

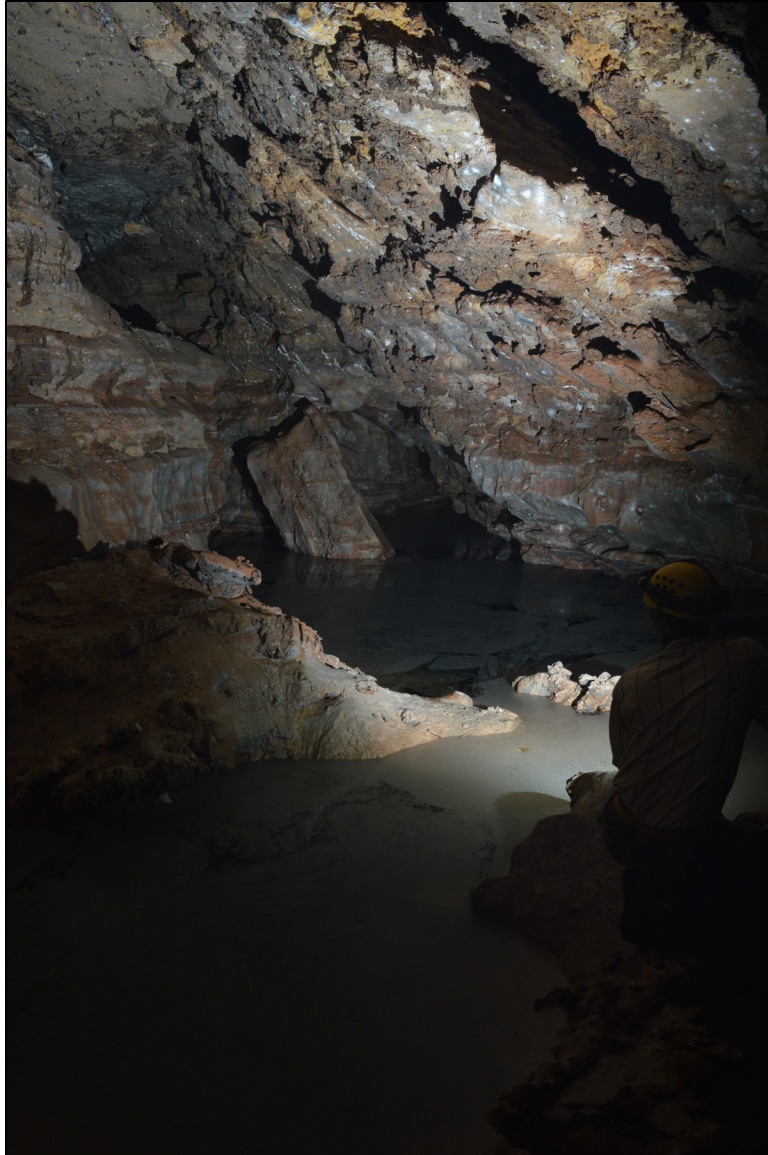


Cave Water Quality Monitoring for Wind Cave National Park

2021 Data Report

Natural Resource Data Series NPS/WICA/NRDS—2022/1374





ON THIS PAGE

Calcite Lake, Wind Cave National Park, March 20, 2013.

Photo by Dan Austin

ON THE COVER

What the Hell Lake, Wind Cave National Park, March 20, 2013.

Photo by Dan Austin

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2021 Data Report

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Contents

	Page
Figures.....	iv
Tables.....	iv
Abstract.....	v
Acknowledgements.....	vi
Introduction.....	1
Methods.....	4
Data Collection.....	4
Results.....	5
Calcite Lake.....	5
What the Hell Lake.....	7
Further Analysis.....	10
Literature Cited.....	11
Appendix A. Data	13

Figures

	Page
Figure 1. Map of Wind Cave NP with mapped cave passages in yellow and approximate location of cave lakes.....	2

Tables

	Page
Table 1. Factors affecting cave water quality within Jewel and Wind Cave and potential measures for vital sign monitoring.....	3
Table 2. Physical Characteristics at Calcite Lake.	5
Table 3. Metals at Calcite Lake.....	6
Table 4. Nutrients at Calcite Lake.....	6
Table 5. Hydrocarbons at Calcite Lake.....	7
Table 6. Physical Characteristics at What the Hell Lake.	7
Table 7. Metals at What the Hell Lake.....	8
Table 8. Nutrients at What the Hell Lake.....	8
Table 9. Hydrocarbons at What the Hell Lake.....	9

Abstract

The Northern Great Plains Inventory and Monitoring Network (NGPN) began monitoring cave water quality in Wind Cave National Park (WICA) in 2021. This report summarizes the first sampling period for grab samples for physical constituents, nutrients, and volatile organic compounds (VOCs). The sampling was conducted at Calcite and What The Hell cave lakes within the Wind Cave system on September 9, 2021. For details, see [DataStore - Project - \(Code: 2259815\) \(nps.gov\)](#).

Acknowledgements

We would like to acknowledge WICA Cave staff including Hollie Lybarger-Pucket and Marc Ohms for collecting all the data contained in this report.

Introduction

The National Park Service (NPS) established the [Inventory & Monitoring Program](#) to facilitate information sharing and natural resource monitoring in national parks. The goal of the program is to gather and analyze information on specific park resources to help parks make sound, science-based decisions. The [Northern Great Plains Inventory and Monitoring Network](#) (NGPN), is comprised of 13 NPS park units across Nebraska, Wyoming, North and South Dakota. Two of these units, [Jewel Cave National Monument](#) (JECA) and [Wind Cave National Park](#) (WICA) protect and preserve large caves in the Black Hills, South Dakota. With more than 200 miles mapped and surveyed, Jewel Cave is recognized as the third longest cave in the world and new passages continue to be discovered (NPS 2022a). Wind Cave contains over 160 miles of mapped passages and is known for its unique boxwork formations (NPS 2022b). Wind Cave is also being actively explored and mapped. Both caves contain important water resources. There are several large groundwater lakes, 1500 drip sites, 200 perched pools, and 3 places of constant running water in Wind Cave (Ohms 2016). Jewel Cave contains over 50 drip sites and small pools (NPS 2000, 2007) and several groundwater lakes have recently been discovered (National Parks Traveler 2017). The cave lakes intersect the Madison Aquifer which underlies eight states and is a vital water resource in the Northern Great Plains area (USGS, 2021).

Wind Cave National Park (WICA) was established in 1903 on the southern edge of the Black Hills of South Dakota approximately 45 miles south of Rapid City in Custer and Fall River counties to protect Wind Cave as a national resource. The park is bounded by Forest Service land to the west, Custer State Park to the north, and private land to the south and east (Ohms 2016). The 33,851 acres of WICA is a mosaic of ponderosa pine forest and mixed-grass prairie. Approximately 1/3 of the land area of Wind Cave is ponderosa pine forest, and the rest grassland or shrubland. Forests provide cover and shelter for wildlife while the grasslands provide abundant food.

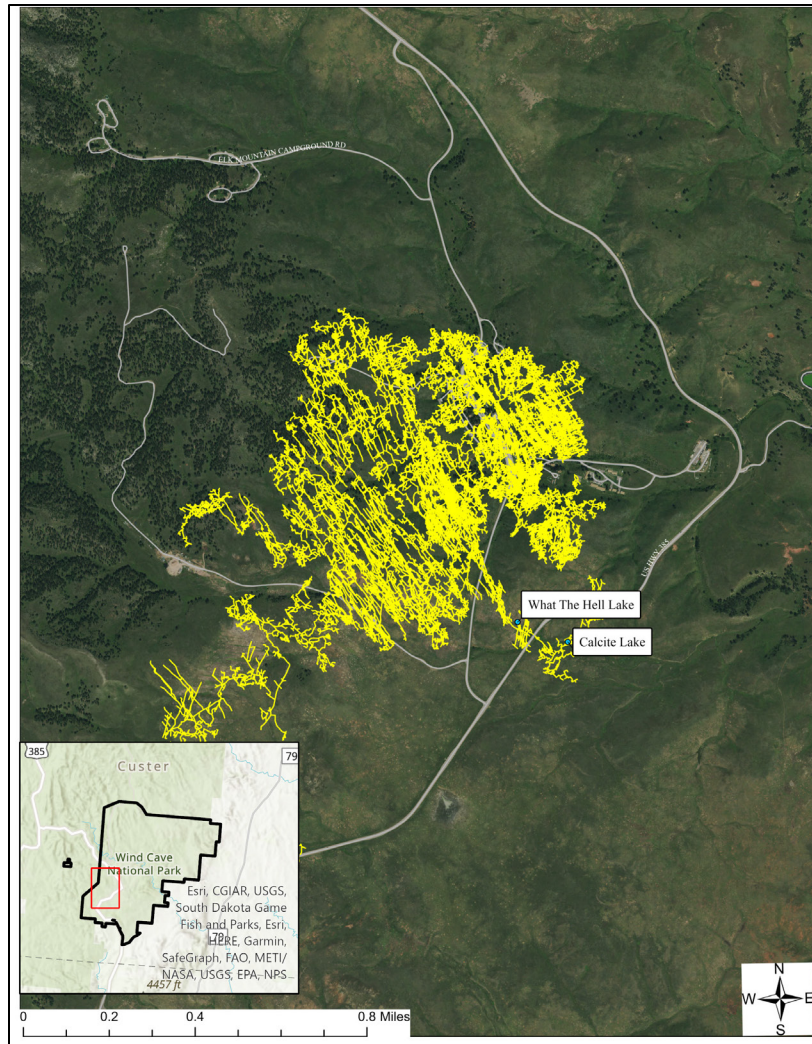


Figure 1. Map of Wind Cave NP with mapped cave passages in yellow and approximate location of cave lakes.

Cave water quality is an important resource for park managers to understand because it is closely connected to surface water inputs (Gitzen et al. 2010). Models and tracer studies suggest that much of the groundwater in Wind and Jewel caves is sourced from local surface recharge (Long and Valder 2011, Ohms 2016). Subsurface water quantity and quality in the caves is a concern due to groundwater depletion and groundwater pollution from pesticides (aboveground applications), hydrocarbons (vehicle use and related activities), and wastewater effluent (sewage systems) (NPS 2007). There is strong evidence that elevated levels of hydrocarbons, sodium, nitrate, and chlorides in the cave drip water is indicative of surface contamination, often from overlying parking lots (Alexander 1986, NPS 2007). Proper monitoring of cave water quality is critical to protecting the resource and preventing it from surface pollution. Factors affecting cave resources are shown in Table 1.

Table 1. Factors affecting cave water quality within Jewel and Wind Cave and potential measures for vital sign monitoring. Measures in bold are included in the protocol and this data report.

Category	Management Issue (s) informed by monitoring	Potential water quality measures
Water Quality	Stormwater runoff or spills from parking areas, roads, and holding tanks can change water quality in caves.	Concentrations of chloride, dissolved salts, specific conductance, and other physical constituents in cave water. Concentrations of hydrocarbons, such as toluene and benzene in cave water.
	Sewer lines from developments in the park (e.g., housing, visitor center) or surroundings can corrode and leach contaminants into the underlying cave.	Concentrations of nutrients, metals, and other organics in cave water. Presence and concentration of <i>E. coli</i> .
	Changes in climate or above ground features (fire regime) can change timing and amount of surface water inputs to the cave.	Change in rate of infiltration and water levels. Potential for increased concentrations of nutrients, metals, and contaminants over time.
	Livestock grazing above the lakes in Jewel Cave can alter water quality.	Concentrations of nutrients and in cave water. Presence and concentration of <i>E.coli</i> .
	Integrated pest and exotic plant management activities, including pesticide and herbicide use, can contaminate cave water.	Concentrations of pesticides, such as glyphosphate, in cave water.

The Northern Great Plains Inventory & Monitoring Network (NGPN) began monitoring water quality at WICA cave lakes to better understand current conditions and changes over time. The monitoring at WICA is conducted at the Calcite Lake and What the Hell Lake. Monitoring at JECA will be conducted at Hourglass Lake and New Year's Lake. The objective is to determine the status and long-term trends of cave water quality parameters. NGPN repeats cave water quality monitoring at WICA and JECA every three years, (Ashton et. al 2019), conducting in-depth analysis of status and trends after 3 to 5 cycles of sampling. This report summarizes data from the first season of cave water quality sampling at Wind Cave in 2021.

Methods

The NGPN Cave Water Quality Monitoring Protocol (Ashton et al. 2019) sets out the methods used for sampling cave lake water quality. The general approach is briefly described below. For more detail, please see Ashton et al. 2019 (available at [DataStore - Project - \(Code: 2259815\) \(nps.gov\)](#)).

Data Collection

In September 2021, Wind Cave staff traveled to Calcite and What the Hell Lakes to collect samples. Duplicate samples were collected at each lake and blanks were taken as well. The means reported here are psuedoreplicates. Samples were taken 15 minutes apart. Samples were refrigerated overnight and taken on ice to Mid Continent Testing Labs, Inc in Rapid City.

Quality assurance and quality control was conducted by MidContinent Staff following established EPA methods [Environmental Sampling and Analytical Methods \(ESAM\) Program | US EPA](#) in an EPA-certified lab. NGPN received the final corrected (approved) data in September 2021 from the lab. Data was stored in excel files and uploaded to IRMA.

Results

The following tables show the results from 2021 sample collection. Historical data from NWIS 2022a and 2022b are included for context. Data are also in Appendix A. The PQL (practical quantification limit) is included to describe the dilution and detection limits used in the lab analysis. Units remain the same as the reporting limit described in the protocol. Windy City and Calcite Lake merged in 1999 and so are comparable to each other (Long et al. 2012).

Calcite Lake

Table 2. Physical Characteristics at Calcite Lake. Windy City Historical data ([USGS 433302103281501 6S 5E12DBAB Water Quality Data](https://www.waterquality.gov/usgs/433302103281501/6S5E12DBAB/WaterQualityData/)) provided for context.

Constituent(s)	Historic data average (Windy City 2007–2015)	NGPN 2021 Calcite Lake Data	MDL-2021	PQL-2021	Reporting level (protocol)	Units
Calcium	35.75 ± 0.04	34.6 ± 0.21	0.07	1	0.022	mg/L
Chloride	4.34 ± 0.08	5.01 ± 0.01	0.186	0.5	0.02	mg/L
Fluoride	–	0.43 ± 0	0.008	0.05	0.01	mg/L
Iron	–	.07 ± 0.01	0.093	0.05	10	µg/L
Magnesium	19.5 ± 0.07	17.85 ± 0.04	0.036	0.5	0.011	mg/L
Manganese	0.56 *	0.02 ± 0	0.06	0.01	0.2	µg/L
pH, laboratory	7.9 ± 0.07	8.28 ± 0.01	–	–	0.1	pH
Potassium	2.28 *	2.35 ± 0	0.04	0.5	0.1	mg/L
Total dissolved solids	192 *	162.5 ± 0.35	13	50	20	mg/L
Silica	13.05 ± 0.60	14 ± 0.21	–	–	0.018	mg/L
Sodium	7.44 ± 0.16	8.25 ± 0	0.02	0.5	0.1	mg/L
Specific conductance	337.67 ± 10.89	354.5 ± 0.35	0.153	5	5	µS/cm
Sulfate	4.34 ± 0.08	11.1 ± 0	0.483	10	0.02	mg/L

* only one sample available, no SE calculated

Table 3. Metals at Calcite Lake. Windy City Historical data ([USGS 433302103281501 6S 5E12DBAB Water Quality Data](https://waterquality.usgs.gov/dataaccess/datacatalog/?dataset=USGS_433302103281501_6S_5E12DBAB)) provided for context.

Constituent(s)	Historic data average (Windy City 2007–2015)	NGPN 2021 Calcite Lake Data	MDL-2021	PQL-2021	Reporting level (protocol)	Units
Arsenic	14.55 ± 1.31	17.3 ± 0.14	0.061	5	0.05	µg/L
Chromium	–	1 ± 0	0.12	1	0.5	µg/L
Copper	–	5 ± 0	0.16	5	0.2	µg/L
Lithium	–	8.45 ± 0.25	–	–	0.15	µg/L
Manganese	0.56 *	15.55 ± 3.92	0.06	10	0.4	µg/L
Strontium	–	287.5 ± 1.06	0.096	5	0.5	µg/L
Uranium, natural	–	4.72 ± 0.01	0.011	1	0.01	µg/L
Vanadium	–	8.62 ± 0.08	0.05	5	0.1	µg/L
Zinc	–	50 ± 0	0.44	50	2	µg/L

* only one sample available, no SE calculated

Nitrate in the Calcite Lake water sample is of interest. Generally in the US, natural ground water is than 2.0 mg/l (Mueller 1995), though water underlying carbonate rock has median values of 2.3 mg/L, higher than average due to great surface connectivity. Values above 3.0 mg/L which have not been approached yet, indicate human activity. Williamson and Carter (2001) found median nitrate values of 0.2 mg/l in the Madison aquifer with a maximum of 2.6 mg/l. Nitrate is elevated at Calcite Lake in comparison to What the Hell Lake (Table 8).

Table 4. Nutrients at Calcite Lake. Windy City Historical data ([USGS 433302103281501 6S 5E12DBAB Water Quality Data](https://waterquality.usgs.gov/dataaccess/datacatalog/?dataset=USGS_433302103281501_6S_5E12DBAB)) provided for context.

Nutrients	Historic data average (Windy City 1987–1988)	Historic data average (Windy City 2007–2015)*	NGPN 2021 Calcite Lake Data	MDL - 2021	PQL - 2021	Reporting level (protocol)	Units
Nitrogen, ammonia	<0.02*	<0.02*	<0.05 ± 0	0.009	0.05	0.01	mg/L
Nitrogen, nitrite	<0.01*	<0.01*	<0.05 ± 0	0.005	0.05	0.001	mg/L
Nitrogen, nitrite + nitrate	1*	1.85*	2.3 ± 0.014	0.039	0.25	0.01	mg/L
TKN	–	–	<0.5 ± 0	0.045	0.5	–	mg/L
Total nitrogen, filtered**	–	–	2.3 ± 0.014	–	–	0.05	mg/L
Total nitrogen, unfiltered	–	–	–	–	–	0.05	mg/L
Phosphorus	–	0.023*	<.01 ± 0	0.004	0.01	0.003	mg/L
Orthophosphorus	–	0.008*	<.01 ± 0	–	–	0.004	mg/L

* only one sample available, no SE calculated

Hydrocarbons in 2021 were not detected in any of the samples and had not been detected in earlier studies.

Table 5. Hydrocarbons at Calcite Lake. Windy City Historical data ([USGS 433302103281501 6S 5E12DBAB Water Quality Data](#)) provided for context.

Hydrocarbons	Historic data average (Windy City 2007–2015)	NGPN 2021 Calcite Lake Data	MDL- 2021	PQL- 2021	Reporting level (protocol)	Units
Benzene	<0.026*	<0.5	0.008	0.5	0.026	µg/L
Ethylbenzene	<0.036*	<0.5	0.012	0.5	0.036	µg/L
m- and p-Xylene	<0.08*	<1	0.039	1	0.08	µg/L
Methyl tert-butyl ether	<0.10*	<1	0.18	1	0.1	µg/L
o-Xylene	<0.032*	<1	0.18	1	0.032	µg/L
Toluene	<0.02*	<0.5	0.006	0.5	0.05	µg/L

* only one sample available, no SE calculated

What the Hell Lake

Table 6. Physical Characteristics at What the Hell Lake. What the Hell Historical data ([USGS 433302103281502 6S 5E12DBAB2 Water Quality Data](#)) provided for context.

Constituent(s)	Historic data average (WTH 2007–2015)	2021 What the Hell Data	MDL- 2021	PQL- 2021	Reporting level (protocol)	Units
Calcium	45.35 ± 1.45	45.6 ± 0.14	0.07	1	0.022	mg/L
Chloride	2.98 ± 0.02	2.78 ± 0.02	0.186	0.5	0.02	mg/L
Fluoride	–	0.28 ± 0	0.008	0.05	0.01	mg/L
Iron	–	<0.05	0.093	0.05	10	µg/L
Magnesium	25.6 ± 1.06	25.2 ± 0	0.036	0.5	0.011	mg/L
Manganese	<0.2 *	<0.01	0.06	0.01	0.2	µg/L
pH, laboratory	7.85 ± 0.04	8.27 ± 0.01	–	–	0.1	pH
Potassium	1.71 *	1.66 ± 0	0.04	0.5	0.1	mg/L
Total dissolved solids	237 *	205 ± 2.12	13	50	20	mg/L
Silica	12.6 ± 0.42	13.5 ± 0.28	–	–	0.018	mg/L
Sodium	4.86 ± 0.16	5.25 ± 0.01	0.02	0.5	0.1	mg/L
Specific conductance	419 ± 5.6	435 ± 1.06	0.153	5	5	µS/cm
Sulfate	7.24 ± 0.23	<10	0.483	10	0.02	mg/L

* only one sample available, no SE calculated

Table 7. Metals at What the Hell Lake. What the Hell Historical data ([USGS 433302103281502 6S 5E12DBAB2 Water Quality Data](#)) provided for context.

Constituent(s)	Historic data average (WTH 2007–2015)	2021 What the Hell Data	MDL 2021	PQL-2021	Reporting level (protocol)	Units
Arsenic	–	11.35 ± 0.04	0.061	5	0.05	µg/L
Chromium	–	<1	0.12	1	0.5	µg/L
Copper	–	<5	0.16	5	0.2	µg/L
Lithium	–	8.3 ± 0.64	–	–	0.15	µg/L
Manganese	–	<10	0.06	10	0.4	µg/L
Strontium	–	264 ± 3.53	0.096	5	0.5	µg/L
Uranium, natural	–	5.05 ± 0.08	0.011	1	0.01	µg/L
Vanadium	–	7.58 ± 0.13	0.05	5	0.1	µg/L
Zinc	–	<50	0.44	50	2	µg/L

* only one sample available, no SE calculated

Table 8. Nutrients at What the Hell Lake. What the Hell Historical data ([USGS 433302103281502 6S 5E12DBAB2 Water Quality Data](#)) provided for context.

Nutrients	Historic data average (WTH 2007–2015)	2021 What the Hell Data	MDL - 2021	PQL-2021	Reporting level (protocol)	Units
Nitrogen, ammonia	<0.01*	<0.05 ± 0	0.009	0.05	0.01	mg/L
nitrogen, nitrite	<0.01*	<0.05 ± 0	0.005	0.05	0.001	mg/L
nitrogen, nitrite + nitrate	1.225*	1.65 ± 0.01	0.039	0.25	0.01	mg/L
TKN	–	<0.5 ± 0	0.045	0.5	–	mg/L
Total nitrogen, filtered**	–	1.65 ± 0.01	–	0.25	0.05	mg/L
Total nitrogen, unfiltered	–	–	–	–	0.05	mg/L
Phosphorus	0.007*	<0.01 ± 0	0.004	0.01	0.003	mg/L
Orthophosphorus	0.022*	<0.01 ± 0	–	0.01	0.004	mg/L

* only one sample available, no SE calculated

Table 9. Hydrocarbons at What the Hell Lake. What the Hell Historical data ([USGS 433302103281502 6S 5E12DBAB2 Water Quality Data](https://www.usgs.gov/data-data-products/6S5E12DBAB2-Water-Quality-Data)) provided for context.

Hydrocarbons	Historic data average (WTH 2007–2015)	2021 What the Hell Data	MDL-2021	PQL-2021	Reporting level (protocol)	Units
Benzene	<0.026*	<0.5	0.008	0.5	0.026	µg/L
Ethylbenzene	<0.036*	<0.5	0.012	0.5	0.036	µg/L
m- and p-Xylene	<0.08*	<1	0.039	1	0.08	µg/L
Methyl tert-butyl ether	<0.1*	<1	0.18	1	0.1	µg/L
o-Xylene	<0.032*	<1	0.18	1	0.032	µg/L
Toluene	<0.02*	<0.5	0.006	0.5	0.05	µg/L

* only one sample available, no SE calculated

Further Analysis

This Data Report is intended to provide a basic review of data collected during the 2021 cave water quality monitoring season at Wind Cave National Park. Data is available from NGPN or [DataStore - Project - \(Code: 2259815\) \(nps.gov\)](#).

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Appendix A. Data

Site: Calcite

Table A-1. Physical Properties.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Electrical Conductivity	355	µmhos/cm	1	0.153	5.00	SM 2510B	JAM	09/13/21
pH	8.26	S.U.	1	–	–	SM 4500-H+ B	JAM	09/13/21
Total Dissolved Solids	163	mg/L	100ml	13.0	50.0	SM 2540 C	JNG	09/13/21

Table A-2. Non-Metallics.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Chloride (Cl-)	5.02	mg/L	1	0.186	0.500	SM 4500-Cl E	BLL	09/13/21
Fluoride	0.427	mg/L	1	0.008	0.050	SM 4500 F-C	TMN	09/13/21
Nitrogen, Ammonia (NH3)	<0.050	mg/L	1	0.009	0.050	SM 4500-NH3 D	JAM	09/14/21
Nitrogen, Nitrite (NO2)	<0.050	mg/L	1	0.005	0.050	SM 4500-NO2 B	BLL	09/10/21
Nitrate + Nitrite	2.28	mg/L	5	0.039	0.250	SM 4500-NO3F	BLL	09/10/21
Phosphorus (P) Total	0.010	mg/L	1	0.004	0.010	SM 4500-P E	SAA	09/16/21
Phosphorus, Ortho	<0.010	mg/L	1	–	–	SM 4500-P E	SAA	09/16/21
Nitrogen, Kjeldahl (Soluble TKN)	<0.500	mg/L	1	–	–	EPA 351.2	GRT	09/21/21
Sulfate (SO4)	11.1	mg/L	1	0.483	10.0	SM 4500-SO4 E	BLL	09/13/21
Nitrogen, Kjeldahl (TKN)	<0.500	mg/L	1	0.045	0.500	EPA 351.2	GRT	09/21/21
Total Nitrogen	2.28	mg/L	1	–	–	SM 4500-N	RAM	09/22/21

Table A-3. Metals – Dissolved.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Calcium (Ca)	34.9	mg/L	1	0.070	1.00	SM 3111 B	GRT	09/13/21
Magnesium (Mg)	17.9	mg/L	1	0.036	0.500	SM 3111 B	GRT	09/13/21
Potassium (K)	2.36	mg/L	1	0.040	0.500	SM 3111 B	GRT	09/13/21
Sodium (Na)	8.26	mg/L	1	0.020	0.500	SM 3111 B	GRT	09/13/21

Table A-4. Metals - Total.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Arsenic (As)	0.018	mg/L	10	0.00061	0.005	EPA 200.8	TNA	09/13/21
Chromium (Cr)	<0.001	mg/L	10	0.00012	0.001	EPA 200.8 DRC	TNA	09/13/21
Copper (Cu)	<0.005	mg/L	10	0.00016	0.005	EPA 200.8	TNA	09/13/21
Iron (Fe)	0.089	mg/L	10	0.00093	0.050	EPA 200.8	TNA	09/13/21
Lithium (Li)	0.009	mg/L	10	–	–	EPA 200.8	TNA	09/13/21
Manganese (Mn)	0.021	mg/L	10	0.00006	0.010	EPA 200.8	TNA	09/13/21
Silicon as Silica (SiO ₂)	14.3	mg/L	1	–	–	Calculation	RAM	09/17/21
Silicon (Si)	6.67	mg/L	1	–	–	SM 3111 D	GRT	09/15/21
Strontium (Sr)	0.289	mg/L	10	0.000096	0.005	EPA 200.8	TNA	09/13/21

Table A-5. Metals - Total.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Uranium (U)	0.005	mg/L	10	0.000011	0.001	EPA 200.8	TNA	9/13/21
Vanadium (V)	0.009	mg/L	10	0.00005	0.005	EPA 200.8	TNA	9/13/21
Zinc (Zn)	<0.050	mg/L	10	0.00044	0.050	EPA 200.8	TNA	9/13/21

Table A-6. Volatile.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Benzene	<0.500	µg/L	1	0.008	0.500	SW846 8260B	RAM	09/16/21
Ethylbenzene	<0.500	µg/L	1	0.012	0.500	SW846 8260B	RAM	09/16/21
Methyl tertiary-Butyl Ether	<1.00	µg/L	1	0.180	1.00	SW846 8260B	RAM	09/16/21
Toluene	<0.500	µg/L	1	0.006	0.500	SW846 8260B	RAM	09/16/21
Xylenes(o,m,p)	<1.00	µg/L	1	0.039	1.00	SW846 8260B	RAM	09/16/21

Quality Control Data**Table A-7.** Total Metals - Internal Std.

Parameter	Result	Limits	DF	Method	Analyst	Date
Bismuth (Bi)	91.2%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Germanium (Ge72)	91.3%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Germanium (Ge74)	89.2%	(60.0–125.0) %	10	EPA 200.8 DRC	TNA	09/13/21
Indium (In)	91.3%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Lithium (Li)	88.7%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Scandium (Sc)	91.1%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21

Table A-8. Surrogate Recovery-Volatile.

Parameter	Result	Limits	DF	Method	Analyst	Date
4-Bromofluorobenzene	104.5%	(74.34)–(136.5)	1	SW846 8260B QC	RAM	09/16/21
Dibromofluoromethane	96.1%	(87.17)–(112.6)	1	SW846 8260B QC	RAM	09/16/21
1,2-Dichloroethane-d4	102.9%	(74.70)–(119.5)	1	SW846 8260B QC	RAM	09/16/21
Toluene-d8	101.9%	(83.43)–(127.6)	1	SW846 8260B QC	RAM	09/16/21

Site: Calcite Rep

Table A-9. Physical Properties.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Electrical Conductivity	354	µmhos/cm	1	0.153	5.00	SM 2510B	JAM	09/13/21
pH	8.30	S.U.	1	–	–	SM 4500-H+ B	JAM	09/13/21
Total Dissolved Solids	162	mg/L	100ml	13.0	50.0	SM 2540 C	JNG	09/13/21

Table A-10. Non-Metallics.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Chloride (Cl-)	4.99	mg/L	1	0.186	0.500	SM 4500-Cl E	BLL	09/13/21
Fluoride	0.432	mg/L	1	0.008	0.050	SM 4500 F-C	TMN	09/13/21
Nitrogen, Ammonia (NH3)	<0.050	mg/L	1	0.009	0.050	SM 4500-NH3 D	JAM	09/14/21
Nitrogen, Nitrite (NO2)	<0.050	mg/L	1	0.005	0.050	SM 4500-NO2 B	BLL	09/10/21
Nitrate + Nitrite	2.32	mg/L	5	0.039	0.250	SM 4500-NO3F	BLL	09/10/21
Phosphorus (P) Total	0.010	mg/L	1	0.004	0.010	SM 4500-P E	SAA	09/16/21
Phosphorus, Ortho	<0.010	mg/L	1	–	–	SM 4500-P E	SAA	09/16/21
Nitrogen, Kjeldahl (Soluble TKN)	<0.500	mg/L	1	–	–	EPA 351.2	GRT	09/21/21
Sulfate (SO4)	11.1	mg/L	1	0.483	10.0	SM 4500-SO4 E	BLL	09/13/21
Nitrogen, Kjeldahl (TKN)	<0.500	mg/L	1	0.045	0.500	EPA 351.2	GRT	09/21/21
Total Nitrogen	2.32	mg/L	1	–	–	SM 4500-N	RAM	09/22/21

Table A-11. Metals - Dissolved.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Calcium (Ca)	34.3	mg/L	1	0.070	1.00	SM 3111 B	GRT	09/13/21
Magnesium (Mg)	17.8	mg/L	1	0.036	0.500	SM 3111 B	GRT	09/13/21
Potassium (K)	2.35	mg/L	1	0.040	0.500	SM 3111 B	GRT	09/13/21
Sodium (Na)	8.25	mg/L	1	0.020	0.500	SM 3111 B	GRT	09/13/21

Table A-12. Metals - Total.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Arsenic (As)	0.017	mg/L	10	0.00061	0.005	EPA 200.8	TNA	09/13/21
Chromium (Cr)	<0.001	mg/L	10	0.00012	0.001	EPA 200.8 DRC	TNA	09/13/21
Copper (Cu)	<0.005	mg/L	10	0.00016	0.005	EPA 200.8	TNA	09/13/21
Iron (Fe)	<0.050	mg/L	10	0.00093	0.050	EPA 200.8	TNA	09/13/21
Lithium (Li)	0.008	mg/L	10	–	–	EPA 200.8	TNA	09/13/21
Manganese (Mn)	<0.010	mg/L	10	0.00006	0.010	EPA 200.8	TNA	09/13/21
Silicon as Silica (SiO ₂)	13.7	mg/L	1	–	–	Calculation	RAM	09/17/21
Silicon (Si)	6.40	mg/L	1	–	–	SM 3111 D	GRT	09/15/21
Strontium (Sr)	0.286	mg/L	10	0.000096	0.005	EPA 200.8	TNA	09/13/21

Table A-13. Metals - Total.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Uranium (U)	0.005	mg/L	10	0.000011	0.001	EPA 200.8	TNA	09/13/21
Vanadium (V)	0.009	mg/L	10	0.00005	0.005	EPA 200.8	TNA	09/13/21
Zinc (Zn)	<0.050	mg/L	10	0.00044	0.050	EPA 200.8	TNA	09/13/21

Table A-14. Volatile.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Benzene	<0.500	µg/L	1	0.008	0.500	SW846 8260B	RAM	09/16/21
Ethylbenzene	<0.500	µg/L	1	0.012	0.500	SW846 8260B	RAM	09/16/21
Methyl tertiary-Butyl Ether	<1.00	µg/L	1	0.180	1.00	SW846 8260B	RAM	09/16/21
Toluene	<0.500	µg/L	1	0.006	0.500	SW846 8260B	RAM	09/16/21
Xylenes(o,m,p)	<1.00	µg/L	1	0.039	1.00	SW846 8260B	RAM	09/16/21

Quality Control Data**Table A-15.** Total Metals - Internal Std.

Parameter	Result	Limits	DF	Method	Analyst	Date
Bismuth (Bi)	91.2%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Germanium (Ge72)	91.5%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Germanium (Ge74)	89.2%	(60.0–125.0) %	10	EPA 200.8 DRC	TNA	09/13/21
Indium (In)	89.8%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Lithium (Li)	88.5%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Scandium (Sc)	90.1%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21

Table A-16. Surrogate Recovery-Volatile.

Parameter	Result	Limits	DF	Method	Analyst	Date
4-Bromofluorobenzene	103.1%	(74.34)–(136.5)	1	SW846 8260B QC	RAM	09/16/21
Dibromofluoromethane	97.3%	(87.17)–(112.6)	1	SW846 8260B QC	RAM	09/16/21
1,2-Dichloroethane-d4	91.3%	(74.70)–(119.5)	1	SW846 8260B QC	RAM	09/16/21
Toluene-d8	108.9%	(83.43)–(127.6)	1	SW846 8260B QC	RAM	09/16/21

Site: What the Hell

Table A-17. Physical Properties.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Electrical Conductivity	437	µmhos/cm	1	0.153	5.00	SM 2510B	JAM	09/13/21
pH	8.29	S.U.	1	–	–	SM 4500-H+ B	JAM	09/13/21
Total Dissolved Solids	208	mg/L	100ml	13.0	50.0	SM 2540 C	JNG	09/13/21

Table A-18. Non-Metallics.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Chloride (Cl-)	2.75	mg/L	1	0.186	0.500	SM 4500-Cl E	BLL	09/13/21
Fluoride	0.287	mg/L	1	0.008	0.050	SM 4500 F-C	TMN	09/13/21
Nitrogen, Ammonia (NH3)	<0.050	mg/L	1	0.009	0.050	SM 4500-NH3 D	JAM	09/14/21
Nitrogen, Nitrite (NO2)	<0.050	mg/L	1	0.005	0.050	SM 4500-NO2 B	BLL	09/10/21
Nitrate + Nitrite	1.18	mg/L	1	0.008	0.050	SM 4500-NO3F	BLL	09/10/21
Phosphorus (P) Total	<0.010	mg/L	1	0.004	0.010	SM 4500-P E	SAA	09/16/21
Phosphorus, Ortho	<0.010	mg/L	1	–	–	SM 4500-P E	SAA	09/16/21
Nitrogen, Kjeldahl (Soluble TKN)	<0.500	mg/L	1	–	–	EPA 351.2	GRT	09/21/21
Sulfate (SO4)	<10.0	mg/L	1	0.483	10.0	SM 4500-SO4 E	BLL	09/13/21
Nitrogen, Kjeldahl (TKN)	<0.500	mg/L	1	0.045	0.500	EPA 351.2	GRT	09/21/21
Total Nitrogen	1.18	mg/L	1	–	–	SM 4500-N	RAM	09/22/21

Table A-19. Metals - Dissolved.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Calcium (Ca)	45.8	mg/L	1	0.070	1.00	SM 3111 B	GRT	09/13/21
Magnesium (Mg)	25.2	mg/L	1	0.036	0.500	SM 3111 B	GRT	09/13/21
Potassium (K)	1.66	mg/L	1	0.040	0.500	SM 3111 B	GRT	09/13/21
Sodium (Na)	5.27	mg/L	1	0.020	0.500	SM 3111 B	GRT	09/13/21

Table A-20. Metals - Total.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Arsenic (As)	0.011	mg/L	10	0.00061	0.005	EPA 200.8	TNA	09/13/21
Chromium (Cr)	<0.001	mg/L	10	0.00012	0.001	EPA 200.8 DRC	TNA	09/13/21
Copper (Cu)	<0.005	mg/L	10	0.00016	0.005	EPA 200.8	TNA	09/13/21
Iron (Fe)	<0.050	mg/L	10	0.00093	0.050	EPA 200.8	TNA	09/13/21
Lithium (Li)	0.007	mg/L	10	–	–	EPA 200.8	TNA	09/13/21
Manganese (Mn)	<0.010	mg/L	10	0.00006	0.010	EPA 200.8	TNA	09/13/21
Silicon as Silica (SiO ₂)	13.1	mg/L	1	–	–	Calculation	RAM	09/17/21
Silicon (Si)	6.12	mg/L	1	–	–	SM 3111 D	GRT	09/15/21
Strontium (Sr)	0.259	mg/L	10	0.000096	0.005	EPA 200.8	TNA	09/13/21

Table A-21. Metals - Total.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Uranium (U)	0.005	mg/L	10	0.000011	0.001	EPA 200.8	TNA	09/13/21
Vanadium (V)	0.007	mg/L	10	0.00005	0.005	EPA 200.8	TNA	09/13/21
Zinc (Zn)	<0.050	mg/L	10	0.00044	0.050	EPA 200.8	TNA	09/13/21

Table A-22. Volatile.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Benzene	<0.500	µg/L	1	0.008	0.500	SW846 8260B	RAM	09/16/21
Ethylbenzene	<0.500	µg/L	1	0.012	0.500	SW846 8260B	RAM	09/16/21
Methyl tertiary-Butyl Ether	<1.00	µg/L	1	0.180	1.00	SW846 8260B	RAM	09/16/21
Toluene	<0.500	µg/L	1	0.006	0.500	SW846 8260B	RAM	09/16/21
Xylenes(o,m,p)	<1.00	µg/L	1	0.039	1.00	SW846 8260B	RAM	09/16/21

Quality Control Data**Table A-23.** Total Metals - Internal Std.

Parameter	Result	Limits	DF	Method	Analyst	Date
Bismuth (Bi)	90.2%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Germanium (Ge72)	90.6%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Germanium (Ge74)	88.9%	(60.0–125.0) %	10	EPA 200.8 DRC	TNA	09/13/21
Indium (In)	89.9%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Lithium (Li)	88.6%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Scandium (Sc)	89.9%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21

Table A-24. Surrogate Recovery-Volatile.

Parameter	Result	Limits	DF	Method	Analyst	Date
4-Bromofluorobenzene	104.4%	(74.34)–(136.5)	1	SW846 8260B QC	RAM	09/16/21
Dibromofluoromethane	103.0%	(87.17)–(112.6)	1	SW846 8260B QC	RAM	09/16/21
1,2-Dichloroethane-d4	92.7%	(74.70)–(119.5)	1	SW846 8260B QC	RAM	09/16/21
Toluene-d8	112.7%	(83.43)–(127.6)	1	SW846 8260B QC	RAM	09/16/21

Site: What the Hell Rep

Table A-25. Physical Properties.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Electrical Conductivity	434	µmhos/cm	1	0.153	5.00	SM 2510B	JAM	09/13/21
pH	8.25	S.U.	1	–	–	SM 4500-H+ B	JAM	09/13/21
Total Dissolved Solids	202	mg/L	100ml	13.0	50.0	SM 2540 C	JNG	09/13/21

Table A-26. Non-Metallics.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Chloride (Cl-)	2.81	mg/L	1	0.186	0.500	SM 4500-Cl E	BLL	09/13/21
Fluoride	0.282	mg/L	1	0.008	0.050	SM 4500 F-C	TMN	09/13/21
Nitrogen, Ammonia (NH3)	<0.050	mg/L	1	0.009	0.05	SM 4500-NH3	JA	09/14/21
Nitrogen, Nitrite (NO2)	<0.050	mg/L	1	0.005	0.050	SM 4500-NO2 B	BLL	09/10/21
Nitrate + Nitrite	1.15	mg/L	1	0.008	0.050	SM 4500-NO3F	BLL	09/10/21
Phosphorus (P) Total	<0.010	mg/L	1	0.004	0.010	SM 4500-P E	SAA	09/16/21
Phosphorus, Ortho	<0.010	mg/L	1	–	–	SM 4500-P E	SAA	09/16/21
Nitrogen, Kjeldahl (Soluble TKN)	<0.500	mg/L	1	–	–	EPA 351.2	GRT	09/21/21
Sulfate (SO4)	<10.0	mg/L	1	0.483	10.0	SM 4500-SO4 E	BLL	09/13/21
Nitrogen, Kjeldahl (TKN)	<0.500	mg/L	1	0.045	0.500	EPA 351.2	GRT	09/21/21
Total Nitrogen	1.15	mg/L	1	–	–	SM 4500-N	RAM	09/22/21

Table A-27. Metals - Dissolved.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Calcium (Ca)	45.4	mg/L	1	0.070	1.00	SM 3111 B	GRT	09/13/21
Magnesium (Mg)	25.2	mg/L	1	0.036	0.500	SM 3111 B	GRT	09/13/21
Potassium (K)	1.67	mg/L	1	0.040	0.500	SM 3111 B	GRT	09/13/21
Sodium (Na)	5.23	mg/L	1	0.020	0.500	SM 3111 B	GRT	09/13/21

Table A-28. Metals - Total.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Arsenic (As)	0.011	mg/L	10	0.00061	0.005	EPA 200.8	TNA	09/13/21
Chromium (Cr)	<0.001	mg/L	10	0.00012	0.001	EPA 200.8 DRC	TNA	09/13/21
Copper (Cu)	<0.005	mg/L	10	0.00016	0.005	EPA 200.8	TNA	09/13/21
Iron (Fe)	<0.050	mg/L	10	0.00093	0.050	EPA 200.8	TNA	09/13/21
Lithium (Li)	0.009	mg/L	10	–	–	EPA 200.8	TNA	09/13/21
Manganese (Mn)	<0.010	mg/L	10	0.00006	0.010	EPA 200.8	TNA	09/13/21
Silicon as Silica (SiO ₂)	13.9	mg/L	1	–	–	Calculation	RAM	09/17/21
Silicon (Si)	6.48	mg/L	1	–	–	SM 3111 D	GRT	09/15/21
Strontium (Sr)	0.269	mg/L	10	0.000096	0.005	EPA 200.8	TNA	09/13/21

Table A-29. Metals - Total.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Uranium (U)	0.005	mg/L	10	0.000011	0.001	EPA 200.8	TNA	09/13/21
Vanadium (V)	0.008	mg/L	10	0.00005	0.005	EPA 200.8	TNA	09/13/21
Zinc (Zn)	<0.050	mg/L	10	0.00044	0.050	EPA 200.8	TNA	09/13/21

Table A-30. Volatile.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Benzene	<0.500	µg/L	1	0.008	0.500	SW846 8260B	RAM	09/16/21
Ethylbenzene	<0.500	µg/L	1	0.012	0.500	SW846 8260B	RAM	09/16/21
Methyl tertiary-Butyl Ether	<1.00	µg/L	1	0.180	1.00	SW846 8260B	RAM	09/16/21
Toluene	<0.500	µg/L	1	0.006	0.500	SW846 8260B	RAM	09/16/21
Xylenes(o,m,p)	<1.00	µg/L	1	0.039	1.00	SW846 8260B	RAM	09/16/21

Quality Control Data**Table A-31.** Total Metals - Internal Std.

Parameter	Result	Limits	DF	Method	Analyst	Date
Bismuth (Bi)	88.7%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Germanium (Ge72)	90.2%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Germanium (Ge74)	88.2%	(60.0–125.0) %	10	EPA 200.8 DRC	TNA	09/13/21
Indium (In)	89.4%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Lithium (Li)	87.4%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Scandium (Sc)	90.4%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21

Table A-32. Surrogate Recovery-Volatile.

Parameter	Result	Limits	DF	Method	Analyst	Date
4-Bromofluorobenzene	97.5%	(74.34)–(136.5)	1	SW846 8260B QC	RAM	09/16/21
Dibromofluoromethane	103.7%	(87.17)–(112.6)	1	SW846 8260B QC	RAM	09/16/21
1,2-Dichloroethane-d4	94.7%	(74.70)–(119.5)	1	SW846 8260B QC	RAM	09/16/21
Toluene-d8	104.4%	(83.43)–(127.6)	1	SW846 8260B QC	RAM	09/16/21

Site: Calcite Blank

Table A-33. Physical Properties.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Electrical Conductivity	<5.00	µmhos/cm	1	0.153	5.00	SM 2510B	JAM	09/13/21
pH	5.77	S.U.	1	–	–	SM 4500-H+ B	JAM	09/13/21
Total Dissolved Solids	<5.0	mg/L	1	1.0	5.0	MC-1041	JAM	09/13/21

Table A-34. Non-Metallics.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Chloride (Cl-)	<0.500	mg/L	1	0.186	0.500	SM 4500-Cl E	BLL	09/13/21
Fluoride	<0.050	mg/L	1	0.008	0.050	SM 4500 F-C	TMN	09/13/21
Nitrogen, Ammonia (NH3)	<0.050	mg/L	1	0.009	0.050	SM 4500-NH3 D	JAM	09/14/21
Nitrogen, Nitrite (NO2)	<0.050	mg/L	1	0.005	0.050	SM 4500-NO2 B	BLL	09/10/21
Nitrate + Nitrite	<0.050	mg/L	1	0.008	0.050	SM 4500-NO3F	BLL	09/10/21
Phosphorus (P) Total	0.012	mg/L	1	0.004	0.010	SM 4500-P E	SAA	09/16/21
Phosphorus, Ortho	<0.010	mg/L	1	–	–	SM 4500-P E	SAA	09/16/21
Nitrogen, Kjeldahl (Soluble TKN)	<0.500	mg/L	1	–	–	EPA 351.2	GRT	09/21/21
Sulfate (SO4)	<10.0	mg/L	1	0.483	10.0	SM 4500-SO4 E	BLL	09/13/21
Nitrogen, Kjeldahl (TKN)	<0.500	mg/L	1	0.045	0.500	EPA 351.2	GRT	09/21/21
Total Nitrogen	<0.500	mg/L	1	–	–	SM 4500-N	RAM	09/22/21

Table A-35. Metals - Dissolved.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Calcium (Ca)	<1.00	mg/L	1	0.070	1.00	SM 3111 B	GRT	09/13/21
Magnesium (Mg)	<0.500	mg/L	1	0.036	0.500	SM 3111 B	GRT	09/13/21
Potassium (K)	<0.500	mg/L	1	0.040	0.500	SM 3111 B	GRT	09/13/21
Sodium (Na)	<0.500	mg/L	1	0.020	0.500	SM 3111 B	GRT	09/13/21

Table A-36. Metals - Total.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Arsenic (As)	<0.005	mg/L	10	0.00061	0.005	EPA 200.8	TNA	09/13/21
Chromium (Cr)	<0.001	mg/L	10	0.00012	0.001	EPA 200.8 DRC	TNA	09/13/21
Copper (Cu)	<0.005	mg/L	10	0.00016	0.005	EPA 200.8	TNA	09/13/21
Iron (Fe)	<0.050	mg/L	10	0.00093	0.050	EPA 200.8	TNA	09/13/21
Lithium (Li)	<0.005	mg/L	10	–	–	EPA 200.8	TNA	09/13/21
Manganese (Mn)	<0.010	mg/L	10	0.00006	0.010	EPA 200.8	TNA	09/13/21
Silicon as Silica (SiO ₂)	<2.14	mg/L	1	–	–	Calculation	RAM	09/17/21
Silicon (Si)	<1.00	mg/L	1	–	–	SM 3111 D	GRT	09/15/21
Strontium (Sr)	<0.001	mg/L	10	0.000096	0.005	EPA 200.8	TNA	09/13/21

Table A-37. Metals - Total.

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Uranium (U)	<0.001	mg/L	10	0.000011	0.001	EPA 200.8	TNA	09/13/21
Vanadium (V)	<0.005	mg/L	10	0.00005	0.005	EPA 200.8	TNA	09/13/21
Zinc (Zn)	<0.050	mg/L	10	0.00044	0.050	EPA 200.8	TNA	09/13/21

Quality Control Data

Table A-38. Total Metals - Internal Std.

Parameter	Result	Limits	DF	Method	Analyst	Date
Bismuth (Bi)	90.9%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Germanium (Ge72)	89.4%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Germanium (Ge74)	88.0%	(60.0–125.0) %	10	EPA 200.8 DRC	TNA	09/13/21
Indium (In)	89.2%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Lithium (Li)	86.6%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21
Scandium (Sc)	87.5%	(60.0–125.0) %	10	EPA 200.8	TNA	09/13/21

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

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National Park Service
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