulidae	Limonia	–
Arthropoda	Insecta	Diptera	Tipulidae	Tipula	–
Arthropoda	Insecta	Diptera	Tipulidae	–	–
Arthropoda	Insecta	Diptera	–	–	–

Appendix B. Macroinvertebrate Taxa List, Gila Cliff Dwellings National Monument, WY2016, cont.

Phylum	Class	Order	Family	Genus	Species
Arthropoda	Insecta	Ephemeroptera	Baetidae	Acentrella	–
Arthropoda	Insecta	Ephemeroptera	Baetidae	Baetis	–
Arthropoda	Insecta	Ephemeroptera	Baetidae	Callibaetis	–
Arthropoda	Insecta	Ephemeroptera	Baetidae	Camelobae-tidius	–
Arthropoda	Insecta	Ephemeroptera	Baetidae	Centroptilum	–
Arthropoda	Insecta	Ephemeroptera	Baetidae	Cloeodes	–
Arthropoda	Insecta	Ephemeroptera	Baetidae	Fallceon	quilleri
Arthropoda	Insecta	Ephemeroptera	Baetidae	Fallceon	–
Arthropoda	Insecta	Ephemeroptera	Baetidae	–	–
Arthropoda	Insecta	Ephemeroptera	Caenidae	Caenis	amica
Arthropoda	Insecta	Ephemeroptera	Caenidae	Caenis	–
Arthropoda	Insecta	Ephemeroptera	Caenidae	–	–
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	tibialis
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	–
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	–	–
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	Drunella	grandis
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Epeorus	–
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	–
Arthropoda	Insecta	Ephemeroptera	Heptageniidae	–	–
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Leptohyphes	–
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	Tricorythodes	–
Arthropoda	Insecta	Ephemeroptera	Leptohyphidae	–	–
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	–	–
Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophle-bia	–
Arthropoda	Insecta	Hemiptera	Belostomatidae	Belostoma	–
Arthropoda	Insecta	Hemiptera	Belostomatidae	Lethocerus	–
Arthropoda	Insecta	Hemiptera	Belostomatidae	–	–
Arthropoda	Insecta	Hemiptera	Corixidae	Graptocorixa	–
Arthropoda	Insecta	Hemiptera	Corixidae	Neocorixa	–
Arthropoda	Insecta	Hemiptera	Corixidae	–	–
Arthropoda	Insecta	Hemiptera	Gerridae	Metrobates	–
Arthropoda	Insecta	Hemiptera	Gerridae	Trepobates	–
Arthropoda	Insecta	Hemiptera	Gerridae	–	–
Arthropoda	Insecta	Hemiptera	Macroveliidae	Macrovelia	–
Arthropoda	Insecta	Hemiptera	Naucoridae	Ambrysus	–
Arthropoda	Insecta	Hemiptera	Naucoridae	–	–
Arthropoda	Insecta	Hemiptera	Nepidae	Ranatra	–
Arthropoda	Insecta	Hemiptera	Notonectidae	Buenoa	–
Arthropoda	Insecta	Hemiptera	Notonectidae	Notonecta	–
Arthropoda	Insecta	Hemiptera	Notonectidae	–	–
Arthropoda	Insecta	Hemiptera	Veliidae	Microvelia	–

Appendix B. Macroinvertebrate Taxa List, Gila Cliff Dwellings National Monument, WY2016, cont.

Phylum	Class	Order	Family	Genus	Species
Arthropoda	Insecta	Hemiptera	Veliidae	Rhagovelia	–
Arthropoda	Insecta	Hemiptera	Veliidae	–	–
Arthropoda	Insecta	Lepidoptera	Crambidae	Petrophila	–
Arthropoda	Insecta	Megaloptera	Corydalidae	Corydalus	cornutus
Arthropoda	Insecta	Odonata	Aeshnidae	–	–
Arthropoda	Insecta	Odonata	Calopterygidae	Hetaerina	americana
Arthropoda	Insecta	Odonata	Calopterygidae	Hetaerina	–
Arthropoda	Insecta	Odonata	Calopterygidae	–	–
Arthropoda	Insecta	Odonata	Coenagrionidae	Argia	–
Arthropoda	Insecta	Odonata	Coenagrionidae	–	–
Arthropoda	Insecta	Odonata	Corduliidae	–	–
Arthropoda	Insecta	Odonata	Gomphidae	Erpetogomphus	–
Arthropoda	Insecta	Odonata	Gomphidae	–	–
Arthropoda	Insecta	Odonata	Gomphidae	Ophiogomphus	–
Arthropoda	Insecta	Odonata	Lestidae	Archilestes	–
Arthropoda	Insecta	Odonata	Libellulidae	Libellula	–
Arthropoda	Insecta	Odonata	Libellulidae	–	–
Arthropoda	Insecta	Odonata	–	–	–
Arthropoda	Insecta	Plecoptera	Capniidae	Capnia	–
Arthropoda	Insecta	Plecoptera	Capniidae	–	–
Arthropoda	Insecta	Plecoptera	Chloroperlidae	–	–
Arthropoda	Insecta	Plecoptera	Nemouridae	–	–
Arthropoda	Insecta	Plecoptera	Nemouridae	Zapada	columbiana
Arthropoda	Insecta	Plecoptera	Perlidae	Claassenia	sabulosa
Arthropoda	Insecta	Plecoptera	Perlidae	Hesperoperla	pacifica
Arthropoda	Insecta	Plecoptera	Perlidae	–	–
Arthropoda	Insecta	Plecoptera	Perlodidae	Isogenoides	–
Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperla	–
Arthropoda	Insecta	Plecoptera	Perlodidae	–	–
Arthropoda	Insecta	Plecoptera	Perlodidae	Skwala	americana
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcys	californica
Arthropoda	Insecta	Plecoptera	Pteronarcyidae	Pteronarcys	–
Arthropoda	Insecta	Plecoptera	Taeniopterygidae	–	–
Arthropoda	Insecta	Plecoptera	–	–	–
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	americanus
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	occidentalis
Arthropoda	Insecta	Trichoptera	Brachycentridae	Brachycentrus	–
Arthropoda	Insecta	Trichoptera	Brachycentridae	Micrasema	–
Arthropoda	Insecta	Trichoptera	Calamoceratidae	Phylloicus	–
Arthropoda	Insecta	Trichoptera	Glossosomatidae	–	–
Arthropoda	Insecta	Trichoptera	Glossosomatidae	Glossosoma	–

Appendix B. Macroinvertebrate Taxa List, Gila Cliff Dwellings National Monument, WY2016, cont.

Phylum	Class	Order	Family	Genus	Species
Arthropoda	Insecta	Trichoptera	Helicopsychidae	Helicopsyche	–
Arthropoda	Insecta	Trichoptera	Hydrobiosidae	Atopsyche	–
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Cheumato-psyche	–
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	–
Arthropoda	Insecta	Trichoptera	Hydropsychidae	Smicridea	–
Arthropoda	Insecta	Trichoptera	Hydropsychidae	–	–
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptila	–
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Leucotrichia	–
Arthropoda	Insecta	Trichoptera	Hydroptilidae	Oxyethira	–
Arthropoda	Insecta	Trichoptera	Hydroptilidae	–	–
Arthropoda	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	–
Arthropoda	Insecta	Trichoptera	Leptoceridae	Nectopsyche	–
Arthropoda	Insecta	Trichoptera	Leptoceridae	Oecetis	–
Arthropoda	Insecta	Trichoptera	Leptoceridae	–	–
Arthropoda	Insecta	Trichoptera	Limnephilidae	–	–
Arthropoda	Insecta	Trichoptera	Odontoceridae	Marilia	flexuosa
Arthropoda	Insecta	Trichoptera	Philopotamidae	Chimarra	–
Arthropoda	Insecta	Trichoptera	Philopotamidae	Wormaldia	–
Arthropoda	Insecta	Trichoptera	Philopotamidae	–	–
Arthropoda	Insecta	Trichoptera	Psychomyiidae	Psychomyia	–
Arthropoda	Insecta	Trichoptera	Psychomyiidae	–	–
Arthropoda	Insecta	Trichoptera	–	–	–
Arthropoda	Malacostraca	Amphipoda	Gammaridae	Gammarus	–
Arthropoda	Malacostraca	Amphipoda	Hyalellidae	Hyalella	–
Arthropoda	Malacostraca	Decapoda	Cambaridae	–	–
Arthropoda	Malacostraca	Decapoda	–	–	–
Mollusca	Bivalvia	Veneroida	Pisidiidae	Pisidium	–
Mollusca	Bivalvia	Veneroida	Pisidiidae	Sphaerium	–
Mollusca	Bivalvia	Veneroida	Pisidiidae	–	–
Mollusca	Gastropoda	Basommatophora	Physidae	Physa	–
Mollusca	Gastropoda	Basommatophora	Planorbidae	Gyraulus	–
Mollusca	Gastropoda	Basommatophora	Planorbidae	–	–
Mollusca	Gastropoda	Neotaenioglossa	Hydrobiidae	–	–
Mollusca	Gastropoda	–	–	–	–
Platyhelminthes	Turbellaria	–	–	–	–

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