



Water Quality Monitoring for Tsaile Creek and Chinle Wash in Canyon de Chelly National Monument

2012–2013 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2016/1222



ON THE COVER
Chinle Wash in Canyon de Chelly National Monument
Photography by SCPN

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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1 Introduction

The National Park Service Inventory and Monitoring Program was designed to determine the current status and monitor long-term trends in the condition of park natural resources, providing park managers with a scientific foundation for making decisions and working with other agencies and the public to protect park ecosystems. Hydrologic vital signs are the fundamental components that define overall riparian and aquatic ecosystem integrity. The Southern Colorado Plateau Network (SCPN) has identified 7 vital signs pertaining to riparian and spring ecosystems: 1) aquatic macroinvertebrates, 2) stream water quality, 3) stream flow and depth to groundwater, 4) spring water quality, 5) fluvial geomorphology, 6) riparian vegetation, composition, and structure, and 7) spring ecosystems. These vital signs are closely related and are all included in the Vital Signs Monitoring Plan for the Southern Colorado Plateau Network (Thomas et al. 2006). The context and ecological significance of these vital signs are further explained in Scott et al. (2005). In this report we focus on stream water quality.

Specific objectives for monitoring stream water quality in SCPN parks are

- Determine status and trends for selected core water quality parameters (water temperature, pH, specific conductance, dissolved oxygen, turbidity and discharge) at selected sites in priority streams within SCPN parks.
- Determine status and trends of selected water quality constituents, including bacteria, nutrients, major elements, and trace metals, at selected sites in priority streams within SCPN parks.
- Compare water quality data against state and tribal standards for chronic exceedances. Multiple exceedances in a year typically indicate non-compliance.

1.1 Selecting potential water quality monitoring sites

We targeted SCPN streams and springs with potential for water quality monitoring by reviewing (1) water quality data inventory and analysis reports prepared by the Water Resources Division (WRD) of the National Park Service (NPS); (2) a USGS summary and review of available water quality data from streams in SCPN parks (Brown 2008); (3) data collected during a Level 1 water quality inventory of streams in SCPN parks (Macy and Monroe 2006); and (4) results of water quality monitoring planning meetings with park staff.

SCPN water bodies were selected for water quality monitoring based on the following criteria:

- 303(d) listed waters¹ — where previous sampling indicates one or more parameters regularly approach or exceed established water quality standards or recommended levels
- waters with demonstrated threat levels—where an analysis of existing data indicate that measured conditions regularly approach or exceed standards or recommended levels, but where the frequency of exceedances or the quality of the database do not support a 303(d) listing
- pristine waters—where there is no direct impact of human activities (provides baseline data)
- ecological significance—presence of unique species or species of concern
- waters of management concern—where past sampling may not indicate constituent values of concern, but where anthropogenic activities indicate that contamination is a significant threat
- historic data—waters identified as important, for which substantial historic water quality data are available
- data gaps—waters identified as important, but where little or no water quality information exists

Whenever possible, water quality monitoring sites are located where a history of water quality data collection exists, and co-located with SCPN aquatic macroinvertebrate monitoring sites.

¹ Under section 303(d) of the Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters—waters that are too polluted or otherwise degraded to meet the water quality standards set by states, territories, or authorized tribes (EPA 2011).

1.2 Water quality monitoring at Canyon de Chelly National Monument

Chinle Wash is an intermittent stream that drains a 1655 km² watershed, which includes Canyon de Chelly and a major tributary canyon, Canyon del Muerto. This canyon network was formed by streams originating in the Chuska Mountains along the Arizona/New Mexico border. Located entirely on the Navajo Nation, these canyon bottoms are used extensively for grazing, farming, and tourism, and the broad and sandy streambed of Chinle Wash is used as the main road through the canyon.

Tsaile Creek is a perennial stream that drains a 424 km² area on the western flank of the Chuska Mountains. It is the headwater stream to Canyon del Muerto, and eventually joins Chinle Wash in Canyon de Chelly. Flow in Tsaile Creek is heavily influenced by Tsaile Dam, which was built in 1963 and formed Tsaile Lake. The dam has reduced base flows in the stream and moderated high flows that normally would result from spring snowmelt (NRCS 2000).

In 2010 SCPN implemented water quality monitoring at the following sites along Chinle Wash and Tsaile Creek

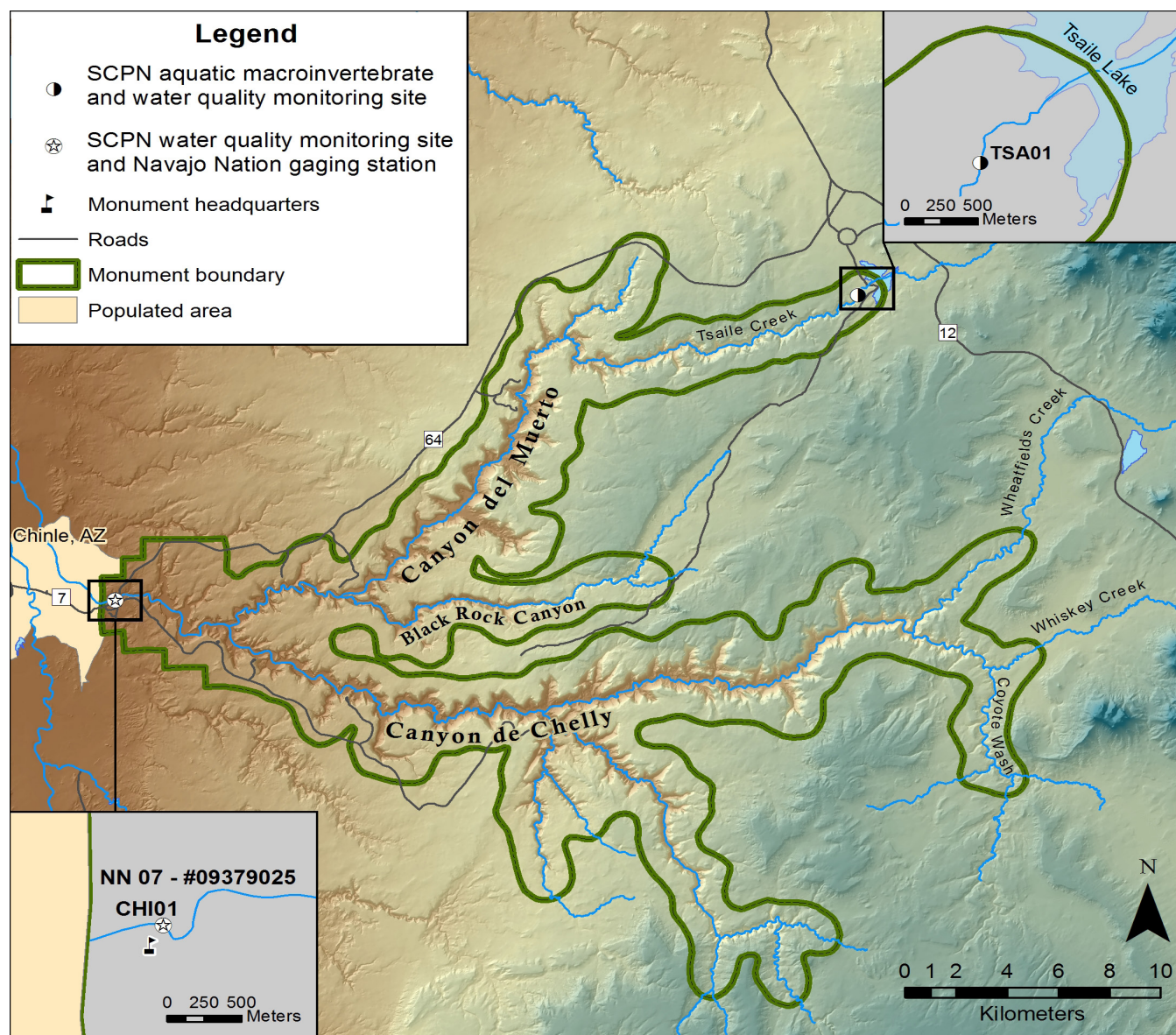


Figure 1. Map of Canyon de Chelly NM, Arizona, with the locations of Southern Colorado Plateau Network's aquatic macroinvertebrate and water quality monitoring sites, TSA01 and CHI01 in Canyon de Chelly NM.

in Canyon de Chelly NM (CACH).

- *Chinle Wash at Chinle* (CACHCHI01) is identified in this report as CHI01. The site is located downstream of the mouth of Canyon de Chelly near a streamflow gaging station (Chinle Wash at Chinle, station number 09379025 NN 07), operated by the Navajo Nation Department of Water Resources, Water Management Branch (Figure 1).
- *Tsaile Creek below Tsaile Dam* (CACHTSA01), identified in this report as TSA01, is co-located with SCPN's aquatic macroinvertebrate monitoring site. TSA01 is located in Canyon del Muerto, 0.95 km downstream of Tsaile Dam.

SCPN collects core water quality data and water quality samples at regular intervals throughout the year. Water quality samples are analyzed by SCPN staff and by a qualified contract laboratory. In 2012, SCPN staff made seven water quality monitoring visits to TSA01 and three to CHI01 at six-week intervals. In 2013, visits to CACH were reduced to four quarterly visits. CHI01 was visited once in 2013, but no samples were collected, only core parameter data. Because Chinle Wash is an intermittent stream, water quality measurements could be made only when the wash was flowing. This report summarizes all SCPN water quality monitoring activities at CACH in 2012–2013.

2 Methods

A brief description of water quality data collection and processing procedures followed by SCPN staff at CACH during 2012–2013 is presented here. Detailed descriptions of these procedures will be available in Water Quality Monitoring Protocol for Streams and Springs in the Southern Colorado Plateau Network (Monroe et al. in preparation).

2.1 Water quality core parameters

National Park Service core water quality parameters include water temperature, pH, specific conductance, dissolved oxygen, turbidity, and discharge. During each site visit, the SCPN water resources field crew noted the hydrologic conditions and collected water quality core parameter data using the following methods:

- As soon as possible after arrival at the site a multiparameter sonde (Hydrolab-MS5; Hach Inc.) was calibrated and deployed in a well-mixed part of the stream channel, logging temperature, pH, specific conductance, and dissolved oxygen data at 5-second intervals. The sonde was left stationary in the stream for the duration of the site visit.
- Turbidity samples were kept on ice for no longer than 24 hours, and analyzed with a HACH 2100P Portable Turbidimeter (Hach Inc.).
- Discharge was measured using a Marsh-McBirney Flo-mate (Hach, Inc.), a Hach FH950, Baski Flume, or a Flowtracker ADV.

2.2 Water quality samples

During each site visit, SCPN crew also collected samples to analyze for bacteria, nutrients, major elements and trace metals, and contaminants of emerging concern. We collected bacterial samples by dipping a sample bottle into the center of flow. SCPN staff analyzed the sample for total coliforms and *E. coli* using the Quanti-Tray® 2000 system (IDEXX Inc.).

We collected samples to be tested for other analytes in a similar manner. Sample water was filtered and/or acid-treated (as required), kept on ice, and shipped to the contract laboratory. In 2012–2013 SCPN continued an Interagency Agreement with the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado for analysis of water samples for selected water quality constituents (Table 1). Information documenting NWQL methods is included in SOP #8 of the SCPN water quality monitoring protocol (Monroe et al. in preparation).

In 2011, SCPN entered into a partnership with the US Environmental Protection Agency (EPA) to sample at network parks for a suite of contaminants of emerging concern (CEC), which include pharmaceuticals, personal care products, waste water indicators, and pesticides (Appendix C). The procedures described in NPS 2013 were followed. The purpose is to develop a baseline dataset documenting the occurrence of these contaminants within SCPN parks. One sample was collected at CACH in 2012; none were collected in 2013.

Table 1. USGS National Water Quality Laboratory and U.S. Environmental Protection Agency Laboratory sample analytes.

Analytical group	Analytes
Nutrients	ammonia, nitrite, nitrite + nitrate, orthophosphate
Major elements	calcium, chloride, fluoride, magnesium, potassium, silica, sodium, sulfate, acid neutralizing capacity (ANC; as CaCO ₃), total dissolved solids
Trace metals	aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, uranium, vanadium, zinc
Contaminants of emerging concern	pharmaceuticals, personal care products, waste water indicators, pesticides

2.3 Data handling and analysis

All SCPN water quality data are entered in NPSTORET, v.1.83, a Microsoft Access database created by the Water Resources Division of the NPS. All multiparameter sonde electronic data and discharge data are stored on the SCPN server. In this report, we include the median values of a subset of seven consecutive multiparameter sonde measurements, with the exception of the data presented in Table 4. Similarly, only the median values for each set of turbidity samples are presented.

All results from the NWQL and EPA are presented as they were reported from the lab. In cases where analytes were not detected, we present the applicable laboratory reporting level, which is the lowest concentration that can be reliably measured by a given analytical method. For the NWQL data, results which are below the laboratory reporting level but above the method detection level are flagged to indicate that the analyte was detected, but the concentration was not high enough to report. These analytes are also flagged in this report.

2.4 Understanding water quality data and standards

The NPS Natural Resource Challenge (NRC) provides funding for water quality monitoring in NPS park units. This funding is intended to advance NPS's long-term goals to protect pristine water quality and improve impaired water quality in parks by supporting Clean Water Act protections and provisions for designated unimpaired and impaired waters. Preliminary analysis of data available through the water quality data synthesis (Brown 2008), a Level 1 water quality inventory (Macy and Monroe 2006), and SCPN monitoring indicate that water quality conditions at many SCPN parks exceed established USEPA, State or Tribal standards.

The SCPN water quality monitoring program collects samples quarterly to document the range of hydrologic conditions that occur in network parks. Thus, rare and short-term events may not be captured. These “grab” samples represent conditions at the point and time of sampling; they do not represent the condition of the entire water body, spatially or temporally.

The Navajo Nation EPA has developed water quality standards and criteria to meet requirements of the Federal Clean Water Act. This report includes water quality standards and criteria applicable to waters on the Navajo Nation (NNEPA 2008). A water quality standard refers to a specific parameter and its associated beneficial use, in conjunction with a criterion, which is the numeric component against which a result is compared. For example, the standard for chronic selenium (parameter) for aquatic and wildlife habitat (use designation) is 2 µg/L (numeric criterion). This criterion is for the total selenium concentration in the sample.

All of SCPN's sample results are for the dissolved concentration, meaning the samples are filtered through a 0.45µ filter to remove the particulate component of the sample before it is shipped for analysis of the dissolved fraction. Most Navajo Nation aquatic life criteria for metals are based on the dissolved fraction. This method more accurately addresses the form of metals that is most toxic to aquatic life while excluding less toxic forms. However, not all Navajo Nation water quality criteria are based on dissolved samples. Many are based on the total sample concentration, which includes the portion of the analyte bound to particulates. Because our samples exclude the particulate component, our data are not necessarily comparable to criteria based on the total sample. Because of this, only the criteria for dissolved parameters are listed in the Results section of this report. However, we note when dissolved concentrations exceed the criteria for total concentrations.

In this report results for each parameter are evaluated against applicable water quality standards as defined for each stream by the Navajo Nation EPA. Navajo Nation surface waters can have up to eight beneficial uses; most are applicable to the streams discussed in this report. Each use designation may have different criteria for one parameter. Also, aquatic life criteria are often dependent upon water hardness, which varies at each site visit. In these cases, the criteria are expressed as a range encompassing the lowest and highest values for the year.

For *E. coli*, we compared our results against the criteria for primary and secondary human contact. SCPN bacteria data are expressed as a most probable number (MPN) per 100 mL. MPN is a statistical estimate of the number of

bacteria per unit volume of a sample, determined by using a lookup table provided by the manufacturer (IDEXX Inc.). Although the NNEPA water quality criteria are expressed as the number of colony forming units per 100 mL (cfu/100 mL) and do not assume an estimation, the two units are comparable.

2.4.1 Chronic and acute standards

Numeric criteria for aquatic life water quality standards address potential effects of both chronic exposure to a parameter over an extended period of time (months) and acute exposure over a short period of time (hours or days). Acute standards apply to any single sample and are not to be exceeded at any time. Criteria are much lower for chronic exposure than for acute exposure and are not directly comparable to the results obtained from a single sample because chronic standards are based on the arithmetic mean of samples collected during four consecutive days (NNEPA 2008). From a compliance standpoint, the acute instantaneous criteria afford the only direct comparison for such data because they apply to a single sample. However, from a resource conservation standpoint, instantaneous grab-sample data, when compared against more stringent chronic criteria, can provide a means of early warning and an indication of a problem that may require more attention. Therefore, we have identified when results are outside the chronic criteria in the results section of this report.

2.4.2 Regulatory authority

The National Park Service does not have regulatory authority over waters in the U.S., or even the authority to make assessments for beneficial use. This report compares water quality data to beneficial use criteria without stating whether a beneficial use was attained. Those designations are reported by the states or tribes in their triennial 305(b) reports to Congress. However, the NPS cooperates with states and tribes in collecting data used in the protection of water bodies under state jurisdiction.

3 Results

This section presents data collected by SCPN from Chinle Wash (CHI01) and Tsaile Creek (TSA01) in 2012–2013. All data collected for CHI01 and TSA01, including dates and sample times, are also included in Appendix B. At TSA01, water quality core parameter data, bacteria, and NWQL samples for nutrients, major elements and trace metals were collected during each of eleven site visits. Because there was not always water in Chinle Wash, only four monitoring visits were made to CHI01. Three samples were submitted to NWQL for chemical analysis in 2012, but none in 2013. NPS core parameter and bacteria data were collected during all four site visits.

3.1 Chinle Wash at Chinle

3.1.1 Water quality core parameter data

In 2012–2013, four sets of core parameter measurements were collected at CHI01. Water was flowing in the wash during the February and April 2012 site visits due to releases from Tsaile Dam. Water flow in August 2012 and 2013 was due to recent precipitation in the area. NPS core parameter data collected during these visits are summarized in Table 2. Water temperature ranged from 8.3°C to 31.2°C. Dissolved oxygen levels met the water quality criteria in three of the four site visits, ranging from 5.8 to 9.5 mg/L. In August 2013, the water was very warm and dissolved oxygen did not meet the 6.0 mg/L criterion for aquatic and wildlife habitat, however all measurements were near 100% saturation. The values for pH varied between 7.9 to 8.6; higher results occurred during the cooler months but remained within the water quality criteria. Specific conductance ranged from 160 to 397 $\mu\text{S}/\text{cm}$. Turbidity was highly variable among the site visits and ranged from 580 to 48,500 NTU. The highest turbidity was observed in August 2013, and the lowest was observed in February 2012. Discharge measurements ranged from 4.4 to 20.7 cfs.

Table 2. Summary of water quality core parameter data from CHI01 in Canyon de Chelly NM during 2012 (n=3) and 2013 (n=1). Data for 2010 and 2011 (n ranges from 6 to 10) are included for comparison, and the associated NNEPA criteria are reported. A “nc” indicates that no criteria exist for a specific parameter.

Core Parameter	2010–2011			2012		2013	NNEPA Criteria
	n	Median	Range	Median	Range		
Water temperature (°C)	10	9.2	0.0–27.7	13.7	8.3–18.9	31.9	nc
pH	10	8.4	8.0–8.6	8.4	7.9–8.6	7.9	>6 and <9
Specific conductance ($\mu\text{S}/\text{cm}$)	10	370	165–516	340	160–397	216	nc
Dissolved oxygen (mg/L)	10	9.3	6.3–11.9	8.0	7.6–9.5	5.8	≥ 6 mg/L
Turbidity (NTU)	6	680	62–7800 ^a	750	580–9250 ^a	48500 ^a	nc
Discharge (cfs)	9	13.7	0.4–177	4.7	4.4–20.7	9.5	nc

^a Turbidity exceeded the instrument maximum detection limit of 1000 NTU. Values are estimates based on diluted samples.

3.1.2 Total coliforms and *E. coli*.

Bacteria results for total coliforms and *E. coli* in 2012 and 2013 are presented in Figure 2, with 2010 and 2011 data plotted for comparison. Numeric results are provided in Appendix B. In 2012, three samples were collected at CHI01—in February, April, and August. In 2013, one sample was collected in August. The NNEPA has not established water quality criteria for total coliforms, which are a diverse group of bacteria used in water quality sampling as indicators of the likely presence of pathogenic bacteria, such as *E. coli*. Total coliforms exceeded 2400 MPN/100 mL, the maximum limit of the IDEXX test, in three of the four samples.

E. coli are a type of coliform bacteria that originate from animal feces, and are of concern because some strains can cause illness upon entering the human digestive system. Two NNEPA *E. coli* standards apply to CHI01:

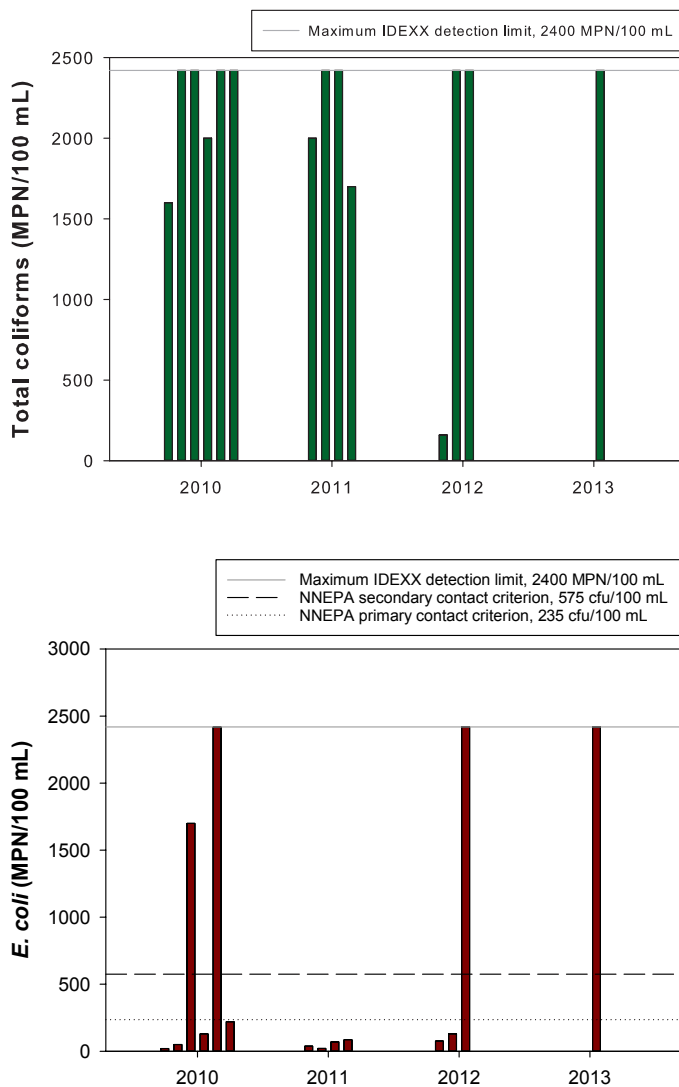


Figure 2. Total coliforms (top) and *E. coli* (bottom) results for samples collected at CHI01 in Canyon de Chelly NM, 2010–2013.

primary (swimming) and secondary (incidental) contact. These standards can be evaluated as either a geometric mean of four samples collected in 30 days, or as a single-sample maximum. The primary contact criteria are a geometric mean of 126 cfu/100 mL, or a single sample maximum of 235 cfu/100 mL. The secondary contact criteria are a geometric mean of 126 cfu/100 mL, or a single sample maximum of 575 cfu/100 mL (NNEPA 2008). In 2012, *E. coli* results were 76 MPN/100 mL in February, 130 MPN/100 mL in April, and >2400 MPN/100 mL in August. In August 2013, the *E. coli* result was >2400 MPN/100 mL. Therefore, August results for 2012 and 2013 exceeded both the primary and secondary contact criteria. The April result exceeded the 126 cfu/100 mL, but a single sample is not sufficient to confirm an exceedance of this chronic standard.

3.1.3 Water quality laboratory data

Results for nutrients, major elements, and trace metals are presented in Tables 3, 4, and 5. Only three samples were collected for these analytes—on 2/21, 4/4, and 8/25/2012. All results were compared against the Navajo Nation water quality criteria that are applicable to this reach of Chinle Wash. Nutrient levels (Table 3) were very low for ammonia, nitrite + nitrate, and nitrite, and always near or below the reporting levels, which were 0.0100, 0.040, and 0.00100 mg/L, respectively. While there are water quality criteria for ammonia, it was not detected in these samples and the criteria are set well above the reporting level.

Major element data are summarized in Table 4. These include the major ions, silica, acid neutralizing capacity, and total dissolved solids. Major ion data for CHI01 in 2012 are plotted in Figure 3; data for TSA01

Table 3. Summary of dissolved nutrient data for water quality samples collected at CHI01 on Chinle Wash in Canyon de Chelly NM, 2012, and number of times that the samples exceeded the applicable water quality criteria. A “nc” indicates that no criteria have been developed for a particular nutrient, and a “ndc” indicates there is no dissolved criterion. Results that were lower than the National Water Quality Laboratory reporting levels are noted as “<[reporting level]”.

Nutrient (mg/L)	Sampling date and time			Most stringent criterion	# of exceedances	Beneficial use
	2/21/12 12:30	4/4/12 20:00	8/25/12 9:10			
Ammonia as N	<0.0100	<0.0100	<0.0100	ndc	ndc	ndc
Nitrite + nitrate as N	<0.040	<0.040	0.054	ndc	ndc	ndc
Nitrite as N	0.00121	<0.00100	0.00226	ndc	ndc	ndc
Orthophosphate as P	0.026	0.0473	0.0668	nc	nc	nc

Table 4. Summary of major element data from samples collected from CHI01 in Canyon de Chelly NM, 2012. All major elements are dissolved, except for acid neutralizing capacity, which was measured in unfiltered samples. There are no NNEPA water quality criteria for these analytes.

Major element (mg/L)	Sampling date and time		
	2/21/12 12:30	4/4/12 20:00	8/25/12 9:10
Calcium	58.5	46.6	22.3
Chloride	7.18	6.86	1.58
Fluoride	0.166	0.171	0.177
Magnesium	12.2	10.3	3.88
Potassium	2.56	2.74	3.45
Silica	18.7	24.4	9.31
Sodium	13.9	14.2	4.37
Sulfate	20.8	14.6	7.14
Acid neutralizing capacity, as CaCO ₃ (unfiltered)	216	194	219
Total dissolved solids	245	214	91

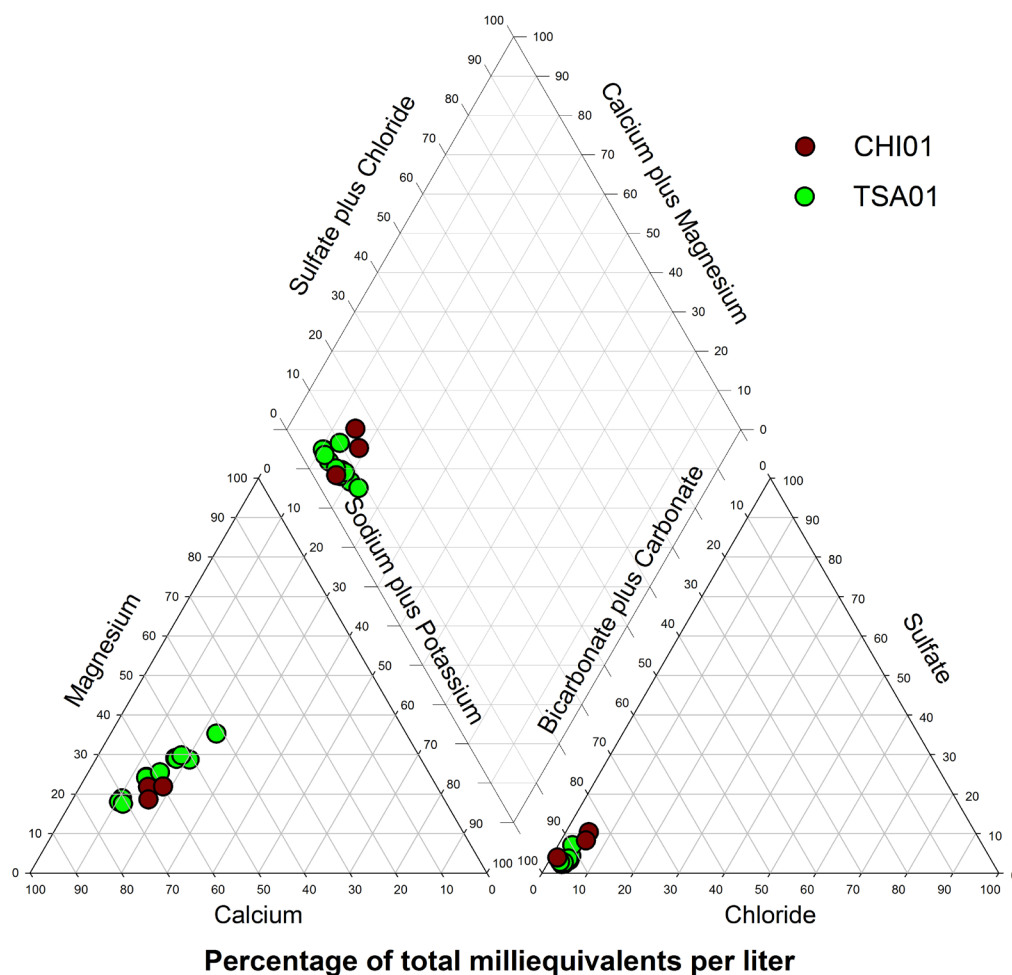


Figure 3. Major ion composition at CHI01 (2012) and TSA01 (2012 and 2013) in Canyon de Chelly NM.

are included for comparison. During the February and April monitoring visits, water was being released from Tsale Dam, a short distance upstream from TSA01 and eventually flowing down to CHI01. During the August site visit, Chinle Wash was flowing due to recent monsoonal precipitation in the area; no water was being released from the dam. Despite the differences in the source of the water flowing to CHI01, the major ion composition was similar across all three samples. Anions were overwhelmingly dominated by carbonate/bicarbonate, while cations mainly consisted of calcium, followed by magnesium, sodium and potassium.

Trace metal data are presented in Table 5, along with the the most stringent water quality criteria applicable at CHI01 for dissolved metals. Six metals were not detected above the laboratory reporting levels (LRL), which were below the NNEPA water quality criteria: beryllium, cadmium, chromium, mercury, silver, and zinc. Another metal, mercury, was also not detected above the LRL, which is 0.005 µg/L. However, the water quality criterion for mercury is 0.001 µg/L, which is below the LRL, so it could not be determined whether these samples exceeded the aquatic and wildlife standard. The remaining metals were present, but not at levels which exceeded the NNEPA water quality criteria.

Table 5. Summary of trace metal data for samples collected from CHI01 in Canyon de Chelly NM, 2012–2013, NNEPA water quality criteria (most stringent criteria that applies to CHI01), and number of times that the samples were outside those criteria. A “nc” indicates that no criteria have been developed for a particular trace metal, and a “ndc” indicates there is no dissolved criterion. Results that were lower than the NWQL reporting levels are noted as “<[reporting level]”.

Trace metal, dissolved (µg/L)	Sampling date and time			Most stringent criterion	# of exceedances	Beneficial uses ^a
	2/21/12 12:30	4/4/12 20:00	8/25/12 9:10			
Aluminum	32.5	9.79	71.6	5000	0	AgWS
Antimony	0.115	0.131	0.257	30 (chronic)	0	A&WHbt
Arsenic	2.00	2.97	2.82	150 (chronic)	0	A&WHbt
Barium	191	174	106	ndc	ndc	ndc
Beryllium	<0.040	<0.040	<0.040	ndc	ndc	ndc
Boron	32.8	38.5	35.1	5000	0	LW
Cadmium	<0.060	<0.060	<0.060 ^b	0.20–0.39 (chronic)	0	A&WHbt
Chromium	<0.60	<0.60	<0.60	11 (chronic, for Cr(VI))	0	A&WHbt
Cobalt	1.30	0.247	1.61	50	0	AgWS
Copper	1.39	0.909	3.56	6.74–16.0 (chronic)	0	A&WHbt
Iron	22.7	6.22	82.0	nc	nc	nc
Lead	<0.08	<0.08	0.338	1.75–5.21 (chronic)	0	A&WHbt
Manganese	15.0	6.52	4.77	nc	nc	nc
Mercury	<0.005	<0.005	<0.005	0.001 (chronic)	unknown	A&WHbt
Molybdenum	0.875	0.770	0.978	1000	0	AgWS
Nickel	0.988	1.11	1.27	39.3–92.1 (chronic)	0	A&WHbt
Selenium	0.120	0.139	0.262	ndc	ndc	ndc
Silver	<0.040	<0.040	<0.040	1.82–10.3 (acute)	0	A&WHbt
Uranium	2.06	1.62	0.903	ndc	ndc	ndc
Vanadium	3.36	6.33	7.21	100	0	AgWS, LW
Zinc	<4.00	<4.00	<4.00	89–209 (chronic)	0	A&WHbt

^aBeneficial use codes: A&WHbt - aquatic and wildlife habitat; AgWS - agricultural water supply; FC - fish consumption; LW - livestock watering; PrHC - primary human contact; ScHC - secondary human contact

^bThe trace metal was detected above the method detection level, but was below the laboratory reporting level.

3.2 Tsaile Creek below Tsaile Dam

3.2.1 Water quality core parameter data

Discharge at TSA01 was very low throughout 2012–2013, unless dam releases were occurring. Water was released from the dam on 2/21/12, 4/5/12, and 12/9/13. Otherwise, the creek relied on leakage from the dam to maintain a trickle. The creek was completely dry, including pools, at the water quality site during site visits on 7/8/12 and 10/3/12. On 5/24/13, the pools contained some water, but there was no flowing surface water connecting them. In these instances, we sampled at the nearest flowing water, which was about 150 m upstream. Stream discharge ranged from 0 to 17.0 cfs, though the median was only 0.0047 cfs.

Table 6. Summary of water quality core parameter data from samples collected at TSA01 in Canyon de Chelly NM in 2012 (n=7) and 2013 (n=4). The median value and range of values across all site visits, as well as the associated NNEPA criteria are reported. A “nc” in this table indicates that no criteria exists for the metric at TSA01.

Core parameter	n	2009–2011		2012		2013		NNEPA Criteria
		Median	Range	Median	Range	Median	Range	
Water temperature (°C)	15	8.6	0.1–23.4	17.8	0.6–24.8	6.1	(-)0.3–24.8	nc
pH	15	8.4	7.6–8.7	8.4	8.1–8.8	8.4	8.1–8.6	>6 and <9
Specific conductance (µS/cm)	15	361	193–537	335	252–497	377	299–489	nc
Dissolved oxygen (mg/L)	15	9.5	4.0–11.2	10.5	1.8–12.0	9.6	7.4–10.6	≥6 mg/L
Turbidity (NTU)	14	34	2.3–108	32	3.1–44.3	19	7.7–42	nc
Discharge (cfs)	13	3.4	0.02–21.3	0.01 ^a	0.0047–5.7	16.9 ^b	n/a	nc

^a Represents 5 measurements

^b Represents 1 measurement

Core parameter data for TSA01 are summarized in Table 6; 2010 and 2011 data are also included for comparison. All measurements were taken in flowing water. Water temperature ranged from -0.3 to 24.8°C. Values for pH

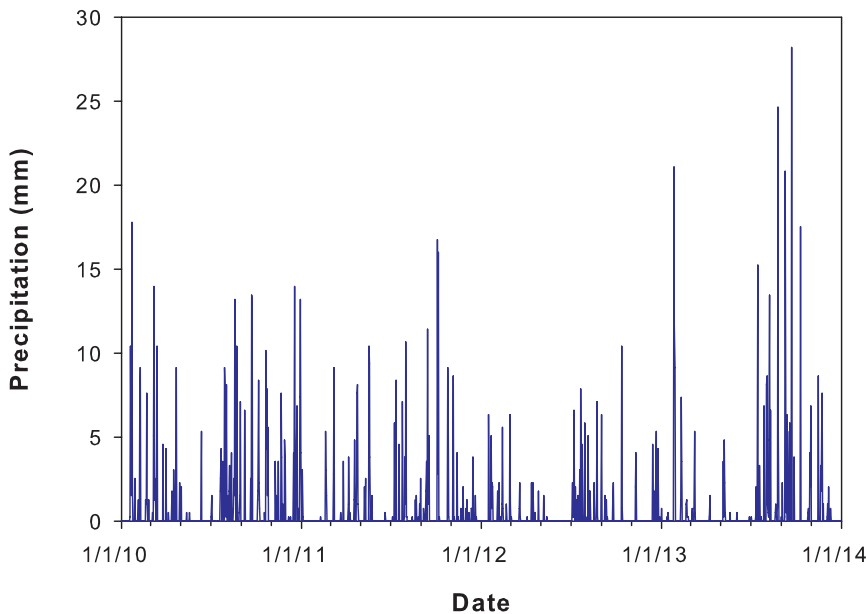


Figure 4. Daily precipitation totals from NOAA/NCDC station TSAILE 1 SSW, near TSA01 in Tsaile, AZ.

ranged from 8.1 to 8.8. The low streamflow did affect dissolved oxygen measurements. On 5/24/13, streamflow was very low and the creek was full of algae that had grown while dam releases were occurring, and then died when the flow dried up. Multiparameter sonde measurements were taken at the outlet of a pool. The dissolved oxygen (DO) level there was at 25% saturation and only 1.8 mg/L, which was below the NNEPA water quality criterion of 6mg/L. For all other site visits, DO was above this criterion. DO varied greatly between site visits, ranging between 1.8 to 11.4 mg/L, and was between 25–150% saturation. Specific conductance for 2012–2013 ranged from 252 to 497 µS/cm. Turbidity

ranged from 3.1 to 44 NTU.

3.2.2 Precipitation

Daily precipitation data for all of 2012 and half of 2013 in Tsaile are shown in Figure 4. The data were acquired from a National Oceanic and Atmospheric Administration's National Climatic Data Center (NOAA/NCDC) weather station located at Diné College near TSA01 (TSAILE 1 SSW). No data for this weather station were available after 6/23/2013. Precipitation totaled 253 mm in 2012 and 103 mm for the first half of 2013 (data are missing for 1/30/13, 5/7/13, and after 6/23/13). In 2012, six precipitation events exceeded 10 mm, and the majority of the precipitation occurred from July–December. The winter of 2013 was slightly wetter than in 2012, but the spring seasons were dry in both years.

3.2.3 Total coliforms and *E. coli*

Eleven bacteria samples were collected at TSA01 and analyzed by SCPN during 2012–2013. Total coliforms at TSA01 ranged from 40 to greater than 2400 MPN/100 mL. Results were generally lower in winter than in the summer months.

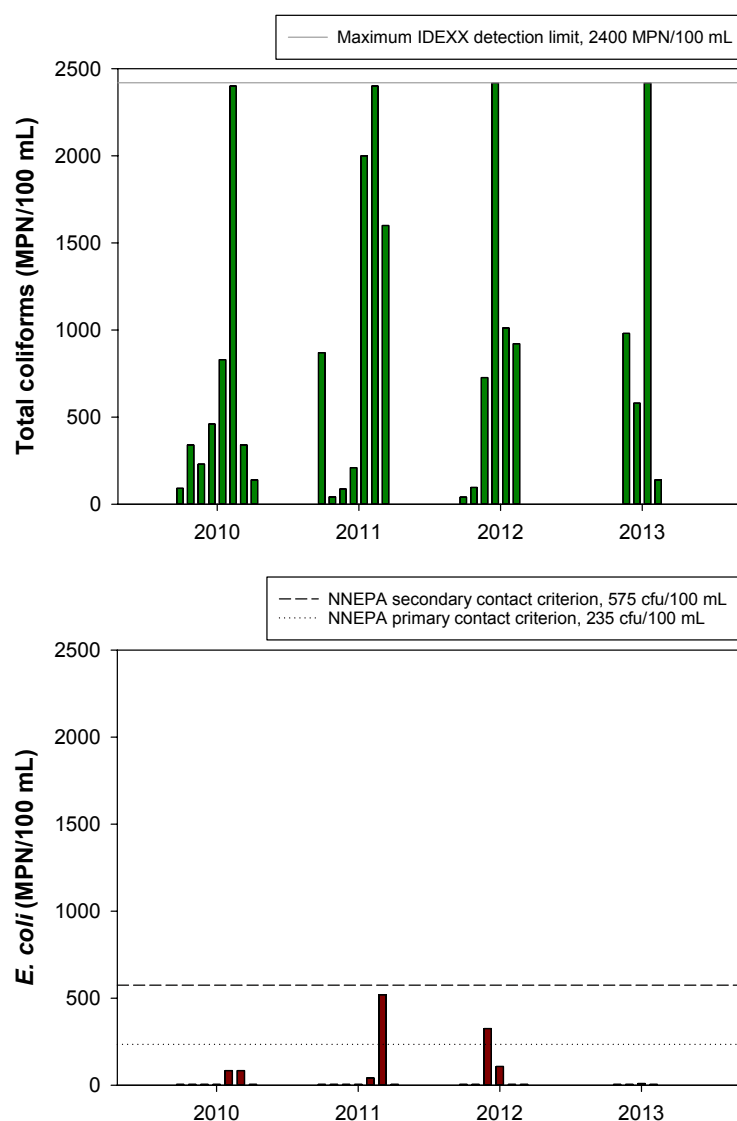


Figure 5. Total coliform (top) and *E. coli* (bottom) results for samples collected at TSA01 in Canyon de Chelly NM in 2012 and 2013.

E. coli levels at TSA01 were higher in 2012 than they were in 2013, but one sample exceeded the NNEPA primary contact criteria (single sample maximum of 235 cfu/100 mL or a geometric mean of 126 cfu/100 mL) on May 16, 2012. Despite the small size of the stream, primary contact is a beneficial use on this reach of Tsaile Creek (NNEPA 2008). This sample, however, did not exceed the secondary contact single sample maximum (575 cfu/100 mL). Sample results for *E. coli* in 2012 ranged from <1 to 260 MPN/100 mL, with a median of 108 MPN/100mL. In 2013, the range was <1 to 10 MPN/100 mL. Sample analysis results for bacteria are presented in Figure 5; 2010 and 2011 data are included for comparison.

3.2.4 Water quality laboratory data

Nutrients, major element, and trace metal results from eleven water samples collected from TSA01 in 2012 and 2013 are summarized below in Tables 7–9. Complete results are in Appendix B. Where applicable, results are compared against NNEPA water quality standards (NNEPA 2008).

Levels for the nutrients ammonia, nitrite+nitrate, and nitrite were very low (Table 7). Of eleven samples, ammonia and nitrite were both detected in four samples at levels near their corresponding laboratory reporting levels of 0.0100 mg/L and 0.00100 mg/L respectively. There were no exceedances of water quality criteria for ammonia. Nitrite+nitrate was

Table 7. Summary of nutrient data from samples collected from TSA01 at Canyon de Chelly NM, 2012–2013 (n=11). A “nc” indicates that no criteria have been developed for a particular nutrient, and a “ndc” indicates there is no dissolved criterion. Results that were lower than the National Water Quality Laboratory reporting levels are noted as “<[reporting level]”.

Nutrient (mg/L)	Minimum	Maximum	Median	Standard deviation	Most stringent criterion	# of exceedances	Beneficial use
Ammonia as N	<0.0100	0.062	---- ^a	----	ndc	ndc	ndc
Nitrite + nitrate as N	<0.040	0.126	----	----	ndc	ndc	ndc
Nitrite as N	<0.00100	0.0059	----	----	ndc	ndc	ndc
Orthophosphate as P	0.0049	0.0455	0.0156	0.0147	nc	nc	nc

^aMedians and standard deviations were not calculated when more than 70% of the results fell below the laboratory reporting level.

Table 8. Summary of major element data from samples collected from TSA01 in Canyon de Chelly NM, 2012–2013 (n=11). All major elements are dissolved, except for acid neutralizing capacity, which was measured in unfiltered samples. There are no NNEPA water quality criteria for these analytes.

Major element (mg/L)	Minimum	Maximum	Median	Standard deviation
Calcium	32.0	77.4	47.6	13.6
Chloride	2.32	6.36	5.52	1.46
Fluoride	0.104	0.276	0.223	0.0613
Magnesium	6.53	18.6	14.6	4.28
Potassium	1.72	3.93	2.40	0.710
Silica	0.579	30.4	22.6	8.17
Sodium	5.93	19.1	16.3	4.85
Sulfate	4.81	20.6	6.06	4.44
Acid neutralizing capacity, as CaCO ₃ (unfiltered)	134	267	181	42.2
Total dissolved solids	157	308	214	45.5

Table 9. Summary of trace metal data for samples collected from TSA01 in Canyon de Chelly NM, 2012–2013 (n=11), NNEPA water quality criteria (most stringent criteria that applies to TSA01), and number of times that the samples were outside those criteria. A “nc” indicates that no criteria have been developed for a particular nutrient, and a “ndc” indicates there is no dissolved criterion. Results that were lower than the NWQL reporting levels are noted as “<[reporting level]”.

Trace metal, dissolved, (µg/L)	Minimum	Maximum	Median	Standard deviation	Lowest criterion	# of exceedances	Beneficial use ^a
Aluminum	<2.20	35.7	11.4	9.64	5000	0	AgWS
Antimony	<0.0270	0.208	0.113	0.0587	30 (chronic)	0	A&WHbt
Arsenic	0.265	3.13	2.61	0.902	150 (chronic)	0	A&WHbt
Barium	39.6	525	223	147	ndc	ndc	ndc
Beryllium	<0.040	<0.040	---- ^b	----	ndc	ndc	ndc
Boron	18.3	67.1	50.4	15.6	5000	0	LW
Cadmium	<0.060	<0.060	----	----	0.30–0.49 (chronic)	0	A&WHbt

Table 9. *continued.* Summary of trace metal data for samples collected from TSA01 in Canyon de Chelly NM, 2012–2013.

Trace metal, dissolved, (µg/L)	Minimum	Maximum	Median	Standard deviation	Lowest criterion	# of exceedances	Beneficial use ^a
Chromium	<0.60	<0.60	----	----	11, (chronic, for Cr(VI))	0	A&WHbt
Cobalt	<0.100	2.01	0.877	0.651	50	0	AgWS
Copper	<0.800	6.59	1.36	2.12	11.3–20.9 (chronic)	0	A&WHbt
Iron	<4.00	66.4	14.7	18.8	nc	nc	nc
Lead	<0.08	0.787	0.243	0.286	3.39–7.28 (chronic)	0	A&WHbt
Manganese	1.62	86.5	7.08	27.5	nc	nc	nc
Mercury	<0.005	<0.005	----	----	0.001 (chronic)	unknown	A&WHbt
Molybdenum	0.348	1.29	0.837	0.328	1000	0	AgWS
Nickel	<0.400	1.34	0.826	0.235	65.6–121 (chronic)	0	A&WHbt
Selenium	<0.100	0.154	0.106	0.018	ndc	ndc	ndc
Silver	<0.040	<0.040	----	----	5.16–17.8 (acute)	0	A&WHbt
Uranium	0.298	1.61	0.741	0.434	ndc	ndc	ndc
Vanadium	0.736	5.66	4.16	1.72	100	0	AgWS, LW
Zinc	<4.00	5.14	----	----	149–274 (chronic)	0	A&WHbt

^aBeneficial use codes: A&WHbt - aquatic and wildlife habitat; AgWS - agricultural water supply; FC - fish consumption; LW - livestock watering; PrHC - primary human contact; ScHC - secondary human contact.

^bMedians and standard deviations were not calculated when more than 70% of the results fell below the laboratory reporting level

detected in only two samples, and the detections were near the laboratory reporting level. Orthophosphate was detected in all samples in concentrations ranging from 0.0049 to 0.0455 mg/L. However, no NNEPA water quality criteria exist for this analyte.

Major element data for samples collected at TSA01 in 2012–2013 are summarized in Table 8. Major ion composition is plotted in Figure 3 along with the CHI01 data. Ion composition of the two sites was very similar; anions almost entirely consisted of carbonate/bicarbonate, while cation chemistry was dominated by magnesium, with sodium and potassium having a much smaller role.

Trace metal results for TSA01 are summarized in Table 9. Five metals were not detected in any of the samples: beryllium, cadmium, chromium, mercury, and silver. Levels of most metals did not vary significantly across the samples collected over the two years, and concentrations were very low. As was the case with CHI01, none of the metals exceeded the applicable water quality criteria, and mercury could not be evaluated because the criterion is below the reporting level.

3.2.5 Contaminants of emerging concern

In 2012, we submitted one sample to be analyzed by the USEPA Region 8 lab for contaminants of emerging concern, which are split into three categories: pesticides, pharmaceuticals and personal care products, and waste indicators. The complete list of analytes and reporting levels is in Appendix C. The sample was collected on 10/3/2012 and none of these analytes were detected.

4 Quality assurance/Quality control

We followed the Quality Assurance/Quality Control (QA/QC) procedures described in Monroe et al. (in preparation) and in the Water Resources Inventory and Monitoring Program guidance (National Park Service 2013). To ensure accuracy of the instruments, we calibrated and performed maintenance on the multiparameter sondes in an indoor laboratory four times per year. We checked the current meters according to manufacturer recommendations to determine that they were in working order, and calibrated the turbidimeter quarterly in the lab. The turbidimeter was also checked for drift in the field prior to each measurement. We collected ten duplicate bacteria samples at several SCPN monitoring sites by filling two sample bottles in succession and comparing tray results after the incubation period. Three blank samples were processed using sterile water provided by IDEXX.

To verify the cleanliness of both the sampling equipment and the sample filtration process for nutrients, major elements, and trace metals, NWQL analyzed four sample sets of certified inorganic blank water in 2012 and 2013. The results were compared against the 2013 reporting levels.

5 Summary

In 2010, SCPN implemented long-term water quality monitoring at CHI01 and TSA01 on Chinle Wash and Tsaille Creek in CACH, and continued this work through 2013. This report summarizes data collected during site visits to CHI01 and TSA01 during 2012–2013, and compares these results against applicable NNEPA water quality standards (Navajo Nation Environmental Protection Agency 2008).

CHI01 was visited on the same days as TSA01 and was sampled whenever water was flowing there: three times in 2012 and once in 2013. Samples for nutrients, major elements, and trace metals were collected in 2012 and sent to a contract laboratory. NPS core parameter measurements were made at four site visits and three bacteria samples were collected. All core parameters and laboratory analytes were in compliance with NNEPA water quality standards. *E. coli* levels exceeded both the primary and secondary contact criteria twice.

TSA01 was visited seven times in 2012 and four times in 2013. During each site visit, NPS core parameter measurements were made and bacteria samples were collected. Additionally, water samples were collected for nutrients, major element, and trace metal analysis at each site visit. All core parameters were in compliance with applicable NNEPA water quality standards at each site visit, except dissolved oxygen. One *E. coli* result exceeded the NNEPA primary contact criterion for this stream, but not the secondary contact criterion. Laboratory-measured results for nutrients and trace metals were below the NNEPA water quality criteria.

The data in this report should be viewed as a snapshot of water quality conditions existing at the time data was collected. Data and analyses in this report are provisional and are subject to change. When sampling has occurred over a sufficient number of years (5 years), SCPN will prepare an in-depth trend analysis report of water quality data for Chinle Wash and Tsaille Creek.

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Appendix A. Southern Colorado Plateau Network Water Quality Monitoring Sites in Canyon de Chelly National Monument

Table A1. Southern Colorado Plateau Network water quality monitoring sites for Canyon de Chelly National Monument, 2012–2013.

Site code	Common name	Report name	Northing ¹	Easting ¹	Elevation (m) ¹
CACHCHI01	Chinle Wash at Chinle	CHI01	4002062	631525	1689
CACHTSA01	Tsaile Creek below Tsaile Dam	TSA01	4015393	660576	2125

¹ Horizontal coordinates are reported in Universal Transverse Mercator (UTM) Projection, Zone 12, North American Datum of 1983 (NAD 83). Vertical coordinates are referenced to the North American Vertical Datum of 1988 (NAVD 88)

Appendix B. Water quality monitoring results for Canyon de Chelly National Monument, 2012–2013

Table B1. Water quality core parameter data for CHI01 on Chinle Wash in Canyon de Chelly NM, 2012–2013

Parameter	Unit	Sample collection date and time			
		2/21/12 1230	4/4/12 2000	8/25/12 0910	8/12/13 1420
Water temperature	°C	8.3	13.7	18.9	31.9
pH	none	8.4	8.5	7.9	7.9
Specific conductance	µS/cm	397	340	160	216
Dissolved oxygen	mg/L	9.5	8.0	7.6	5.8
Dissolved oxygen	% saturation	99	95	100	97
Turbidity	NTU	580	750	9,250 ^a	48,500 ^a
Discharge	cfs	4.4	20.7	4.7	9.5

^a Turbidity result is an estimate

Table B2. Total coliforms and *E. coli* in samples collected at CHI01 on Chinle Wash in Canyon de Chelly NM, 2012–2013

	Unit	Sample collection date and time			
		2/21/12 13:45	4/4/12 20:00	8/25/12 09:10	8/12/13 14:20
Total coliforms	MPN/100 mL	160	>2400 ^a	>2400 ^a	>2400 ^a
<i>E. coli</i>	MPN/100 mL	76	130	>2400 ^a	>2400 ^a

^a Exceeded the maximum detection level of the IDEXX system, which is 2400 MPN/100 mL

Table B3. Water quality core parameter data for TSA01 on Tsaille Creek in Canyon de Chelly NM, 2012–2013.

		Sample collection date and time										
Parameter	Unit	2/21/12 15:45	4/5/12 11:11	5/16/12 14:30	7/8/12 15:03	8/25/12 13:30	10/3/12 14:30	11/30/12 12:00	1/30/13 14:37	5/24/13 09:40	8/12/13 05:20	12/9/13 16:00
Water temperature	°C	5.5	10.1	17.8	23.1	24.8	18.2	0.6	-0.3	9.2	24.8	3.0
pH	none	8.5	8.4	8.1	8.9	8.6	8.4	8.5	8.1	8.4	8.3	8.6
Specific conductance	μS/cm	324	252	335	327	344	403	497	489	397	356	299
Dissolved oxygen	mg/L	12.0	9.1	1.8	10.0	10.5	10.7	11.2	10.6	7.4	9.2	10.0
Dissolved oxygen	% saturation	123	105	25	150	165	147	100	93	83	143	96
Turbidity	NTU	20	44	8.6	36	32	37	3.1	7.8	9.9	42	28
Discharge	cfs	4.87	5.67	0.0084	^a	0.0047	^a	0.0084	^b	^a	<0.0043	17.0

^aFlow was too low to be measured

^bCreek was frozen and measurement was not possible

Table B4. Total coliforms and *E. coli* in samples collected at TSA01 on Tsaille Creek in Canyon de Chelly NM, 2012–2013.

		Sample collection date and time									
Unit		2/21/12 15:45	4/5/12 11:11	5/16/12 14:30	8/25/12 13:30	10/3/12 14:30	11/30/12 12:00	1/30/13 14:37	5/24/13 09:40	8/12/13 05:20	12/9/13 16:00
Total coliforms	MPN/100 mL	40	96	730	>2400 ^a	1000	920	980	580	>2400 ^a	140
<i>E. coli</i>	MPN/100 mL	<1	1	330	110	3	<1	1	<1	10	4

^a Exceeded the maximum detection level of the IDEXX system, which is 2400 MPN/100 mL

Table B5. Results of laboratory analyses for TSA01 on Tsaille Creek in Canyon de Chelly NM, as reported by the U.S. Geological Survey National Water Quality Laboratory (NWQL). Parameters are dissolved unless otherwise specified. Results that were lower than the NWQL reporting levels are noted as "<[reporting level]".

Analyte	Sample collection date and time										
	2/21/12 15:45	4/5/12 11:11	5/16/12 14:30	7/8/12 15:03	8/25/12 13:30	10/3/12 14:30	11/30/12 12:00	1/30/13 14:37	5/24/13 09:40	8/12/13 05:20	12/9/13 16:00
Nutrients (mg/L)											
Ammonia as N	<0.0100	0.0169	0.0202	0.0137	<0.0100	<0.0100	<0.0100	0.062	<0.0100	<0.0100	<0.0100
Nitrite + nitrate as N	<0.040	<0.040	<0.040	<0.040	<0.040	0.126	<0.040	0.096	<0.040	<0.040	<0.040
Nitrite as N	<0.00100	0.00173	0.00246	0.00545	<0.00100	<0.00100	<0.00100	0.00592	<0.00100	<0.00100	<0.00100
Orthophosphate as P	0.0184	0.0349	0.00490	0.0314	0.00592	0.00736	0.00873	0.0348	0.00571	0.0156	0.0455
Major elements (mg/L)											
Calcium	52.7	41.9	42.0	32.0	40.2	52.1	77.4	73.1	46.8	47.6	49.6
Chloride	3.57	2.32	5.97	5.52	4.91	6.30	6.36	6.36	6.19	4.99	2.99
Fluoride	0.129	0.104	0.223	0.273	0.203	0.223	0.232	0.270	0.276	0.242	0.133
Magnesium	8.74	6.53	14.6	16.7	13.4	17.3	18.6	17.4	16.5	12.7	7.58
Potassium	1.91	1.72	3.78	2.22	2.26	2.67	2.48	2.40	2.11	2.87	3.93
Silica	23.6	19.5	0.579	28.1	22.6	26.2	30.4	26.9	14.8	22.3	21.2
Sodium	7.92	5.93	17.2	19.1	13.4	18.0	17.3	16.3	17.5	12.8	6.87
Sulfate	5.84	4.81	6.59	8.26	5.86	6.06	6.78	20.6	8.39	5.98	5.1
Acid neutralizing capacity, as CaCO ₃ (unfiltered)	174	134	181	175	164	228	267	263	207	198	163
Total dissolved solids	205	157	214	212	202	259	304	308	248	231	204
Trace metals (µg/L)											
Aluminum	10.3	21.1	35.7	<2.20	11.4	12.9	<2.20	6.86	4.48	12.3	14.2
Antimony	<0.113	0.0965	<0.132	<0.0270	0.208	0.207	<0.0498	0.0667	0.105	0.135	0.159
Arsenic	1.78	1.31	1.18	0.265	2.63	3.13	2.78	2.64	2.25	3.02	2.61
Barium	161	128	180	39.6	223	403	525	444	258	232	168
Beryllium	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Boron	26.2	18.3	47.8	67.1	50.4	61.3	60.5	50	54.2	54.6	30.8
Cadmium	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060	<0.060
Chromium	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
Cobalt	0.877	0.567	1.11	<0.100	1.71	1.70	0.185	0.483	1.04	2.01	0.434

Table B-5 (continued) Results of laboratory analyses for TSA01 on Tsale Creek in Canyon de Chelly NM, as reported by the U.S. Geological Survey National Water Quality Laboratory (NWQL). Parameters are dissolved unless otherwise specified. Results that were lower than the NWQL reporting levels are noted as "<[reporting level]".

Analyte	Sample collection date and time										
	2/22/12 11:05	4/4/12 12:00	5/17/12 11:00	7/9/12 10:30	8/24/12 12:25	10/5/12 16:45	11/29/12 13:15	1/31/13 12:20	5/23/13 13:30	8/13/13 12:00	11/20/13 11:00
Trace metals (µg/L)											
Copper	0.843	<0.800	0.879	<0.800	6.59	6.02	3.23	2.76	1.36	1.5	1.11
Iron	14.7	20.3	43	66.4	10.2	29.2	<4.00	8.84	6.78	10	20.3
Lead	0.0469	<0.080 ^a	<0.080 ^a	<0.080 ^a	0.573	0.622	0.787	0.243	0.78	0.232	0.306
Manganese	58.7	24.1	18.9	2.77	7.08	5.54	1.62	86.5	2.73	7.91	7.06
Mercury	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Molybdenum	0.525	0.486	0.837	0.348	0.837	1.22	1.21	1.16	1.29	0.858	0.68
Nickel	0.73	0.801	0.865	<0.400	0.954	0.878	0.647	0.826	0.728	1.01	1.34
Selenium	0.118	0.123	0.154	<0.100 ^a	0.106	<0.100 ^a	<0.100 ^a	<0.100 ^a	0.122	0.105	0.137
Silver	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Uranium	1.61	1.35	0.864	0.298	0.479	0.531	0.478	0.92	0.741	0.411	1.27
Vanadium	3.3	4.16	2.27	0.736	5.66	4.59	1.51	0.89	4.52	4.58	4.71
Zinc	<4.00	<4.00	<4.00	<4.00	<4.00	5.14	<4.00	<4.00	<4.00	<4.00	<4.00 ^a

^aAnalyte was present above the MDL, but below the LRL.

Appendix C. List of analytes and reporting limits for contaminants of emerging concern

Table C1. Target analytes and U.S. Environmental Protection Agency reporting limits for pesticides.

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
2,4,5-T	10	EPTC	20
2,4,5-TP	10	Ethoprop	10
2,4-D	10	Fipronil	20
3-Hydroxycarbofuran	10	Fipronil sulfide	10
Acetochlor	20	Hexazinone	10
Acetochlor OA	20	Imazaquin	20
Alachlor	20	Imazethapyr	10
Alachlor OA	50	Imidacloprid	20
Aldicarb	10	Linuron	20
Aldicarb sulfone	20	Malathion	10
Aldicarb sulfoxide	10	MCPP	20
Atrazine	10	Metalaxyl	10
Atrazine de-ethyl	20	Methiocarb	10
Atrazine de-isopropyl	20	Methomyl	20
Atraton	50	Metolachlor	10
Azoxystrobin	20	Metolachlor ESA	20
Bentazon	10	Metribuzin	20
Bromacil	50	Monuron	10
Bromoxynil	10	Neburon	50
Butachlor ESA	10	Oryzalin	20
Carbaryl	10	Oxamyl	10
Carbofuran	10	Pentachlorophenol	50
Chlorimuron ethyl	20	Prometon	10
Cyanazine	10	Propachlor	10
3-Hydroxycarbofuran	10	Propachlor ESA	20
Dacthal monoacid	20	Propazine	50
Diazinon	10	Propiconazole	20
Dichloroprop	10	Propoxur	10
Dimethachlor	10	Simazine	20
Dimethenamid	10	Sulfometuron methyl	20
Dimethenamid ESA	20	Tebuconazole	50
Disulfoton sulfone	20	Tebuthiuron	10
Diuron	50	Terbutylazine	10
Diuron Metabolite	50	Thiamethoxam	20

Table C2. Target analytes and U.S. Environmental Protection Agency reporting limits for pharmaceuticals and personal care products.

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
Acebutolol	10.0	Fenbufen	10.0
Albuterol	10.0	Fentanyl	10.0
Alprazolam	10.0	Flunitrazepam	10.0
Amitriptyline	10.0	Furosemide	10.0
Amitriptyline, (+/-)-E-10-hydroxylated	10.0	Gabapentin	25.0
Amphetamine	10.0	Gemfibrozil	10.0
Atenolol	10.0	Glipizide	10.0
Atrazine	10.0	Glyburide	10.0
Benzoyllecgonine	10.0	Hydrocodone	10.0
Benzphetamine	10.0	Hydromorphone	10.0
Bezafibrate	10.0	m-Hydroxybenzoyllecgonine	10.0
Brombuterol	10.0	Ibuprofen	10.0
Butabarbital	25.0	Levorphanol	10.0
Butalbital	10.0	Loratadine	10.0
n-Butylparaben	25.0	Mefenamic acid 3-carboxy	10.0
Carbamazepine 10,11 epoxide	10.0	MDA	10.0
Caffeine	10.0	MDEA	10.0
Cannabidiol	25.0	MDMA	10.0
Cannabinol	25.0	Meperidine	10.0
Carbamazepine	10.0	Mephobarbital	25.0
Carisoprodol	10.0	Meprobamate	10.0
Chloramphenicol	10.0	Metformin	10.0
Chlordiazepoxide	10.0	Methamphetamine	10.0
Chlorpheniramine	10.0	Methaqualone	10.0
Cimetidine	10.0	Methylparaben	10.0
Clenbuterol	10.0	Methypylon	10.0
Clobazam	10.0	Metoprolol	10.0
Clonazepam	10.0	Monensin	10.0
Clonidine	10.0	Morphine	10.0
Cocaethylene	10.0	Naproxen	10.0
Cocaine	10.0	Nifedipine	10.0
Codeine	10.0	Nifedipine oxidized	10.0
DEET	10.0	Nitrazepam	10.0
Dextromethorphan	10.0	Norfentanyl	10.0
Diazepam	10.0	Norfluoxetine	10.0
Diclofenac	10.0	Norverapamil	10.0
diltiazem	10.0	Omeprazole	10.0
Diphenhydramine	10.0	Oxycodone	10.0
Ecognine Methyl Ester	10.0	Oxymorphone	10.0
Erythromycin	10.0	Paroxetine	10.0
Famotidine	10.0	Pentazocine	10.0
Fenbendazole	10.0	Phencyclidine	10.0

Table C2. Target analytes and U.S. Environmental Protection Agency reporting limits for pharmaceuticals and personal care products, *continued*

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
Phendimetrazine	10.0	Talbutal	25.0
Phenmetrazine	10.0	Temazepam	10.0
Phenobarbital	10.0	Testosterone	10.0
Phentermine	10.0	(+/-)11-nor-9-carboxy-delta-THC	10.0
Phenylpropanolamine	10.0	THC	25.0
Phenytoin	10.0	Thebaine	10.0
Pindolol	10.0	Thiabendazole	10.0
Prazepam	10.0	Tramadol	10.0
Progesterone	10.0	Trazodone	10.0
Propranolol	10.0	Triamterene	10.0
Pseudoephedrine	10.0	Triazolam	10.0
Ranitidine	10.0	Triclocarban	10.0
Secobarbital	10.0	Triclosan	10.0
Sildenafil	10.0	Trimethoprim	10.0
Simvastatin	10.0	Tylosin	10.0
Sotalol	10.0	Venlafaxine	10.0
Sulfamethazine	10.0	Verapamil	10.0
Sulfamethoxazole	10.0	Warfarin	10.0
Sumatriptan	10.0		

Table C3. Target analytes and U.S. Environmental Protection Agency reporting limits for wastewater indicators.

Analyte	Reporting limit (ng/L)	Analyte	Reporting limit (ng/L)
Acetophenone	50.0	Menthol	50.0
Benzophenone	50.0	3-Methyl Indole	50.0
Bisphenol A	50.0	Methyl Salicylate	50.0
Bromacil	50.0	2-Methylnaphthalene	50.0
Butylated Hydroxyanisole	50.0	1-Methylnaphthalene	50.0
Caffeine	50.0	2,6-Dimethylnaphthalene	50.0
Camphor	50.0	Metolachlor	50.0
Carbaryl	50.0	Musk ketone	50.0
Carbazole	50.0	Naphthalene	50.0
Celestolide	50.0	Nonylphenol	50.0
Chlorpyrifos	50.0	4-n-Octylphenol	50.0
p-Cresol	50.0	4-tert-Octylphenol	50.0
4-Cumylphenol	50.0	Pentachlorophenol	50.0
Dacthal	50.0	Phantolide	50.0
Diazinon	50.0	Phenanthrene	50.0
1,4-Dichlorobenzene	50.0	Phenol	50.0
Dichlorvos	50.0	Prometon	50.0
Equilenin	50.0	Pyrene	50.0
17beta-Estradiol	50.0	Tonalide	50.0
Estrone	50.0	Tributyl Phosphate	50.0
Ethinylestradiol	50.0	Triclosan	50.0
Fluoranthene	50.0	Tri(dichloroisopropyl) Phosphate	50.0
Galaxolide	50.0	Triethyl Citrate	50.0
Indole	50.0	Tri(2-butoxyethyl) Phosphate	50.0
Isoborneol	50.0	Tri(2-chloroethyl) Phosphate	50.0
Isophorone	50.0	Triphenyl phosphate	50.0
Isoquinoline	50.0		

Appendix D. Abbreviations, chemical formulas, and symbols used in this report

Term	Definition
ANC	acid neutralizing capacity of solutes plus particulates in an unfiltered water sample
CaCO ₃	chemical formula for calcium carbonate
cfs	cubic feet per second
cfu/100 ml	colony forming units, for bacteria sampling, a measure of the number of viable bacteria per 100 mL
LRL	laboratory reporting level
MDL	method detection level
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter at 25°C, a measure of specific conductance
mg/L	milligrams per liter
Milliequivalents per liter	an expression of the concentration of substances that is chemically equivalent in terms atomic weight and electrical charge
MPN/100 mL	most probable number, for sampling bacteria, a statistical estimation of the number of coliform that would give the results shown by the laboratory examination
N	chemical symbol for the element nitrogen
ng/L	nanograms per liter
NTU	nephelometric turbidity unit, a measure of turbidity
P	chemical symbol for the element phosphorous

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