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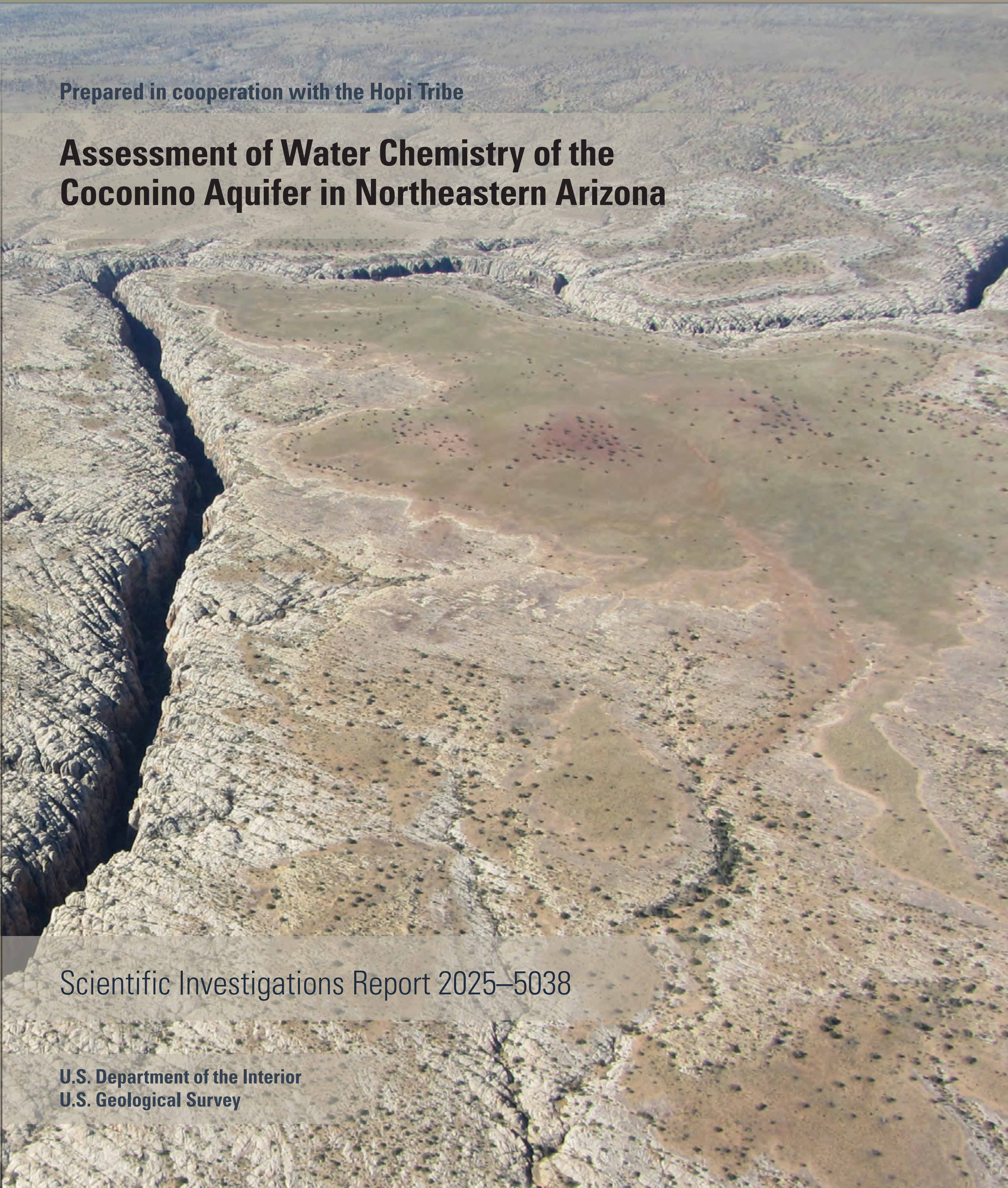
Assessment of Water Chemistry of the Coconino Aquifer in Northeastern Arizona



Scientific Investigations Report 2025–5038

U.S. Department of the Interior
U.S. Geological Survey

Cover. Chevelon Canyon, about 7 miles upstream from the confluence of Chevelon Creek and the Little Colorado River, Arizona. Coconino sandstone is exposed. Photograph by Jon Mason, U.S. Geological Survey, June 27, 2020.

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U.S. Geological Survey, Reston, Virginia: 2025

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Contents

Figures

Tables

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	28.32	cubic decimeter (dm^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Flow rate	
foot per year (ft/yr)	0.3048	meter per year (m/yr)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic decimeter (dm^3)	0.03531	cubic foot (ft^3)
cubic meter (m^3)	35.31	cubic foot (ft^3)
	Flow rate	
meter per year (m/yr)	3.281	foot per year ft/yr)
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
millimeter per year (mm/yr)	0.03937	inch per year (in/yr)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C = (°F – 32) / 1.8.

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F = (1.8 × °C) + 32.

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given in either milligrams per liter (mg/L) or micrograms per liter (µg/L).

Abbreviations

EPA	U.S. Environmental Protection Agency
MCL	maximum contaminant level
NWIS	U.S. Geological Survey National Water Information System
PCA	principal component analysis
SMCL	secondary maximum contaminant level
TDS	total dissolved solids
USGS	U.S. Geological Survey

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By Casey J.R. Jones

Abstract

The Coconino aquifer was investigated as a potential groundwater resource for the Hopi Tribe and Navajo Nation in northeastern Arizona. Basic groundwater chemistry, including major ions, total dissolved solids, and selected trace metal concentrations, are presented and analyzed to characterize the Coconino aquifer. The geochemical compositions of groundwater are associated with changes in geology and groundwater movement and are compared to drinking-water standards to determine suitable areas for potential groundwater resource development. Dissolved-solids concentrations in much of the Coconino aquifer water were higher than the U.S. Environmental Protection Agency's secondary drinking-water standard of 500 milligrams per liter (mg/L) due to a buried halite body in the southeastern part of the study area. However, trace metal concentrations were generally low. Groundwater may need to be treated for high dissolved-solids concentrations before it is suitable for use as a resource for the Hopi Tribe and Navajo Nation.

Introduction

The Coconino aquifer is a multiple-aquifer system that extends throughout northeastern Arizona, northwestern New Mexico, southwestern Colorado, and southeastern Utah (fig. 1). In northern Arizona, the Coconino aquifer underlies most of the Navajo Nation and the entirety of the Hopi Reservation. Despite its substantial area, wells drilled into the Coconino aquifer are most common in the southern and eastern extent of the aquifer. The Coconino aquifer is deeply buried elsewhere, likely buried to depths greater than 3,000 feet (ft) in some areas to the north. Total dissolved solids (TDS) concentrations are likely high in the Coconino aquifer water [greater than 2,000 milligrams per liter (mg/L)] in much of these areas (Bills and others, 2007). Shallower, more accessible aquifers overlie the Coconino aquifer in this region, including the Navajo aquifer, the primary water source for the Hopi Tribe and the southwestern Navajo Nation (Mason, 2021). Sustainable water resources for the Hopi Tribe and Navajo Nation are limited due to their location in an arid to semi-arid desert environment with minimal precipitation and groundwater recharge. However, as groundwater demand increases to keep up with population growth, the Coconino aquifer has the potential to serve as a source of water for a larger portion of the Hopi Tribe and Navajo Nation. Increased water production from the regional Coconino aquifer has the potential to provide greater water security to both Tribes.

This report focuses on groundwater chemistry of the Coconino aquifer between Flagstaff, Arizona, and the area just east of Holbrook, Arizona, and from south of the Little Colorado River to the southern end of the Hopi Reservation (fig. 1). Coconino aquifer water users in the study area include the southwestern part of the Navajo Nation and the cities of Flagstaff, Winslow, and Holbrook (including their surrounding communities; Hart and others, 2002). Although previous studies and production from existing wells have shown that the Coconino aquifer can produce large quantities of water (for example, Mann, 1976), less has been done to examine the suitability of the water quality for development throughout the region. Water chemistry is extremely variable in this area, partially due to high dissolved solids from evaporite deposits near the base of the Coconino aquifer in the southeastern part of the study area (Cooley and others, 1969; Mann, 1976). The U.S. Environmental Protection Agency (EPA) has established non-mandatory secondary drinking-water standards of 500 mg/L for TDS. Above this level, water may taste bad and (or) cause staining and corrosion. However, potable drinking water generally has TDS concentrations of less than 3,000 mg/L (U.S. Environmental Protection Agency, 1987; Stanton and others, 2017). The EPA formally defined potential underground sources of drinking water as having a TDS concentration less than 10,000 mg/L (U.S. Environmental Protection Agency, 1987). Although TDS concentrations in some groundwater in the study area far exceed the EPA secondary maximum contaminant level (SMCL) of 500 mg/L, other areas show substantially lower dissolved-solids concentrations (Hoffmann and others, 2006; Bills and others, 2007).

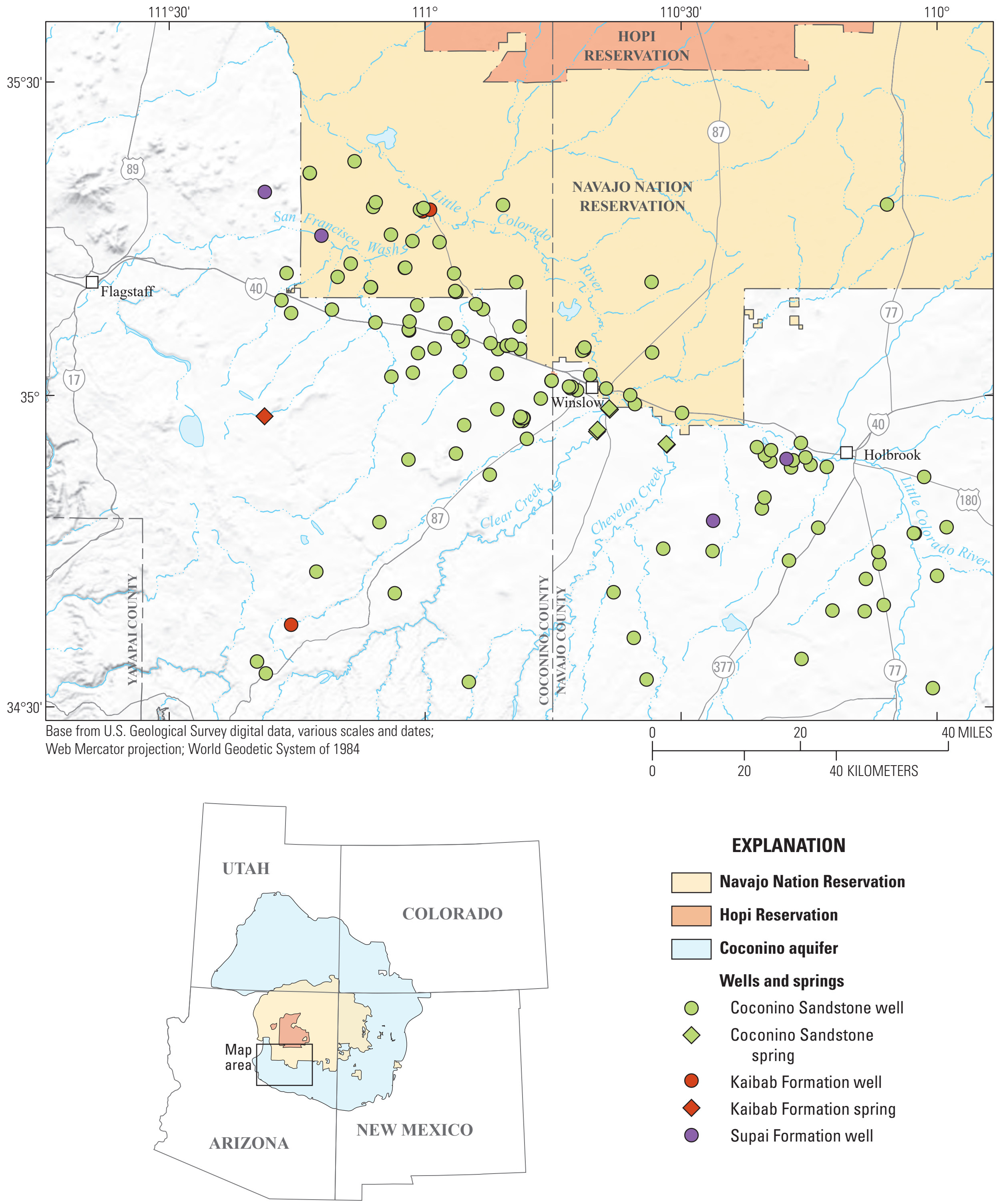

Figure 1. Approximate extent of the Coconino aquifer, boundaries of the Hopi Reservation and Navajo Nation, and the locations of the Coconino aquifer groundwater sites included in this study, northeastern Arizona. Figure is modified from Robson and Banta (1995).

Besides TDS, other constituents, such as major cations and anions (calcium, magnesium, sodium, potassium, sulfate, chloride, and bicarbonate) and trace metals (arsenic, uranium, barium, lead, copper, and fluoride, among others), influence the suitability of groundwater for development. The U.S. Geological Survey (USGS), in cooperation with the Hopi Tribe, led this study to describe the basic groundwater chemistry of the Coconino aquifer. This effort provides information to identify potential areas for groundwater resource development.

Purpose and Scope

The purpose of this report is to describe the basic groundwater chemistry of the Coconino aquifer along the Interstate-40 corridor between Flagstaff, Ariz., and the area just east of Holbrook, Arizona. Specifically, major ion, trace metal, and TDS concentrations are presented and analyzed to identify differing groundwater chemistry in association with changes in geology and groundwater movement, and to compare groundwater chemistry to drinking-water standards to determine suitable areas for potential groundwater-resource development.

Previous Investigations

The hydrogeology and chemistry of the Coconino aquifer in the study area have been described in several previous studies. Darton (1910) compiled some of the first geologic data from the area between Kingman, Arizona, and Albuquerque, New Mexico, to explore groundwater prospects for the Atchison, Topeka, and Santa Fe Railway. Gregory (1916) described the geography, climate, surface water, and groundwater of the Navajo Nation and Hopi Reservations; the hydrogeology in this area was later expanded on by Cooley and others (1969). Harrell and Eckel (1939) presented a comprehensive groundwater study of the Holbrook area, including chemical analyses from 118 wells and springs. Bills and Flynn (2002) and Bills and others (2007) summarized the hydrogeology of the Coconino Plateau. Hart and others (2002) compiled existing Coconino aquifer data from the Little Colorado River Basin to produce a generalized groundwater budget. Hoffmann and others (2006) presented geological, hydrological, and chemical data from the Coconino aquifer near Leupp, Arizona, and Jones and Robinson (2021) presented groundwater levels and basic chemistry of the Coconino aquifer in northeastern Arizona.

Evaporites in the study area also have been explored. Bahr (1962) described evaporite karst features on the Holbrook Anticline. Mann (1976) characterized Coconino aquifer water in southern Navajo County and produced an early delineation of the extent of salt beds. Neal and others (1998, 2013) and Rauzi (2000) described evaporite karst in the Holbrook sedimentary basin. Neal and Colpitts (1997) and Neal and Johnson (2002) described specific Holbrook Basin karst expressions (Richard Lake and McCauley Sinks, respectively).

Description of Study Area

The study area is within the Little Colorado River Basin in the southern part of the Colorado Plateau, specifically between Flagstaff, Arizona, and the area just east of Holbrook, Arizona, and from south of the Little Colorado River to the southern end of the Hopi Reservation (Fenneman and Johnson, 1946; fig. 1). Most of the topography is developed on nearly horizontal sedimentary rocks around 5,000 ft in elevation (Hart and others, 2002). The primary surface feature is the Little Colorado River, which parallels Interstate-40 and discharges into the Colorado River northwest of the study area. The Little Colorado River, along with its tributaries, flows through incised canyons in the Coconino Sandstone. Other local topographic relief is provided by folds and solution-collapse features. More detail will be provided on the solution-collapse features in the “Geology” section of this report.

The climate in the study area is classified as arid to semi-arid (Bills and others, 2007). Average annual precipitation near Winslow was less than 8 inches (in.) from 1991 to 2020 (PRISM Climate Group, 2022). The months with the highest amount of rainfall, July–September, coincide with the North American monsoon (Adams and Comrie, 1997). Mean monthly temperature values from 1991 to 2020 near Winslow were highest in July and August at more than 75 degrees Fahrenheit, with the lowest temperatures in December and January at around 35 degrees Fahrenheit (PRISM Climate Group, 2022).

Geology

The Coconino aquifer is named after the primary water-bearing rock unit within the aquifer, the Coconino Sandstone, but the saturated and hydraulically connected parts of the Kaibab Formation, the Toroweap Formation, the Schnebly Hill Formation, and the upper and middle part of the Supai Formation also constitute part of the Coconino aquifer in the study area (fig. 2; Bills and others, 2000; Bills and Flynn, 2002; Hart and others, 2002; Bills and others, 2007).

The Supai Formation ranges in age from Pennsylvanian to Permian and consists of red siltstone and sandstone (Irwin and others, 1971; Blakey, 1990). Divided into three parts, only the upper and middle parts of the Supai Formation are hydraulically connected to the Coconino aquifer; the lower part of the Supai Formation acts as a confining layer for underlying groundwater in the Redwall-Muav aquifer (Bills and others, 2000).

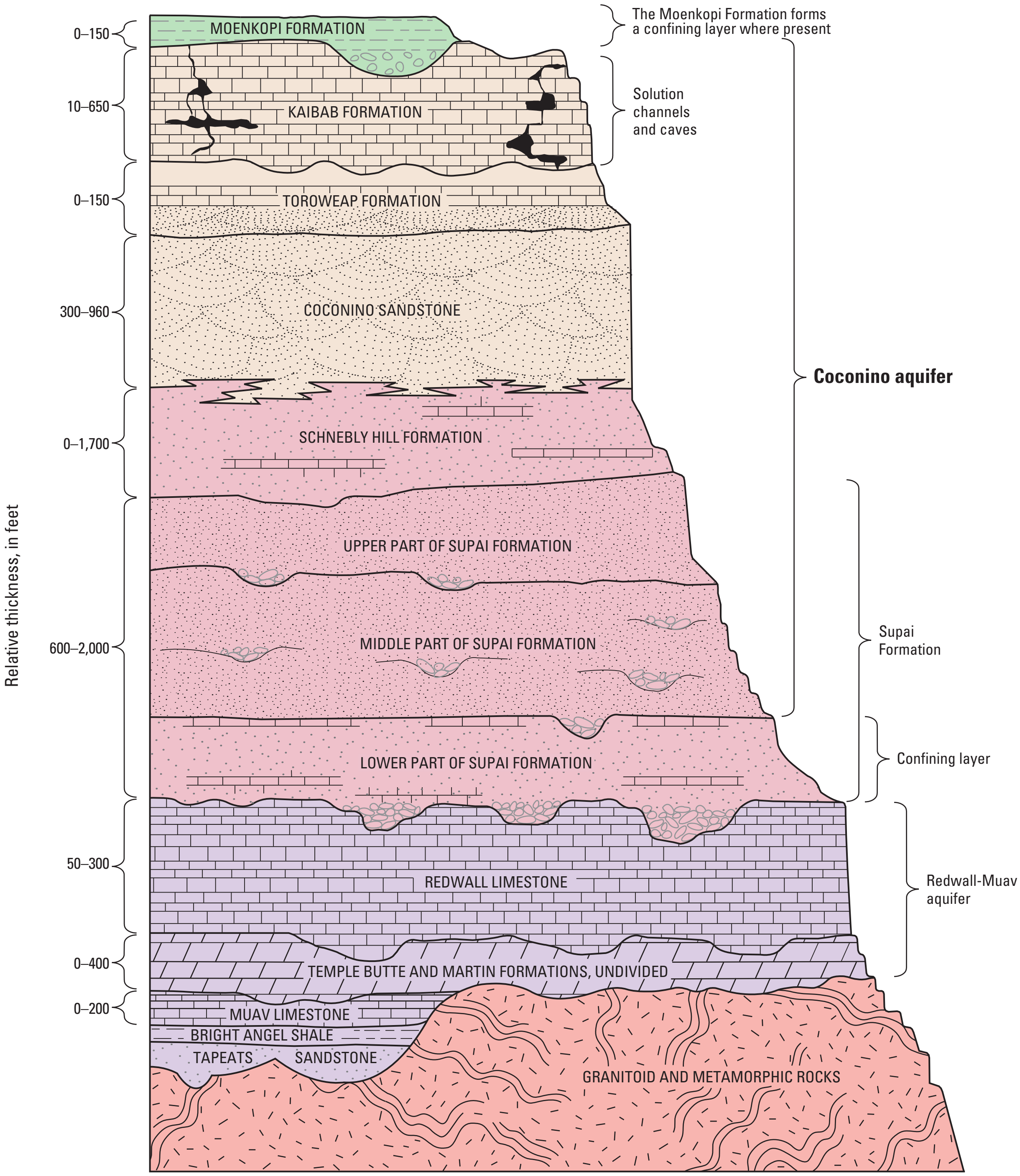

Figure 2. Generalized stratigraphic section of rock units in the study area and surrounding areas, northeastern Arizona. Modified from Bills and others (2007, fig. 11). Muav Limestone and Bright Angel Shale refer to the Muav Limestone and Bright Angel Shale of the Tonto Group. Thickness ranges for the Tapeats Sandstone and Bright Angel Shale are not noted due to lack of data in the study area.

The Hermit Formation overlies the Supai Formation in some areas of northern Arizona. Consisting of red-brown siltstone and sandstone, the Hermit Formation is lithologically similar to the Supai Formation. In much of the study area, the boundary becomes unclear and the Hermit and Supai Formations are indistinguishable. For this reason, the Hermit Formation is usually omitted from stratigraphic columns in this area (Irwin and others, 1971; Blakey, 1990; Bills and others, 2000).

The Permian Schnebly Hill Formation is an important Coconino-aquifer component in the Holbrook Basin, with a thickness as much as 1,700 ft (fig. 2; Blakey, 1990; Bills and others, 2000). The Schnebly Hill Formation is reddish brown to reddish orange and comprises sandstone, mudstone, limestone, and evaporites (Blakey, 1990). East of Holbrook, the Corduroy Member of the Schnebly Hill Formation contains halite and other evaporites of early Permian age as much as 650 ft thick (Blakey, 1990; Conway and Cook, 2013). When present, the Schnebly Hill Formation intertongues with the overlying Coconino Sandstone (Bills and others, 2000; Hoffmann and others, 2006).

The Permian Coconino Sandstone is typically the main water-bearing unit of the aquifer (Hart and others, 2002). The Coconino Sandstone is a tan to white, crossbedded, quartz sandstone of eolian origin (Darton, 1910; Blakey, 1990). In Leupp, geologic logs indicate thicknesses from 300 to 960 ft (Hoffmann and others, 2006). Near Winslow, Coconino Sandstone thickness is about 800 ft (Mann, 1976).

The Permian Toroweap Formation is only known to be present in the western part of the study area. Bills and others (2000; p. 26) describe the formation as beds of “carbonate sandstone, red beds, silty sandstone, siltstone, limestone, and thin layers of gypsum.” The formation is often indistinguishable from Coconino Sandstone, but according to Sorauf and Billingsley (1991), a distinction between the Toroweap Formation and the white, quartz sandstone of the Coconino Sandstone can be observed near Flagstaff to the west of the study area; where indistinct, the Toroweap Formation is often considered to be part of the Coconino Sandstone (Bills and others, 2000).

The Permian Kaibab Formation is often expressed as a light-gray limestone from 10 to 650 ft thick. Sinkholes and depressions formed by dissolution are present on the surface, as well as fractures formed by jointing and faulting in the subsurface (Irwin and others, 1971; Bills and others, 2000).

In parts of the study area where the Coconino aquifer is not exposed, the red to reddish-brown Triassic Moenkopi Formation overlies the aquifer (Mann, 1976). Consisting largely of mudstone and siltstone, the Moenkopi Formation acts as a confining layer when not heavily fractured. In some areas, the Moenkopi Formation can supply small amounts of water to wells (Cooley and others, 1969; Bills and others, 2000). North of the study area, the shallower Navajo, Dakota, and Toreva aquifers are present and often used for water supply (Mason, 2021).

Evaporites

Beds of halite underlie about 3,500 mi^2 in the southeastern part of the study area, with a maximum thickness near the center of an aggregate of 655 ft of salt in 1,500 ft of Schnebly Hill Formation strata (fig. 3). Close to the depositional center of the halite, a zone of potash covers about 600 mi^2. The potash, consisting of sylvite, carnallite, and polyhalite, is nearly 40 ft thick and overlies the halite (Rauzi, 2000). To the south and southeast, halite transitions into gypsum and anhydrite and extends farther than the halite (Rauzi, 2000, pl. 2).

Dissolution of evaporite beds by the movement of Coconino aquifer groundwater has led to numerous solution-collapse features in the study area. Solution-collapse features in evaporite rocks are developed similarly to those in limestone, but the time scale is shorter. Evaporites such as halite and gypsum can form karst features in a matter of days to years due to their high solubility. Evaporite karst features form near the outer edges of a salt deposit (Johnson, 1997). In the study area, the dissolution front is currently migrating to the northeast, and karst features are forming in real time (Bahr, 1962; Johnson, 1997; Neal and others, 1998).

The Holbrook Anticline is present near the southwestern extent of halite, and the axis can be mapped at the surface for more than 60 miles (mi; fig. 3). The northern flank follows a regional dip of about 2 degrees. On the southern side, the regional dip is interrupted and the average dip is about 15 degrees, although some dips can be steeper. Numerous karst sinks are present on the southern flank (Bahr, 1962). More than 500 sinkholes, joints, compression ridges, and other solution-collapse features have been identified along the Holbrook Anticline and the parallel Dry Lake Syncline to the immediate southwest (Mann, 1976; Conway and Cook, 2013). The Holbrook Anticline is not expressed below the salt layer, which may suggest that dissolution is a factor of its formation (Neal and others, 1998).

Just west of the Holbrook Anticline, near the western limits of evaporites of the Schnebly Hill Formation, McCauley Sinks provide a conspicuous karst surface expression (fig. 4). McCauley Sinks include about 50 sinkholes up to 50 meters (m) deep and 100 m in diameter. They appear in three semi-circular “rings” within a 3-kilometer (km) wide depression (Neal and Johnson, 2002). Along with several other, smaller depressions west of the Holbrook Anticline, these structures are related to the dissolution front of the halite and appear similar to breccia pipes on the Colorado Plateau (Neal and Johnson, 2002). However, where these other breccia pipes originate in the Mississippian Redwall Limestone and (or) the Cambrian Muav Limestone of the Tonto Group, the McCauley Sinks and Richard Lake likely originate due to collapse following salt dissolution in the Schnebly Hill Formation. Similar to other karst features in the area, pressure ridges following the general trend of the Holbrook Anticline are present near both structures (Neal and Johnson, 2002). To the southeast of the study location is an area known as “The Sinks,” which includes more than 250 sinkholes, joint fissures, and other collapse features also related to halite dissolution (Neal and others, 1998).

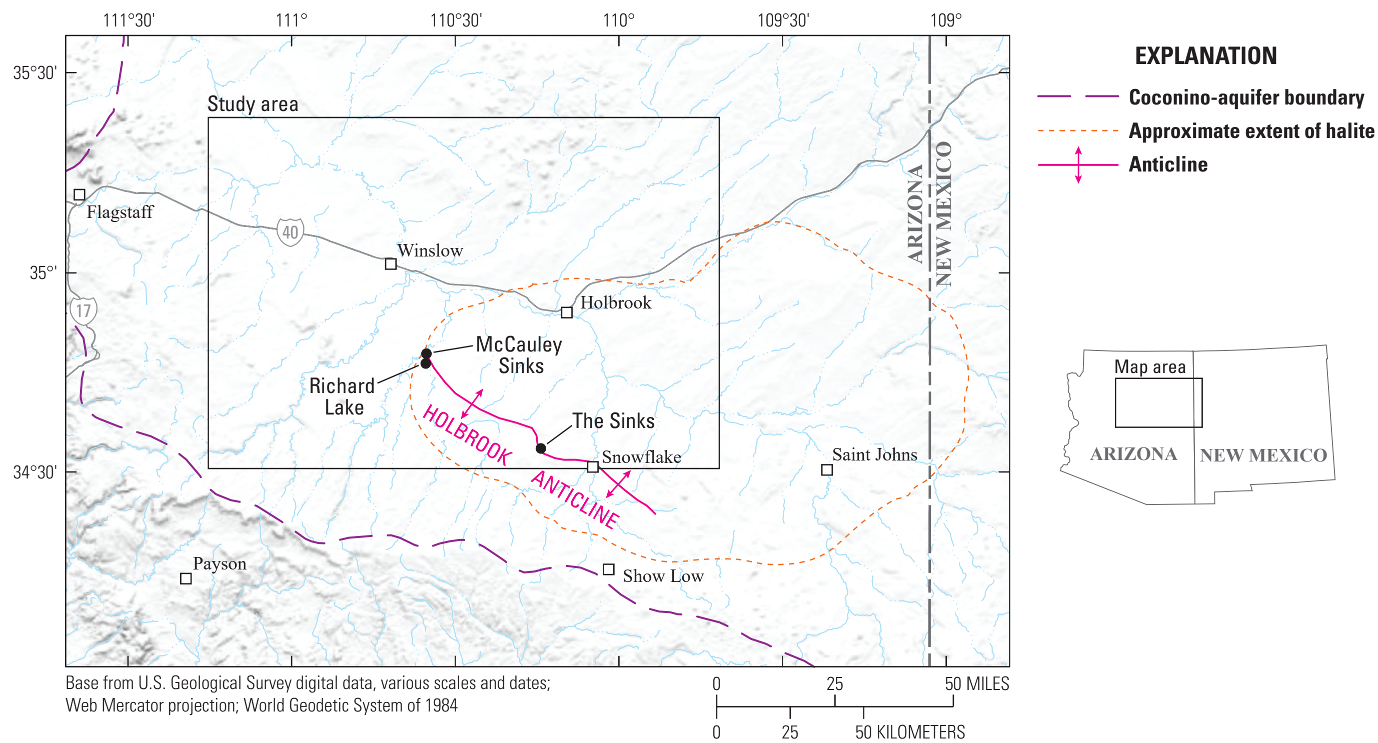

Figure 3. Approximate extent of halite, the Holbrook Anticline, and three surface solution-collapse features—McCauley Sinks, Richard Lake, and an area referred to as "The Sinks," in northeastern Arizona. Halite extent is from the U.S. Geological Survey (USGS) National Map (https://www.usgs.gov/programs/national-geospatial-program/national-map).

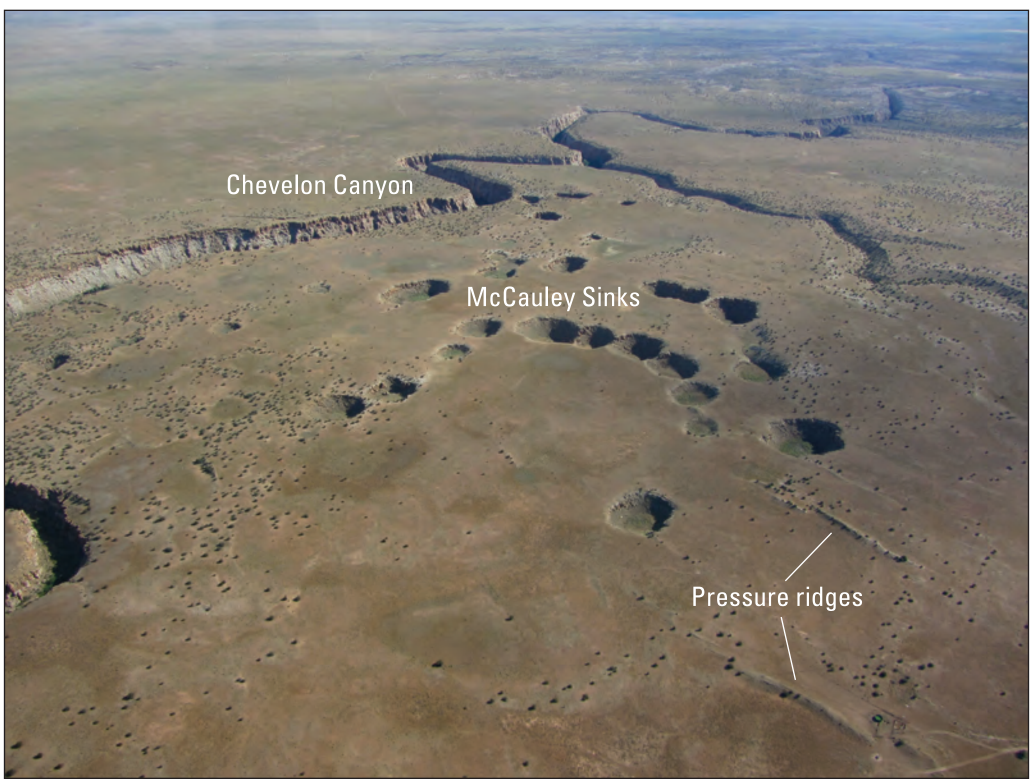

Figure 4. McCauley Sinks as seen looking north. Chevelon Canyon is in the background of the photograph. Pressure ridges are present in the foreground of the photograph. Photograph by Jon Mason, U.S. Geological Survey, June 27, 2020.

Groundwater Movement

Groundwater in the Coconino aquifer generally moves northward, parallel to the regional dip of the strata (Mann, 1976; Hart and others, 2002). Most recharge occurs as snowmelt near the Mogollon Rim to the south; rain events are often flashy and contribute to runoff (Mann, 1976). The Coconino aquifer is unconfined in most of the study area. To the north, the Moenkopi Formation creates confined conditions. The age of groundwater in the Coconino aquifer around Flagstaff in the eastern part of the study area has been estimated as modern to about 7,000 years (Bills and others, 2000).

Well yields from Coconino aquifer wells inventoried by previous studies varied substantially in the study area, from a few gallons per minute to about 2,800 gallons per minute (Mann, 1976; Bills and others, 2000; Hoffmann and others, 2006). Although several factors affect well yields, including pump design and formation lithology, Bills and others (2000) suggested that the greatest effect on Coconino aquifer well efficiency probably is due to proximity to faults and fractures.

Jones and Robinson (2021) discussed wells monitored as part of the USGS C-Aquifer Monitoring Program between Flagstaff and Holbrook, Arizona. They found that measured groundwater levels fluctuate seasonally, and suggested that infiltration from surface water from summer monsoon events and spring snowmelt have the potential to influence wells, as does higher rates of pumping in the summer months. Although some monitored wells have shown little change in groundwater levels (for example, USGS site number 351023111062002, near Leupp), others have shown decreasing water-level trends (for example, USGS site number 345023110111401, south of Holbrook, has decreased about 11 ft from 1969 to 2018; Jones and Robinson, 2021; U.S. Geological Survey, 2023).

Approach and Methods

This report assesses the distribution of major ions, trace metals, and total dissolved solids in the Coconino aquifer. Data used in this report were limited to water-chemistry results from well and spring samples available in the USGS National Water Information System (NWIS) database (U.S. Geological Survey, 2023). No new samples were collected as part of this study. Results within this report provide a representation of the groundwater resource in the Coconino aquifer area in relation to potential potable water based on major-ion chemistry, TDS, and selected trace elements.

Data Compilation

The USGS NWIS database was queried to find existing groundwater sites (wells and springs) that had water-chemistry data associated with them. Those groundwater sites with wells screened-in or springs discharging from the Coconino aquifer and having major ion and (or) TDS data were selected for inclusion in this study.

A total of 130 sites with samples dating from 1933 to 2008 were identified (fig. 1; table 1; U.S. Geological Survey, 2023). These sites were generally in proximity to the Little Colorado River and Interstate-40. Few wells are drilled into the Coconino aquifer in Hopi Tribal Lands or Navajo Nation north of Interstate-40. Some wells may be screened in multiple formations, and it is not always clear which unit(s) the well is producing from. The aquifer coded in NWIS is considered to be the producing unit for this study.

Most wells used (118) were screened in the Coconino Sandstone (fig. 1). Additionally, four of the spring sites discharge from the Coconino Sandstone where it is exposed in canyon walls along Clear and Chevelon Creeks. Three wells and one spring are sourced by the Kaibab Formation in the western part of the study area. Four wells are screened in the Supai Formation. No wells or springs sourced from the Hermit, Toroweap, or Schnebly Hill Formations were present in NWIS in the study area.

Numerous study sites have been sampled multiple times. When computing the median values from all sites for the parameters of pH, specific conductance, and total dissolved solids, the most recent values from each site were used. In three cases, the date when the most recent sample was collected had two samples collected; in those cases, the average value of the two samples was used in the statistical analysis. Additionally, there were 23 samples with estimated results for TDS that were used in the statistical analysis. When computing the water type for sites with multiple samples the most recent sample collected containing all the constituents necessary to compute water type was used.

Table 1. Well and spring locations and selected construction data for Coconino aquifer groundwater sites included in this study, northeastern Arizona (U.S. Geological Survey, 2023).

[ft, feet; bls, below land surface; N/A, not applicable; --, information not available]

USGS site number	USGS station name	Site type	Geologic formation well is completed in (or spring discharges from)	Well depth (ft bls)
342526110155501	A-18-20 30CCD	Well	Coconino Sandstone	145
343149110002701	A-13-22 10CCA	Well	Coconino Sandstone	260
343225110545001	A-13-13 01DDB2	Well	Coconino Sandstone	997
343239110340001	A-13-17 05CAA	Well	Coconino Sandstone	843
343314111183801	A-14-10 32DBD	Well	Coconino Sandstone	600
343423111194001	A-14-10 30ACA	Well	Coconino Sandstone	1,050
343438110155001	A-14-20 30CAA	Well	Coconino Sandstone	400
343640110353001	A-14-17 18BBB	Well	Coconino Sandstone	800
343756111154001	A-14-10 02ACB	Well	Kaibab Formation	420
343914110082601	A-15-21 32ACB	Well	Coconino Sandstone	430
343918110121301	A-15-21 36BCB	Well	Coconino Sandstone	340
343950110061201	A-15-21 27DBD	Well	Coconino Sandstone	816
344058111033101	A-15-12 15DDC	Well	Coconino Sandstone	780
344104110375201	A-15-16 15DDC	Well	Coconino Sandstone	900
344221110081801	A-15-21 08DDC	Well	Coconino Sandstone	400
344239109595701	A-15-22 10DBA	Well	Coconino Sandstone	300
344303111124301	A-15-11 05BDC	Well	Coconino Sandstone	800
344349110064201	A-15-21 03BAC1	Well	Coconino Sandstone	715
344407110171801	A-16-19 36CCB1	Well	Coconino Sandstone	800
344457110065001	A-16-21 27CCD	Well	Coconino Sandstone	635
344502110261601	A-16-18 28DCB	Well	Coconino Sandstone	750
344516110320301	A-16-17 27BCA	Well	Coconino Sandstone	815
344644110023301	A-16-22 17CDC	Well	Coconino Sandstone	160
344644110024201	A-16-22 17CCD	Well	Coconino Sandstone	450
344720109585001	A-16-22 14ADB	Well	Coconino Sandstone	309
344720110135201	A-16-20 16BAC	Well	Coconino Sandstone	450
344749111051901	A-16-12 09BBB	Well	Coconino Sandstone	1,000
344757110261201	A-16-18 09ACD1	Well	Supai Formation	620
344908110202901	A-16-19 04BBC	Well	Coconino Sandstone	328
345011110201101	A-17-19 28CCB	Well	Coconino Sandstone	280
345212110012901	A-17-22 17DDB	Well	Coconino Sandstone	240
345223110522301	A-17-14 17ADD	Well	Coconino Sandstone	600
345308110125301	A-17-20 10CAA3	Well	Coconino Sandstone	110
345316110170910	A-17-19 12CBD	Well	Coconino Sandstone	475
345320110144710	A-17-20 08BDB	Well	Coconino Sandstone	200
345340110193001	A-17-19 04DDC	Well	Coconino Sandstone	550
345344110165101	A-17-19 01CDA	Well	Coconino Sandstone	470
345345110175201	A-17-19 02DBC	Well	Supai Formation	495
345350111015501	A-18-12H35DAD	Well	Coconino Sandstone	680
345410110153201	A-17-20 06DBA	Well	Coconino Sandstone	325
345415110200801	A-17-19 04BDB	Well	Coconino Sandstone	430

Table 1. Well and spring locations and selected construction data for Coconino aquifer groundwater sites included in this study, northeastern Arizona (U.S. Geological Survey, 2023).—Continued

[ft, feet; bls, below land surface; N/A, not applicable; --, information not available]

USGS site number	USGS station name	Site type	Geologic formation well is completed in (or spring discharges from)	Well depth (ft bls)
345425110562101	A-17-13 02BBA	Well	Coconino Sandstone	600
345444110192501	A-18-19 33DAD2	Well	Coconino Sandstone	410
345500110210301	A-18-19 32BDD	Well	Coconino Sandstone	500
345519110314201	A-18-17 34ABB	Spring	Coconino Sandstone	N/A
345548110480201	A-18-15 30BCC	Well	Coconino Sandstone	560
345653110394001	A-18-16 20AAD	Spring	Coconino Sandstone	N/A
345707110552001	A-18-13 13CCD	Well	Coconino Sandstone	475
345730110483001	A-18-14 13ACC	Well	Coconino Sandstone	1,000
345730110485001	A-18-14 13BDC	Well	Coconino Sandstone	900
345746110483701	A-18-14 13BAD	Well	Coconino Sandstone	1,100
345750110482501	A-18-14 13ABD2	Well	Coconino Sandstone	620
345750110482701	A-18-14 13ABD1	Well	Coconino Sandstone	315
345750110482801	A-18-14 13ABD3	Well	Coconino Sandstone	293
345757110484301	A-18-14 13BAA	Well	Coconino Sandstone	700
345800111184701	A-18-10 02CCB	Spring	Kaibab Formation	N/A
345821110295101	A-18-17 12CBA	Well	Coconino Sandstone	330
345840110513001	A-18-14 09AAC	Well	Coconino Sandstone	450
345859110381801	A-18-16 10CBC2	Spring	Coconino Sandstone	N/A
345906110383301	A-18-16 10CAC	Spring	Coconino Sandstone	N/A
345910110352001	A-18-17 06CBB2	Well	Coconino Sandstone	106
345942110462401	A-18-15 05ABB	Well	Coconino Sandstone	350
350002110355501	A-19-16 36DDB [Winslow I-40 Well]	Well	Coconino Sandstone	610
350030110420901	A-19-15 36ABA	Well	Coconino Sandstone	400
350040110384401	A-19-16 28DDD	Well	Coconino Sandstone	150
350042110425601	A-19-15 26DDA	Well	Coconino Sandstone	227
350050110424801	A-19-15 25CBC	Well	Coconino Sandstone	303
350051110430001	A-19-15 26DAC	Well	Coconino Sandstone	120
350124110450901	A-19-15 28AAC	Well	Coconino Sandstone	400
350125110450801	A-19-15 28AAB	Well	Coconino Sandstone	220
350150111040001	A-19-12H15CBB	Well	Coconino Sandstone	760
350158110403601	A-19-16 20BCD	Well	Coconino Sandstone	198
350205110513301	A-19-14 21ACA	Well	Coconino Sandstone	220
350210110560001	A-19-13 23ABB	Well	Coconino Sandstone	450
350210111011001	A-19-12H13BAD	Well	Coconino Sandstone	690
350400111004001	A-19-13 07BBB	Well	Coconino Sandstone	570
350407110332101	A-19-17 05DDD	Well	Coconino Sandstone	680
350414110412201	A-19-16 06CAD	Well	Coconino Sandstone	282
350417110413301	A-19-16 06CDB	Well	Coconino Sandstone	195
350420110590001	A-19-13 05DAB	Well	Coconino Sandstone	570
350427110512501	A-19-14 04DAB	Well	Coconino Sandstone	410

Table 1. Well and spring locations and selected construction data for Coconino aquifer groundwater sites included in this study, northeastern Arizona (U.S. Geological Survey, 2023).—Continued

[ft, feet; bls, below land surface; N/A, not applicable; --, information not available]

USGS site number	USGS station name	Site type	Geologic formation well is completed in (or spring discharges from)	Well depth (ft bls)
350428110484901	A-19-14 01CAB	Well	Coconino Sandstone	270
350440110411801	A-19-16 06ACC	Well	Coconino Sandstone	185
350446110502501	A-19-14 03AAC2	Well	Coconino Sandstone	650
350447110502301	A-19-14 03AAC1	Well	Coconino Sandstone	800
350450110522001	A-19-14 04BBB	Well	Coconino Sandstone	600
350451110494901	A-19-14 02BAC	Well	Coconino Sandstone	727
350518110554801	A-20-13 35DDA	Well	Coconino Sandstone	400
350538110560401	A-20-13 35BDA	Well	Coconino Sandstone	400
350600111015001	A-20-12H24CBB	Well	Coconino Sandstone	640
350618111015601	A-20-12H23ADD	Well	Coconino Sandstone	650
350637110485401	A-20-14 25B UNSURV	Well	Coconino Sandstone	320
350653110573801	A-20-13 22CCB	Well	Coconino Sandstone	350
350700111054001	A-20-12 14CAC	Well	Coconino Sandstone	650
350706111014701	A-20-12H13CBB [Sunshine Well]	Well	Coconino Sandstone	1,155
350756111154001	A-20-11 07ADD	Well	Coconino Sandstone	950
350810111105001	A-20-11 12BAA	Well	Coconino Sandstone	3,628
350816110531001	A-20-14 17B UNSURV	Well	Coconino Sandstone	250
350839111005301	A-20-12H01DDA	Well	Coconino Sandstone	650
350845110540101	A-20-14 07C UNSURV	Well	Coconino Sandstone	200
350909111165401	A-20-10S01AAA	Well	Coconino Sandstone	935
350957110562601	05 144-10.76X05.75 [PW-3]	Well	Coconino Sandstone	1,096
350958110562201	05 144-10.67X05.72(1)	Well	Coconino Sandstone	1,180
351001110562601	05 144-10.79X05.73	Well	Coconino Sandstone	426
351022111061801	05 145-05.92x05.31 [OW-1]	Well	Coconino Sandstone	--
351023111062002	05 145-05.96X05.28 (2) [PW-1A]	Well	Coconino Sandstone	--
351052110491701	05 144-04.07X04.75	Well	Coconino Sandstone	440
351053110332501	05 143-03.22X04.73	Well	Coconino Sandstone	907
351122111101301	05 145-09.63X04.20	Well	Coconino Sandstone	717
351142110563401	05 144-10.91X03.80	Well	Coconino Sandstone	253
351144111161201	A-21-11 19BCB	Well	Coconino Sandstone	935
351214111022101	05 145-02.25X03.18 [OW-2B]	Well	Coconino Sandstone	1,069
351215111021701	05 145-02.17X03.15	Well	Coconino Sandstone	388
351238111084101	05 145-08.18X02.71	Well	Coconino Sandstone	717
351442110581601	05 144-12.50X00.37	Well	Coconino Sandstone	425
351448111012701	05 145-01.37X00.22	Well	Coconino Sandstone	570
351519111120701	05 132-11.42X16.88	Well	Supai Formation	1,161
351525111035801	05 132-03.74X16.74	Well	Coconino Sandstone	635
351739111001501	05 132-00.32X14.24	Well	Kaibab Formation	425
351748110592301	05 131-13.51X13.98	Well	Kaibab Formation	200
351749111003401	05 132-00.52X14.00	Well	Coconino Sandstone	400
351758111000901	05 132-00.14X13.82	Well	Coconino Sandstone	405

Table 1. Well and spring locations and selected construction data for Coconino aquifer groundwater sites included in this study, northeastern Arizona (U.S. Geological Survey, 2023).—Continued

[ft, feet; bls, below land surface; N/A, not applicable; --, information not available]

USGS site number	USGS station name	Site type	Geologic formation well is completed in (or spring discharges from)	Well depth (ft bls)
351804111060301	05 132-05.70X13.70	Well	Coconino Sandstone	391
351815110505001	05 131-05.50X13.50	Well	Coconino Sandstone	510
351818110054901	05 132-05.47X13.45	Well	Coconino Sandstone	687
351831111054501	05 132-05.41X13.21	Well	Coconino Sandstone	582
351930111184801	A-22-10 03ACD	Well	Supai Formation	2,400
352117111132901	05 132-12.70X10.02	Well	Coconino Sandstone	806
352119111132901	05 132-12.70X09.98	Well	Coconino Sandstone	716
352226111081401	05 132-07.77X08.69	Well	Coconino Sandstone	422

Quality Assurance

Water-chemistry samples were analyzed using methods described in Fishman and Friedman (1989), Fishman (1993), and Fishman and others (1994). Major ion data included dissolved calcium, magnesium, sodium, potassium, chloride, sulfate, and bicarbonate (computed from alkalinity or acid-neutralizing capacity). When potassium was not measured, sodium was used by itself in the ion balance and analyses; potassium concentrations are considered minor. In order to validate the dissolved-ion data, the ion balance of samples was checked by converting the concentrations of cations and anions in the sample from milligrams per liter to milliequivalents per liter for comparison. Theoretically, if all ions have been correctly determined, the total milliequivalents per liter of cations should equal the total milliequivalents per liter of anions in a sample (Hem, 1985). Most samples had differences of less than 5 percent between cation and anion concentrations expressed as milliequivalents per liter. Four samples had ion balances with differences from 6 to 12 percent; these samples are included in this study because the percent differences are low, and other unmeasured ions and trace metals may potentially contribute to the ion balances (Hem, 1985). Potassium was not measured in all water samples which undoubtably affected the ion balance of samples where it was missing. However, because potassium is usually a minor constituent of natural waters the omission was considered acceptable. The TDS of groundwater was analyzed using the sum of constituents method (Fishman and Friedman, 1989). Specific conductance, or the ability of a solution to conduct an electric current, is a function of the concentration and charge of the ions (Hem, 1985; Fishman and Friedman, 1989). Specific conductance and TDS from samples used in this study showed a strong relationship as should be expected with an R^2 value of 0.98.

Graphical and Statistical Analysis

The geochemical compositions of water-chemistry samples were graphically depicted with stiff and trilinear diagrams (similar to Piper [1944]). Analyses were performed using R statistical software (v.4.2.2; R Core Team, 2022). Water-chemistry data were downloaded from NWIS using the dataRetrieval package (De Cicco and others, 2022), and stiff diagrams and piper diagrams were created using the smwrGraphs package (Lorenz and Diekoff, 2017). Prior to plotting, concentration data, in milligrams per liter, were transformed to milliequivalents per liter. TDS were plotted in ArcMap (v. 10.8.1, Esri, Redlands, California) and interpolated using the “spline with barriers” method.

In addition to the graphical methods described above, principal component analysis (PCA) on the major ion data was performed in Primer 7 (Clarke and others, 2014; v7.0.17, PRIMER-E Ltd., Plymouth, United Kingdom) to investigate associations in the data. PCA was conducted on transformed and normalized major ion data to better understand how the selected factors explained the observed variation among sites (Clarke and others, 2014). Briefly, PCA captures as much of the variability in the original multi-dimensional space as possible within the two axes of the plane. Output from the PCA includes eigenvalues (variances of each principal component axis), eigenvectors (coefficients for the linear combination of input factors that defines the plane), and principal component scores (coordinates of the samples on the PC axes computed using eigenvector coefficients). A percent variance explained (from eigenvalues) is computed to quantify the extent to which the two principal component axes of the plane provide an accurate representation of the true association between the factors in the original multi-dimensional space.

Results

Water chemistry of the Coconino aquifer varied throughout the study area. The pH values for 112 sites ranged from 6.7 to 11.1, with a median of 7.6 (table 2, found at the end of this report). Three sites had samples that exceeded the SMCL range for pH for drinking water (6.5–8.5; U.S. Environmental Protection Agency, 2015). SMCLs are not enforced or considered to cause health effects, but may affect the taste, color, or corrosiveness of water. USGS site number 345757110484301 exceeded the SMCL with 1 pH value of 8.6, although 16 other samples from the site ranged from 7.4 to 8.1. USGS site number 351758111000901 exceeded the SMCL with a pH value of 9.2, and USGS site number 350407110332101 had the highest pH value of the sites with a pH of 11.1. Specific conductance values from 126 sites ranged from 110 to 15,200 microsiemens per centimeter (µS/cm), with a median of 1,220 µS/cm. Total dissolved solids ranged from 199 to 10,400 milligram per liter (mg/L) from 117 sites, with a median of 755 mg/L (table 2, found at the end of this report).

Maximum TDS exceeded the SMCL in about 73 percent of sites with data (85 of 117; fig. 5). TDS was highest (10,400 mg/L) at USGS site number 344407110171801. This 800-ft well is completed in the Coconino Sandstone and is located south of Holbrook in the southeastern part of the study area. Other sites with high TDS (USGS site number 350407110332101, 6,580 mg/L; USGS site number 351815110505001, 5,800 mg/L; USGS site number 351053110332501, 5,470 mg/L; and USGS site number 351052110491701, 5,030 mg/L; figs. 5 and 6) are located north of Winslow (table 2, found at the end of this report; fig. 5).

A map of interpolated TDS concentrations was created for the study area (fig. 6). Areas of high TDS include the area northwest of The Sinks and Snowflake in the southeastern part of the study area and a broad area north of Winslow. This broad area is unconstrained by TDS sample data; however, a well drilled in the mid-2000s by the Hopi Tribe at the Village of Moenkopi north of the study area required reverse osmosis treatment for municipal use demonstrating that salinity concentrations are elevated in that area (Jon Mason, oral commun., 2023). Spatial distributions of TDS are consistent with a similar map of the southeastern part of the study area from Mann (1976). Figure 6 also displays water-chemistry stiff diagrams at sites with available data. These stiff diagrams are used to spatially compare ionic composition of water samples (Stiff, 1951). Water-chemistry data were adequate to create stiff diagrams for 111 sites; when sites were too close together to distinguish, a representative diagram from one site is displayed in figure 6.

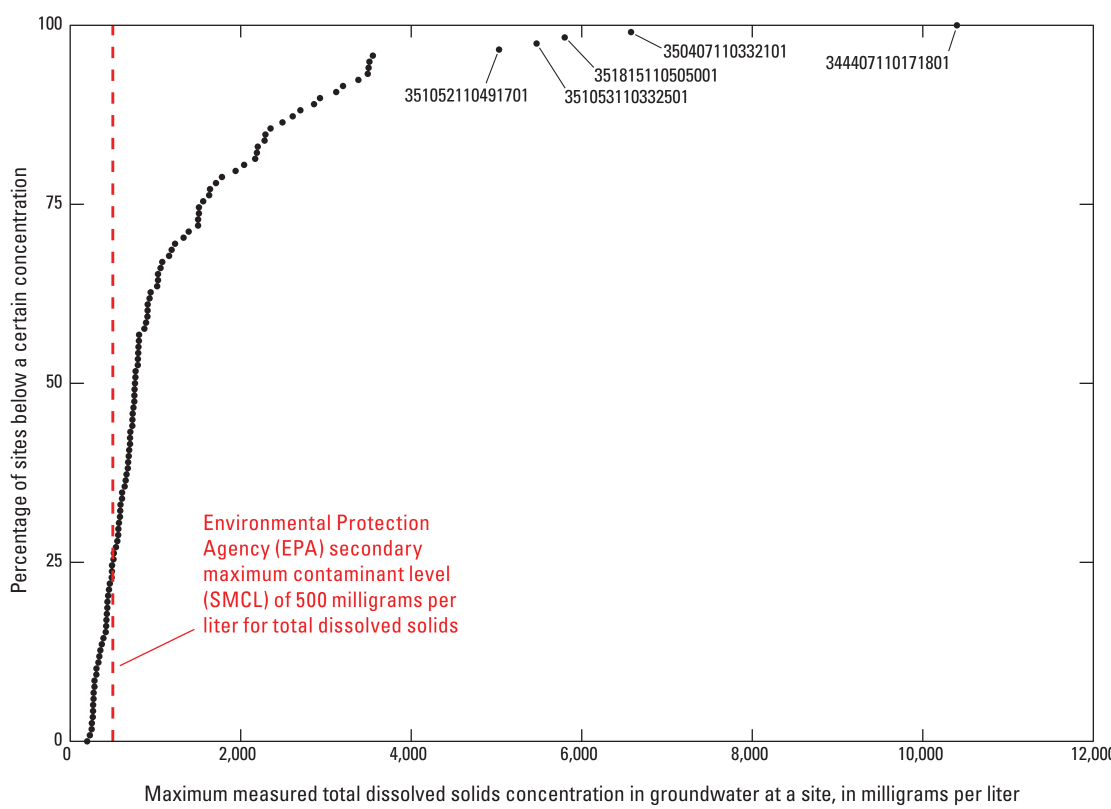

Figure 5. Distribution of the concentration of total dissolved solids (TDS) in Coconino aquifer groundwater samples from 117 sites in the northeastern Arizona study area. Five sites with the highest TDS are labeled with the corresponding U.S. Geological Survey site number.

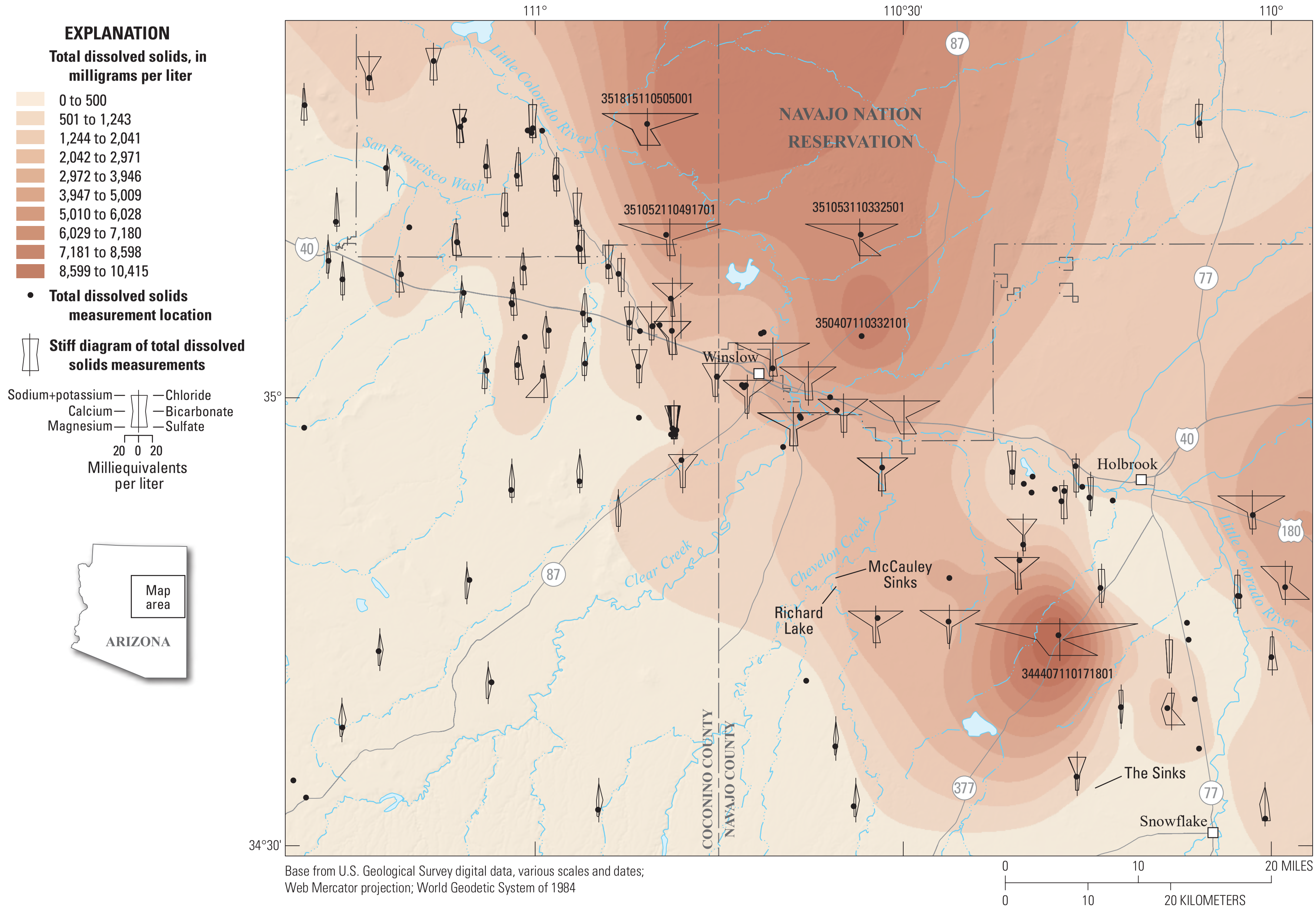

Figure 6. Interpolated total dissolved solids (TDS) and major ion chemistry distribution (U.S. Geological Survey, 2023) in the Coconino aquifer in the northeastern Arizona study area. Not all sites with TDS have major ion data to display. When sites with major ion data were too close together to distinguish, one representative diagram is displayed.

The chemical composition of groundwater was further characterized based on the ratios of major ions present in the water (Hem, 1985). This classification is typically called the water type. Water type is determined by comparing the relative concentrations in milliequivalents of the cations and anions in water separately. To be classified as a specific water type, there must be a dominant cation and anion each making up more than 50 percent of the total. For example, if calcium makes up more than 50 percent of the cations and bicarbonate makes up more than 50 percent of the anions in the water, it is classified as a calcium-bicarbonate water type (or just calcium-bicarbonate water). If no cations and anions make up more than 50 percent of the total, the water is classified as a mixed water type (Hem, 1985). The water types correspond to areas of a trilinear diagram (fig. 7).

Using this method of classification, 42 percent of the sites (47 of 111) have a sodium-chloride water type. These sites correlate with high TDS in the study area, located to the southeast and north of the Little Colorado River (figs. 6, 7, and 8; table 2, found at the end of this report). Another 14 percent (15 of 111) of the sites are a calcium-sulfate water type. About 15 percent (17 of 111) of the sites are considered calcium-bicarbonate water. The calcium-dominated water is mostly located to the west of the study area (fig. 8; table 2, found at the end of this report). The remaining 29 percent (32 of 111) are a mixed water type. They are referred to as calcium-magnesium-chloride sulfate type because combinations of these cations and anions make the majority of the ions (fig. 7; table 2, found at the end of this report).

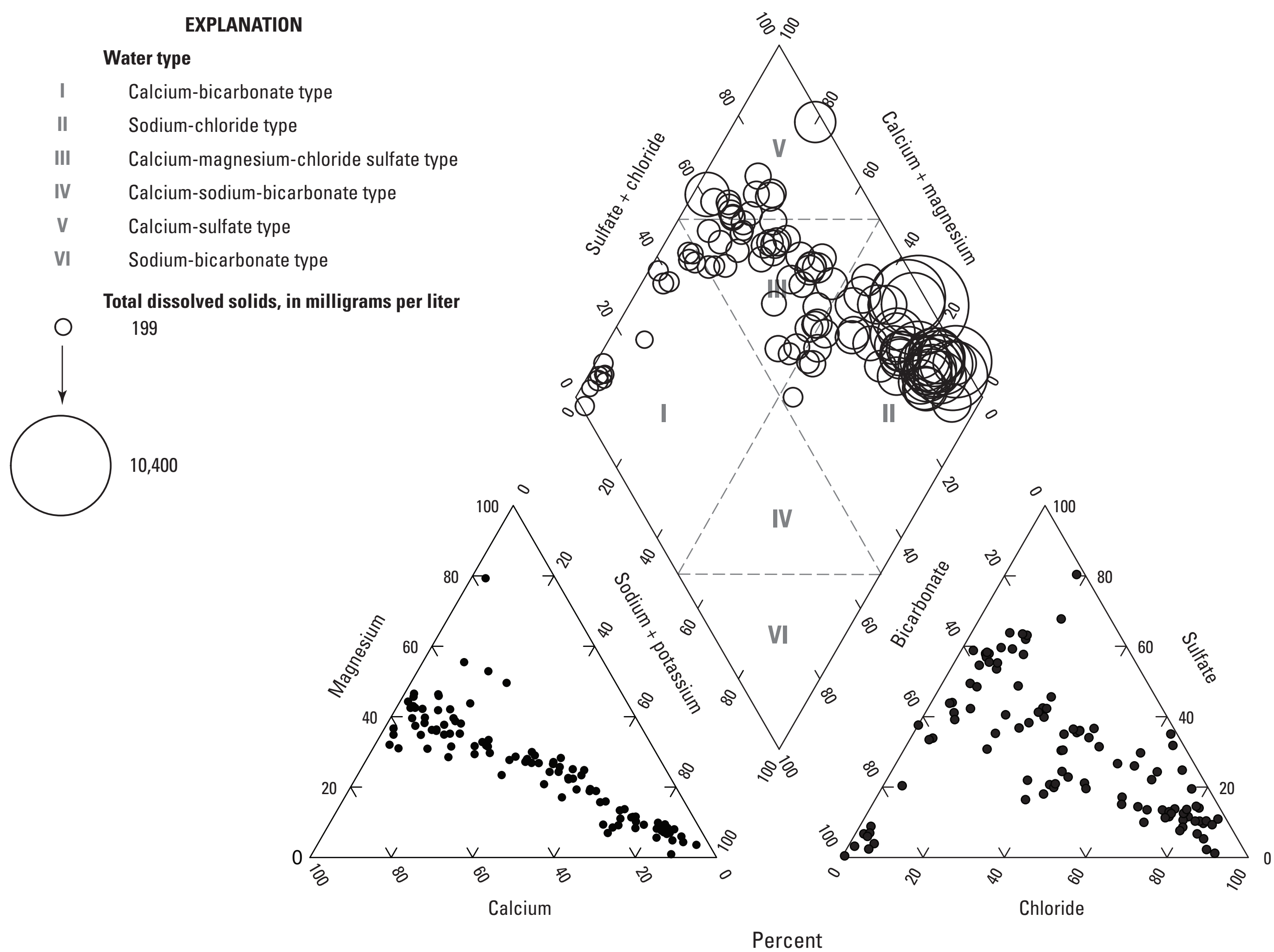

Figure 7. Trilinear diagram and water-type classification of groundwater samples in the Coconino aquifer in the study area. The relative size of the circles represents total dissolved-solids concentrations.

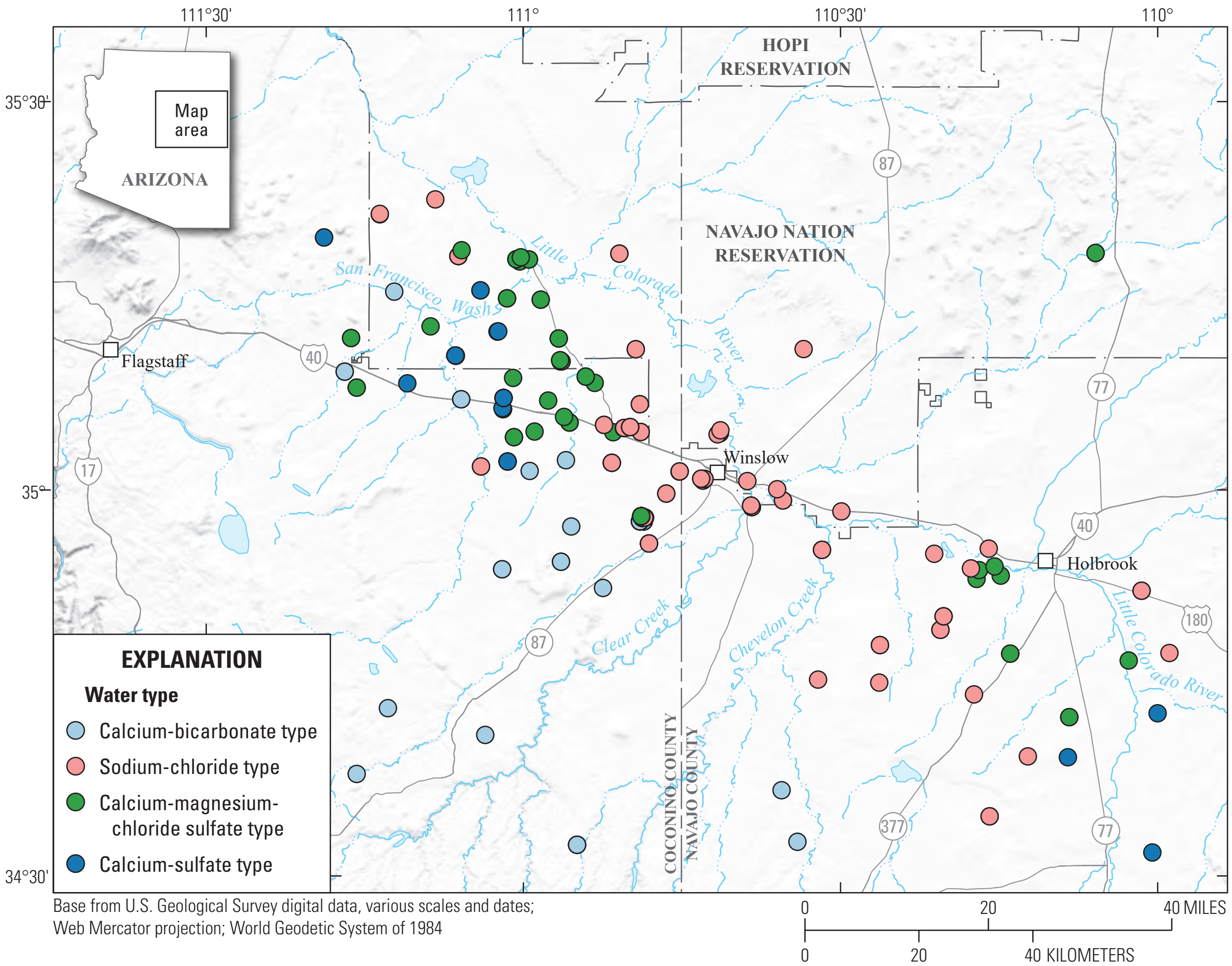

Figure 8. Groundwater types of sites in the Coconino aquifer in the study area, based on the ratios of major ions present.

The loading plot depicts computed PCA of the normalized major ion data and explains 66 percent of the cumulative variability among the data (fig. 9). The principal component along axis 1 (PC1) accounted for 46.1 percent of variation. The principal component along axis 2 (PC2) accounted for an additional 19.9 percent of variation. Vectors plotted on the PC1 represented a positive loading for bicarbonate and negative loading for all other variables. Vectors plotted on the PC2 represented a positive loading in calcium, magnesium, and sulfate, and a negative loading in sodium (+potassium), chloride, and bicarbonate ions. Additionally, non-sodium-chloride water types plotted along a line defined by the bicarbonate vector on one end to magnesium, calcium, and sulfate on the other end, whereas sodium-chloride water types changed along a different line that included the sodium and chloride vectors.

Of these major ions, chloride and sulfate have Environmental Protection Agency (EPA) SMCLs that affect drinking water (table 3; U.S. Environmental Protection Agency, 2015). The SMCL for both ions is 250 mg/L; exceedances can cause the water to taste salty. Chloride exceeded the SMCL in 122 samples from 50 sites (about 45 percent of the sites) in the study area. Sulfate exceeded the SMCL in 68 samples from 46 sites (about 41 percent of the sites). Either chloride, sulfate, or both ions exceeded the SMCL in 154 samples from 69 sites (about 62 percent of the sites)

Selected trace metals also were analyzed. Although most sites did not have any data (with the exception of fluoride, which was measured at 126 sites), available data are presented along with EPA regulations (table 3). Only one sample exceeded the EPA maximum contaminant limit (MCL) for any of the trace metals measured. Unlike SMCLs, MCLs are legal limits of constituents in drinking water that are designed to protect human health (U.S. Environmental Protection Agency, 2009). USGS site number 344407110171801, an 800-foot well in the Coconino Sandstone, exceeded the MCL and SMCL for fluoride (MCL is 4 mg/L; SMCL is 2 mg/L; and sample concentration was 5.4 mg/L). Fluoride concentrations for 126 sites ranged from 0 to 5.4 mg/L.

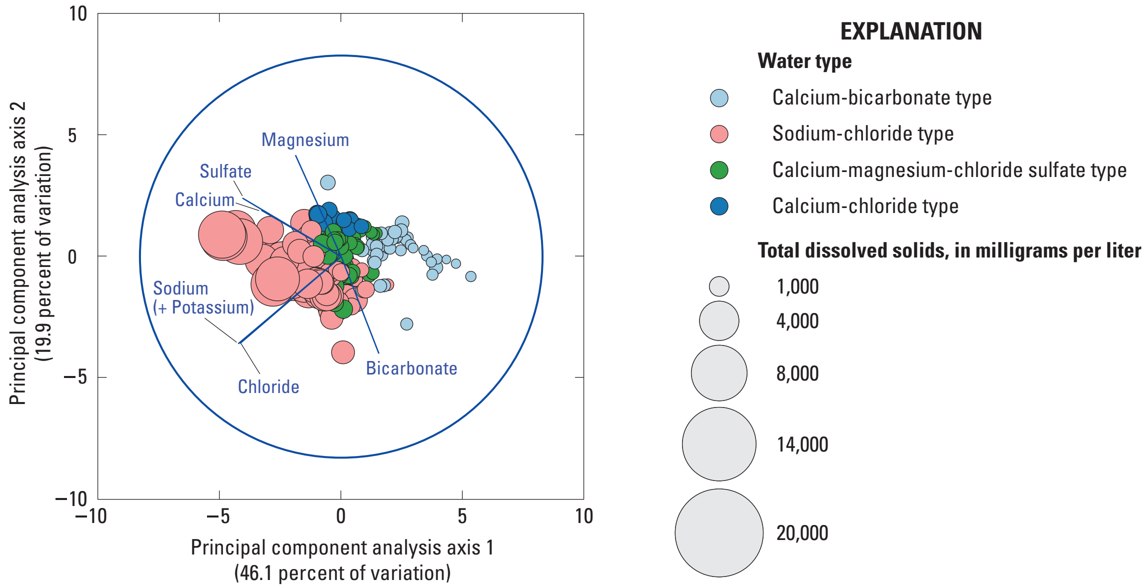

Figure 9. Principal component analysis (PCA) of major ions in the groundwater sites in the Coconino aquifer in the study area.

Table 3. Ranges of constituents in the study area and corresponding Environmental Protection Agency (EPA) maximum contaminant levels (MCLs), treatment techniques (TT), and (or) secondary maximum contaminant levels (SMCLs; U.S. Environmental Protection Agency, 2015), Coconino aquifer, northeastern Arizona.

[**Abbreviations**: µg/L, micrograms per liter; mg/L, milligrams per liter; --, not applicable; TT*, treatment techniques; <, less than]

Constituent	Chemical symbol	No. of sites with measurement	Range	EPA MCL (or TT*)	EPA SMCL
pH	--	112	6.8–11.1	--	6.5–8.5
Total dissolved solids	--	117	199–10,400 mg/L	--	500 mg/L
Chloride	Cl^-	50	0.01–3,980 mg/L	--	250 mg/L
Sulfate	SO_4^{2-}	46	1.3–2,620 mg/L	--	250 mg/L
Arsenic	As	22	<1–7 µg/L	10 µg/L	--
Barium	Ba	22	11.8–262 µg/L	2,000 µg/L	
Copper	Cu	22	0.32–30 µg/L	1,300 µg/L*	1,000 µg/L
Lead	Pb	22	<0.08–30 µg/L	15 µg/L*	--
Fluoride	F^-	126	0–5.4 mg/L	4 mg/L	2 mg/L

Arsenic, barium, copper, and lead were measured at 22 sites for a total of 38 samples. Arsenic concentrations ranged from less than 1 to 7 µg/L (MCL is 10 µg/L). Barium concentrations ranged from 11.8 to 262 µg/L (MCL is 2,000 µg/L). Copper and lead do not have an MCL, but instead are regulated in water systems by treatment techniques (TT). Treatment techniques do not apply to single elements, but no more than 10 percent of tap water samples can exceed the TT action level, or corrective measures must be used (U.S. Environmental Protection Agency, 2009). Copper concentrations ranged from 0.32 to 30 µg/L (TT action level is 1,300 µg/L). Lead concentrations ranged from less than 0.08 to 30 µg/L (TT action level is 15 µg/L). Uranium concentrations were only measured at two sites near Leupp, Arizona, in 2005, and were 2.45 and 4.60 µg/L (MCL is 30 µg/L).

Discussion

Subsurface deposits of halite in the southeastern part of the study area influence the groundwater chemistry. High TDS, which can occur naturally in groundwater due to the dissolution of rocks, likely results from the solution of halite along the regional groundwater flow path. Sodium-chloride is highly soluble in water but is concentrated in many of the groundwater sites in the study area, suggesting a persistent source.

Despite the salt-dissolution features at McCauley Sinks and Richard Lake, TDS is interpreted to be in a low range for the study area near these features (Neal and Johnson, 2002; fig. 6). This supports Neal and Johnson's (2002) conclusion that dissolution here may indeed be less active than in the past, as the dissolution front migrates to the northeast. Another hypothesis presented by Neal and Johnson (2002) is that wells are too shallow to penetrate deep groundwater with high TDS. The top of the saltwater zone is variable, and well logs are not always available. Mann (1976) attributes this irregularity to fractures in the siltstone of the Supai Formation beneath the Coconino aquifer.

Other evaporites that are often present along with naturally forming halite can supply additional ions to groundwater (Richter and Kreitler, 1991). Calcium and sulfate in groundwater likely result from dissolution of gypsum ($CaSO_4$ $2H_20$) and anhydrite ($CaSO_4$), which extend beyond the halite bed. Mann (1976) suggested that sodium, sulfate, and chloride in the Coconino aquifer also may be contaminated from the Moenkopi Formation when wells are open in both stratigraphic layers. However, due to the mudstone and siltstone present, the Moenkopi Formation acts as a confining unit unless heavily fractured.

The calcium, magnesium, and bicarbonate present in the west and southwest may be from water moving downward through the carbonate Kaibab Formation (Mann, 1976). Bills and others (2007) recorded low strontium-isotope ($^{87}Sr/^{86}Sr$) measurements from wells and springs near Flagstaff that indicate inflow interacting with the Kaibab Formation and volcanic rocks.

Potential for Use as Potable Water

High concentrations of TDS in much of the study area affect the quality of Coconino aquifer water for potential potable use. In the southeastern part of the study area, and north of the Little Colorado River, about 73 percent of Coconino aquifer samples contain TDS greater than the SMCL of 500 milligrams per liter (mg/L) up to concentrations greater than 10,000 mg/L. Although this falls into the TDS range that can be potentially remediated, desalination of groundwater for potable use can be costly and energy intensive (Stanton and others, 2017).

Trace metals have not been widely measured, but most concentrations are less than the MCLs for drinking water. Fluoride exceeded the MCL in one sample (table 3). Although both arsenic and uranium samples were less than the MCLs (10 µg/L As and 30 µg/L U), these elements have been a concern for the Navajo Nation and Hopi Tribe. Jones and others (2020) found that both arsenic and uranium exceeded the EPA MCL in western Navajo Nation in unregulated water sources, including around Leupp, Arizona.

Water containing elevated TDS can be used for livestock watering and (or) irrigation in some cases. Irrigation water with specific conductance values ranging from 750 to 1,500 µS/cm may have detrimental effects on sensitive crops, whereas higher specific conductance values may affect many crops (Zaman and others, 2018). Sodium hazard, which describes how sodium affects the soil, and ion toxicity are other potential hurdles.

Less is known about Coconino aquifer water north of the study area on the Hopi Reservation and Navajo Nation. Wells in these areas penetrate the shallower Navajo, Dakota, and Toreva aquifers (Mason, 2021). The Hopi Tribe did drill a single municipal well into the Coconino aquifer at the Village of Moenkopi north of the study area. Water from that well required reverse osmosis treatment demonstrating that salinity concentrations are elevated in that area (Jon Mason, oral commun., 2023). However, to the northeast of the study area, near Arizona's border with New Mexico, Coconino aquifer water contains less dissolved solids (less than 500 mg/L; U.S. Geological Survey, 2023).

Conclusions

As population and development increase in the arid Hopi Reservation and Navajo Nation of northeastern Arizona, the Coconino aquifer has been considered for development as a supplemental groundwater resource. In cooperation with the Hopi Tribe and analyzing existing groundwater samples collected since 1933, the water chemistry of the Coconino aquifer was characterized to determine its potential suitability as a source of drinking water for the Hopi Tribe and Navajo Nation.

Buried halite bodies in the southeastern part of the study area influence the dissolved-solids concentrations in the area. As groundwater moves along the regional dip to the north, sodium, chloride, and other ions are dissolved and transported through the system. The resulting plume of sodium-chloride groundwater differs from the groundwater to the south and west. Total dissolved solids (TDS), sulfate, and chloride exceed the U.S. Environmental Protection Agency (EPA) secondary maximum contaminant level for taste and odor in many samples. Measured trace metals are less than the EPA maximum contaminant level (MCL), except for one sample of fluoride.

Water chemistry data from this study indicate that in much of this area, while the aquifer is potentially productive, it will likely need treatment before it is suitable for human consumption. Few Coconino aquifer wells exist north of the study area in the Hopi Reservation and (or) Navajo Nation. Characterizing the groundwater chemistry of the aquifer resource in this area could reveal its suitability for development as a water supply.

Table 2. Selected field parameters and water-chemistry data for Coconino aquifer groundwater sites included in this study, northeastern Arizona (U.S. Geological Survey, 2023).

[**Sample date:** MM/DD/YYYY, month/day/year. **Water type:** Water type refers to major ion distribution and is only listed if used in the analysis (most recent complete sample). **Abbreviations:** SC, specific conductance; µS/cm, microsiemens per centimeter; Ca^{2+} , calcium; Mg^{+}, magnesium; mg/L, milligrams per liter, Na^{+} + K^{+}, sodium+potassium; SO_4^{2-}, sulfate; Cl, chloride; HCO-, bicarbonate; TDS, total dissolved solids; --, no data available; E, estimate; <, less than]

USGS site number	Sample date	SC (µS/cm)	pH	Ca^{2+} (mg/L)	Mg^{+} (mg/L)	Na^{+} + K^{+} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)	HCO- (mg/L)	TDS (mg/L)	Water type	Arsenic (µg/L)	Uranium (µg/L)	Barium (µg/L)	Lead (µg/L)	Copper (µg/L)	Fluoride (mg/L)
342526110155501	6/14/1946	2,220	--	112	53	290	281	470	206	1,330	sodium-chloride	--	--	--	--	--	0.5
343149110002701	9/5/1972	1,060	7.1	150	45	17.2	350	13	289	729	calcium-sulfate	--	--	--	--	--	0.7
343225110545001	5/15/1952	540	--	62	34	5	12	6	346	--	--	--	--	--	--	--	0.4
343225110545001	5/11/1966	--	7.8	60	38	6.7	110	13	226	--	--	--	--	--	--	--	0.1
343225110545001	8/3/1992	519	7.5	65	31	4.8	1.3	1	352	285	calcium-bicarbonate	--	--	--	--	--	<0.1
343239110340001	6/20/1972	499	7.6	56	30	3.3	18	4.1	310	275	calcium-bicarbonate	--	--	--	--	--	0
343314111183801	8/5/1994	540	7.4	63	31	2.3	1.7	1.9	--	285	--	3	--	47	4	2	0.1
343423111194001	8/26/1975	476	--	--	--	--	--	--	--	265	--	--	--	--	--	--	0.1
343438110155001	9/21/1972	1,870	7.7	53	29	292.1	90	430	219	1,020	--	--	--	--	--	--	0.3
343438110155001	8/5/1992	1,840	7.8	53	28	272	84	430	221	990	sodium-chloride	--	--	--	--	--	0.3
343640110353001	7/5/1969	454	--	63	19	--	8	9	232	--	--	--	--	--	--	--	0.3
343640110353001	8/17/2000	450	7.9	54.7	29	4.89	12.1	5.51	--	E 268	--	7	--	262	4	3.7	0.11
343756111154001	7/13/1978	640	7.4	85	29	4.9	7.2	12	350	331	calcium-bicarbonate	--	--	--	--	--	0.1
343914110082601	6/11/1958	2,260	7	296	99	130	930	150	30	1,780	calcium-sulfate type	--	--	--	--	--	1
343918110121301	9/12/1972	638	7.7	37	13	76.9	50	83	180	371	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.2
343950110061201	1/1/1974	1,080	--	--	--	--	--	--	--	702	--	--	--	--	--	--	--
344058111033101	6/17/1966	532	7.5	66	33	2.8	26	6	330	308	calcium-bicarbonate	--	--	--	--	--	0
344104110375201	1/1/1966	449	7.8	--	--	--	--	--	--	252	--	--	--	--	--	--	0
344104110375201	9/12/2000	410	7.3	49.9	27.5	4.95	13.4	5.04	--	E 246	--	7	--	216	<1	E 0.6	0.17
344221110081801	2/14/1934	--	--	71	31	120*	120	160	252	--	--	--	--	--	--	--	0.4
344221110081801	6/11/1946	110	--	71	28	120*	110	160	260	--	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.3
344239109595701	9/5/1972	1,150	8.2	66	74	66.5	350	71	204	733	calcium-sulfate	--	--	--	--	--	0.6
344303111124301	6/22/1966	475	7.5	57	28	4.8	18	6.5	294	274	calcium-bicarbonate	--	--	--	--	--	0
344349110064201	4/1/1974	670	--	--	--	--	--	--	--	436	--	--	--	--	--	--	--
344407110171801	5/8/1968	15,200	6.8	670	190	2,800	2,620	3,980	276	10,400	sodium-chloride	--	--	--	--	--	5.4
344457110065001	4/1/1974	600	--	--	--	--	--	--	--	390	--	--	--	--	--	--	--
344502110261601	7/24/1969	5,500	7.9	80	28	944.4	27	1,500	217	2,700	sodium-chloride	--	--	--	--	--	0.4
344516110320301	7/24/1969	4,930	7.9	88	42	913.8	330	1,400	152	2,860	sodium-chloride	--	--	--	--	--	0.2
344644110023301	8/5/1986	1,270	7.2	100	34	100.1	270	140	--	765	--	<1	--	19	<10	<10	0.3
344644110024201	5/17/1968	--	7.2	84	29	83	180	91	236	--	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.6
344644110024201	8/19/1992	1,090	7.8	--	--	--	--	--	--	661	--	--	--	--	--	--	0.2
344720109585001	9/12/1972	4,230	7.3	210	51	794	1,600	350	364	3,200	sodium-chloride	--	--	--	--	--	2
344720110135201	6/15/1965	1,110	7.7	72	35	110	120	138	303	--	--	--	--	--	--	--	0.2

Table 2. Selected field parameters and water-chemistry data for Coconino aquifer groundwater sites included in this study, northeastern Arizona (U.S. Geological Survey, 2023).—Continued

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USGS site number	Sample date	SC (µS/cm)	pH	Ca^{2+} (mg/L)	Mg^{+} (mg/L)	$Na^{+} + K^{+}$ (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)	HCO- (mg/L)	TDS (mg/L)	Water type	Arsenic (µg/L)	Uranium (µg/L)	Barium (µg/L)	Lead (µg/L)	Copper (µg/L)	Fluoride (mg/L)
344720110135201	8/5/1986	1,120	7.2	66	37	112.1	130	140	--	639	--	<1	--	39	<10	<10	0.3
344720110135201	8/20/1992	1,650	7.8	69	37	111.9	120	140	301	639	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.2
344749111051901	11/10/1933	315	7.5	--	--	--	--	--	--	205	--	--	--	--	--	--	0.2
344757110261201	9/6/1972	5,470	8	94	54	1,003.4	370	1,500	179	3,120	sodium-chloride	--	--	--	--	--	0.2
344757110261201	9/14/1995	5,200	8.1	93	50	953.4	340	1,500	--	3,020	--	--	--	--	--	--	0.2
344908110202901	6/18/1946	413	--	82	39	770	273	1,110	225	--	--	--	--	--	--	--	--
344908110202901	4/23/1968	4,190	7.1	78	37	760	240	1,100	236	2,350	sodium-chloride	--	--	--	--	--	0.9
345011110201101	4/24/1968	2,800	6.7	16	11	540	166	700	129	1,500	sodium-chloride	--	--	--	--	--	0.8
345011110201101	8/4/1986	3,500	7.4	70	38	563.2	320	820	--	1,940	--	<1	--	31	30	<30	0.6
345212110012901	8/18/1992	6,500	7.8	140	40	1,107.2	250	1,600	204	3,250	sodium-chloride	--	--	--	--	--	0.2
345223110522301	5/3/1966	--	7.5	78	34	8.7	123	0.1	259	--	calcium-bicarbonate	--	--	--	--	--	--
345308110125301	8/5/1986	840	7.4	56	35	59.5	150	69	--	487	--	<1	--	27	<10	20	0.4
345316110170910	8/17/1972	1,320	7.4	72	43	142.5	230	180	232	794	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.5
345320110144710	9/12/1972	885	7.7	39	26	102.1	83	130	201	491	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.5
345340110193001	6/5/2007	1,220	7.6	60.3	35.6	134.42	128	168	--	E 673	--	0.23	--	24.8	<0.12	E 0.32	0.4
345340110193001	6/19/2008	1,300	7.3	61.2	37.1	138.52	131	178	--	E 687	--	0.66	--	24.1	0.118	<1	0.37
345344110165101	8/13/1992	1,160	8	61	37	132.2	170	160	219	680	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.3
345345110175201	1/12/1968	1,140	7.3	55	31	140	114	169	256	651	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.6
345350111015501	5/12/1966	637	7.4	80	34	15	154	9	240	425	--	--	--	--	--	--	0.3
345350111015501	10/5/1978	650	7.4	71	33	13.2	150	13	220	403	calcium-bicarbonate	--	--	--	--	--	0.2
345350111015501	8/17/1995	635	7.6	73	34	11	140	5.4	--	390	--	--	--	--	--	--	0.2
345410110153201	7/24/1968	839	7.4	42	26	84	68	113	198	445	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.4
345415110200801	6/5/2007	1,900	7.5	83	38.6	240.67	204	347	--	E 1060	--	0.27	--	20.2	<0.12	0.51	0.4
345425110562101	5/11/1966	626	7.7	75	36	10	128	12	252	398	--	--	--	--	--	--	0.1
345425110562101	10/19/1978	650	7.5	83	34	12.4	150	19	240	430	calcium-bicarbonate	--	--	--	--	--	0.2
345425110562101	8/16/1995	620	7.6	75	33	10.6	130	7.9	--	390	--	--	--	--	--	--	0.2
345444110192501	5/25/1994	1,430	7.5	57	33	182.4	130	260	--	790	--	<1	--	27	<1	<1	0.4
345444110192501	5/4/1995	1,500	7.6	59	34	192.6	130	280	--	826	--	--	--	--	--	--	0.4
345444110192501	5/7/1996	1,520	7.8	71	36	202.5	190	270	--	909	--	--	--	--	--	--	0.4
345444110192501	4/17/1997	1,480	7.5	56.6	32.8	194.49	134	279	--	822	--	--	--	--	--	--	0.45
345444110192501	4/9/1998	1,500	7.8	56.5	34.4	203.45	133	289	--	836	--	--	--	--	--	--	0.38
345444110192501	6/2/1999	1,550	7.8	56.2	32.1	187.4	127	282	--	810	--	--	--	--	--	--	0.35
345444110192501	7/26/2001	1,540	7.6	57	34	202.4	130	290	--	830	--	--	--	--	--	--	0.34

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USGS site number	Sample date	SC (µS/cm)	pH	Ca^{2+} (mg/L)	Mg^{+} (mg/L)	$Na^{+} + K^{+}$ (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)	HCO- (mg/L)	TDS (mg/L)	Water type	Arsenic (µg/L)	Uranium (µg/L)	Barium (µg/L)	Lead (µg/L)	Copper (µg/L)	Fluoride (mg/L)
345500110210301	8/17/1992	1,290	7.9	64	34	152.2	150	190	262	730	calcium-magnesium-chloride sulfate type	--	--	--	--	--	0.2
345519110314201	7/6/2005	4,800	6.9	86.8	58.5	796.63	255	1,280	245	E 2610	--	1.2	--	23.1	<0.16	1	0.31
345519110314201	6/23/2006	4,660	7.1	78.7	49.9	769.83	251	1,270	248	2,550	sodium-chloride	1.6	--	25.4	<0.16	<0.8	0.31
345519110314201	12/1/2010	4,680	7.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345519110314201	12/1/2010	4,680	7.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345519110314201	9/18/2012	4,730	7.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345519110314201	9/19/2017	4,720	7.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345519110314201	9/25/2018	4,520	7.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345519110314201	9/25/2018	4,520	7.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345519110314201	6/18/2019	4,730	7.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345548110480201	5/3/1966	--	7.6	82	41	480	168	745	236	1,630	--	--	--	--	--	--	0.2
345548110480201	10/19/1978	2,900	7.4	82	38	462.5	170	740	230	1,620	sodium-chloride	--	--	--	--	--	0.2
345653110394001	2/28/2006	2,280	7.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345653110394001	6/28/2006	2,300	7.6	53	25.4	372.98	41.2	601	--	E 1230	--	0.28	--	85.4	<0.08	0.4	0.15
345653110394001	12/2/2010	2,370	7.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345653110394001	9/20/2017	2,320	7.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345653110394001	6/19/2019	2,140	7.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345653110394001	6/19/2019	2,320	7.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345653110394001	6/10/2022	2,320	7.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345707110552001	11/20/1933	2,270	7.6	66	41	14	136	21	232	--	sodium-chloride	--	--	--	--	--	0
345730110483001	4/27/1955	--	7.8	65	35	13*	110	12	246	361	--	--	--	--	--	--	0
345730110483001	7/13/1955	--	7.7	64	37	30*	145	16	249	421	--	--	--	--	--	--	0
345730110483001	11/14/1955	--	8	62	38	20*	120	16	251	387	--	--	--	--	--	--	0.1
345730110483001	1/2/1957	--	7.4	59	39	5*	90	12	254	338	--	--	--	--	--	--	0.1
345730110483001	6/5/1957	--	7.7	63	32	2*	70	10	252	308	--	--	--	--	--	--	0.1
345730110483001	12/6/1957	--	7.6	64	31	8*	90	16	229	331	--	--	--	--	--	--	0.1
345730110483001	5/2/1958	--	7.6	62	33	2*	80	16	229	311	--	--	--	--	--	--	0.1
345730110483001	1/4/1959	--	8.1	61	34	7*	60	16	271	318	--	--	--	--	--	--	0.1
345730110483001	11/17/1959	--	7.3	66	40	8*	100	20	261	374	--	--	--	--	--	--	0.1
345730110483001	6/16/1960	--	7.7	64	40	1*	90	20	249	351	--	--	--	--	--	--	0.2
345730110483001	2/17/1961	--	7.6	68	36	26*	120	28	256	422	--	--	--	--	--	--	0.4
345730110483001	6/3/1963	--	7.7	84	20	33*	115	24	256	412	--	--	--	--	--	--	0
345730110483001	10/16/1964	--	7.6	108	6	37*	112	14	295	433	calcium-bicarbonate	--	--	--	--	--	0.3

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USGS site number	Sample date	SC (µS/cm)	pH	Ca^{2+} (mg/L)	Mg^{+} (mg/L)	Na^{+} + K^{+} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)	HCO- (mg/L)	TDS (mg/L)	Water type	Arsenic (µg/L)	Uranium (µg/L)	Barium (µg/L)	Lead (µg/L)	Copper (µg/L)	Fluoride (mg/L)
345730110483001	10/25/1965	--	7.6	74	9	133*	215	36	288	609	--	--	--	--	--	--	0.2
345730110483001	9/17/1901	--	8	--	--	--	--	--	--	--	--	--	--	--	--	--	0.1
345730110485001	10/20/1953	--	7.4	53	38	35*	110	18	268	397	--	--	--	--	--	--	0
345730110485001	1/8/1955	--	7.9	64	32	14*	90	16	251	348	--	--	--	--	--	--	0
345730110485001	4/27/1955	--	8.1	64	34	22*	120	12	251	380	--	--	--	--	--	--	0
345730110485001	7/13/1955	--	7.7	65	36	31*	150	16	242	425	--	--	--	--	--	--	0
345730110485001	11/14/1955	--	8.2	61	38	39*	130	12	249	412	--	--	--	--	--	--	0
345730110485001	1/2/1957	--	7.7	59	38	4*	90	8	251	333	--	--	--	--	--	--	0.1
345730110485001	6/5/1957	--	7.5	66	29	2*	65	14	244	303	--	--	--	--	--	--	0.1
345730110485001	12/6/1957	--	7.5	65	30	9*	90	16	229	333	--	--	--	--	--	--	0.1
345730110485001	5/2/1958	--	7.7	63	33	3*	80	20	229	318	--	--	--	--	--	--	0.1
345730110485001	1/4/1959	--	8.1	62	30	2*	50	16	254	291	--	--	--	--	--	--	0.1
345730110485001	11/17/1959	--	7.3	66	37	9*	80	22	271	359	--	--	--	--	--	--	0.1
345730110485001	6/16/1960	--	7.6	70	34	1*	92	14	246	--	--	--	--	--	--	--	--
345730110485001	2/17/1961	--	7.6	68	33	33*	120	18	276	425	--	--	--	--	--	--	0.3
345730110485001	6/3/1963	--	7.7	87	16	42*	135	14	261	433	--	--	--	--	--	--	0
345730110485001	10/16/1964	--	7.7	118	0	23*	84	16	278	388	--	--	--	--	--	--	0.3
345730110485001	10/25/1965	--	7.5	68	11	76*	110	24	281	437	--	--	--	--	--	--	0.3
345730110485001	3/3/1966	587	7.6	66	36	7.1*	99	11	257	348	--	--	--	--	--	--	0.2
345730110485001	1/4/1979	570	7.5	68	34	8.9*	110	13	250	370	calcium-bicarbonate	--	--	--	--	--	0.1
345746110483701	1/10/1963	--	7.6	61	42	64*	106	91	--	537	--	--	--	--	--	--	0.3
345746110483701	1/10/1963	--	7.6	113	12	64*	111	106	249	539	--	--	--	--	--	--	0.4
345746110483701	10/16/1964	--	7.6	116	8	152*	100	214	300	748	--	--	--	--	--	--	0.3
345746110483701	10/25/1965	--	7.6	76	12	288*	250	254	300	1,030	--	--	--	--	--	--	0.2
345746110483701	3/1/1966	1,720	8.1	54	54	230	134	360	263	975	--	--	--	--	--	--	0.2
345746110483701	3/1/1966	1,610	8.2	55	54	200	128	315	260	888	--	--	--	--	--	--	0.1
345746110483701	3/2/1966	1,490	8	63	49	180	124	290	263	851	sodium-chloride	--	--	--	--	--	0.3
345750110482501	8/22/1953	--	7.5	68	38	87*	120	124	256	572	--	--	--	--	--	--	0
345750110482501	8/25/1953	--	7.5	60	34	79*	110	92	264	524	--	--	--	--	--	--	0
345750110482501	1/8/1955	--	7.7	75	29	166*	110	252	237	751	--	--	--	--	--	--	0
345750110482501	4/27/1955	--	7.9	75	39	167*	135	258	249	803	--	--	--	--	--	--	0
345750110482501	8/12/1955	--	7.9	76	43	169*	120	290	240	822	--	--	--	--	--	--	0
345750110482501	11/14/1955	--	8	74	40	228*	140	296	242	902	--	--	--	--	--	--	0

Table 2. Selected field parameters and water-chemistry data for Coconino aquifer groundwater sites included in this study, northeastern Arizona (U.S. Geological Survey, 2023).—Continued

[**Sample date:** MM/DD/YYYY, month/day/year. **Water type:** Water type refers to major ion distribution and is only listed if used in the analysis (most recent complete sample). **Abbreviations:** SC, specific conductance; µS/cm, microsiemens per centimeter; Ca^{2+} , calcium; Mg^{+}, magnesium; mg/L, milligrams per liter, Na^{+} + K^{+}, sodium+potassium; SO_4^{2-}, sulfate; Cl, chloride; HCO-, bicarbonate; TDS, total dissolved solids; --, no data available; E, estimate; <, less than]

USGS site number	Sample date	SC (µS/cm)	pH	Ca^{2+} (mg/L)	Mg^{+} (mg/L)	Na^{+} + K^{+} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)	HCO- (mg/L)	TDS (mg/L)	Water type	Arsenic (µg/L)	Uranium (µg/L)	Barium (µg/L)	Lead (µg/L)	Copper (µg/L)	Fluoride (mg/L)
345750110482501	1/2/1957	--	7.6	80	37	297*	120	468	246	1,130	--	--	--	--	--	--	0.1
345750110482501	6/5/1957	--	7.6	78	38	163*	15	346	242	765	--	--	--	--	--	--	0.1
345750110482501	12/6/1957	--	7.6	79	34	171*	140	262	232	808	--	--	--	--	--	--	0.1
345750110482501	5/2/1958	--	7.9	77	38	207*	80	372	229	892	--	--	--	--	--	--	0.1
345750110482501	1/4/1959	--	8.1	79	34	267*	150	402	232	1,050	--	--	--	--	--	--	0.1
345750110482501	11/17/1959	--	7.2	90	39	254*	110	432	256	1,060	--	--	--	--	--	--	0.4
345750110482501	6/16/1960	--	7.6	86	41	243*	150	394	239	1,050	--	--	--	--	--	--	-
345750110482501	2/17/1961	--	7.6	86	40	164*	150	260	256	839	--	--	--	--	--	--	0.3
345750110482501	6/3/1963	--	7.8	136	7	331*	155	486	288	1,270	--	--	--	--	--	--	0
345750110482501	10/16/1964	--	7.7	135	0	382*	220	500	273	1,380	--	--	--	--	--	--	0.3
345750110482501	10/25/1965	--	7.5	98	3	389*	325	390	251	1,340	--	--	--	--	--	--	0.4
345750110482501	3/2/1966	2,100	8.1	60	45	310	140	500	183	1,150	--	--	--	--	--	--	0.2
345750110482501	3/3/1966	1,850	7.5	82	44	250	130	410	258	1,040	--	--	--	--	--	--	0.2
345750110482501	6/13/1989	2,500	7.7	83	39	350*	140	520	--	1,270	--	<1	--	<100	3	6	0.2
345750110482501	5/1/1990	2,400	7.7	72	35	310*	130	560	--	1,250	--	--	--	--	--	--	0.3
345750110482501	7/9/1991	2,300	7.7	73	38	340*	140	500	260	1,230	--	--	--	--	--	--	0.2
345750110482501	5/21/1992	2,270	7.7	74	44	350*	140	490	255	1,240	sodium-chloride	--	--	--	--	--	0.1
345750110482501	5/5/1993	2,450	--	80	40	360*	140	570	--	1,330	--	--	--	--	--	--	0.3
345750110482501	5/26/1994	2,440	7.6	82	40	360*	130	570	--	1,320	--	--	--	--	--	--	0.2
345750110482501	5/4/1995	2,400	7.5	81	40	340*	130	510	--	1,240	--	--	--	--	--	--	0.2
345750110482501	5/7/1996	2,340	7.5	74	37	340*	130	510	--	1,230	--	--	--	--	--	--	0.2
345750110482501	4/17/1997	2,410	7.7	81.7	36.9	373*	139	615	--	1,390	--	--	--	--	--	--	0.17
345750110482501	6/1/1999	2,300	7.7	73.3	35.9	322*	131	528	--	1,230	--	--	--	--	--	--	0.18
345750110482501	6/13/2000	2,290	7.7	77	36.7	324*	135	517	--	E 1230	--	--	--	--	--	--	0.17
345750110482501	9/5/2001	2,350	7.5	81	39	330*	130	490	--	1,210	--	--	--	--	--	--	0.2
345750110482501	5/23/2007	1,110	7.8	80.2	36.4	323*	135	526	--	E 1240	--	0.68	--	29.2	0.13	1.5	0.2
345750110482501	6/18/2008	2,400	7.6	80	36.2	326*	137	506	--	E 1220	--	0.79	--	27	0.352	11.4	0.22
345750110482701	11/21/1933	--	--	67	37	3.5	105	11	246	--	calcium-bicarbonate	--	--	--	--	--	0
345750110482801	3/2/1966	2,100	8.1	60	45	310	140	500	183	--	--	--	--	--	--	--	0.2
345750110482801	5/4/1966	1,870	7.6	80	42	250	132	395	262	--	sodium-chloride	--	--	--	--	--	0.1
345757110484301	11/15/1953	--	7.4	60	40	161*	140	212	276	762	--	--	--	--	--	--	0
345757110484301	1/8/1955	--	7.7	70	37	93*	100	246	276	689	--	--	--	--	--	--	0
345757110484301	4/27/1955	--	8.1	66	42	140*	125	208	264	714	--	--	--	--	--	--	0

Table 2. Selected field parameters and water-chemistry data for Coconino aquifer groundwater sites included in this study, northeastern Arizona (U.S. Geological Survey, 2023).—Continued

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USGS site number	Sample date	SC (µS/cm)	pH	Ca^{2+} (mg/L)	Mg^{+} (mg/L)	Na^{+} + K^{+} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)	HCO- (mg/L)	TDS (mg/L)	Water type	Arsenic (µg/L)	Uranium (µg/L)	Barium (µg/L)	Lead (µg/L)	Copper (µg/L)	Fluoride (mg/L)
345757110484301	7/13/1955	--	7.9	66	49	117*	120	202	254	688	--	--	--	--	--	--	0
345757110484301	11/14/1955	--	7.9	63	47	143*	120	226	264	736	--	--	--	--	--	--	0.2
345757110484301	1/2/1957	--	7.6	62	44	140*	140	200	256	720	--	--	--	--	--	--	0.1
345757110484301	6/5/1957	--	7.5	66	46	169*	95	284	266	798	--	--	--	--	--	--	0.1
345757110484301	12/6/1957	--	7.5	76	35	147*	140	216	244	742	--	--	--	--	--	--	0.1
345757110484301	5/2/1958	--	7.6	67	38	115*	80	206	242	631	--	--	--	--	--	--	0.1
345757110484301	1/4/1959	--	7.9	68	44	193*	160	258	290	872	--	--	--	--	--	--	0.1
345757110484301	11/17/1959	--	7.3	70	43	133*	90	226	276	708	--	--	--	--	--	--	0.5
345757110484301	6/16/1960	--	7.6	75	44	144*	135	224	271	769	--	--	--	--	--	--	0.1
345757110484301	2/17/1961	--	7.7	78	37	158*	140	224	276	793	--	--	--	--	--	--	0.4
345757110484301	6/3/1963	--	7.7	101	22	215*	135	312	276	931	--	--	--	--	--	--	0
345757110484301	10/16/1964	--	7.7	125	7	202*	120	294	293	903	--	--	--	--	--	--	0.3
345757110484301	11/17/1964	1,370	8.6	38	44	180	123	280	150	--	--	--	--	--	--	--	0.2
345757110484301	10/25/1965	--	7.5	92	10	294*	230	308	288	807	sodium-chloride	--	--	--	--	--	0.3
345800111184701	8/4/1995	530	7.8	54	22	18.4	23	27	--	307	--	--	--	--	--	--	0.4
345821110295101	3/3/1970	6,670	--	320	58	1,100*	830	1,760	164	--	sodium-chloride	--	--	--	--	--	0.7
345840110513001	8/22/1995	570	7.7	67	31	9	98	9	--	342	--	--	--	--	--	--	0.2
345859110381801	6/30/2005	6,250	7.2	92.9	65.3	1,148.58	301	1,750	284	E 3500	--	<0.6	--	23.3	0.25	1.4	0.32
345859110381801	6/28/2006	6,390	7.4	90.6	58.9	1,108.08	296	1,750	248	E 3430	sodium-chloride	0.75	--	23.4	E 0.18	<1.2	0.32
345859110381801	9/20/2017	6,110	7.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345859110381801	6/19/2019	6,040	7.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
345906110383301	6/30/2005	6,300	7.3	98.3	68.1	1,188.86	299	1,710	280	E 3510	--	<0.6	--	29	E 0.14	1.4	0.33
345906110383301	6/28/2006	6,180	7.6	89.8	57.2	1,087.97	288	1,680	280	E 3340	sodium-chloride	0.75	--	28.2	<0.08	E 0.36	0.32
345910110352001	3/8/1967	4,500	7.2	280	39	730	680	1,060	274	2,930	--	--	--	--	--	--	0.6
345910110352001	8/12/1992	4,650	7.9	80	37	816	220	1,200	282	2,510	sodium-chloride	--	--	--	--	--	0.2
345942110462401	11/20/1933	--	--	218	63	340	632	510	198	--	--	--	--	--	--	--	0
345942110462401	3/2/1966	2,080	7.5	78	39	300	140	470	246	--	sodium-chloride	--	--	--	--	--	0.3
350002110355501	6/16/1972	5,870	7.5	150	64	1007.5	52	1,500	267	3,380	sodium-chloride	--	--	--	--	--	0.2
350030110420901	4/16/1971	2,380	--	64	26	386*	65	690	--	--	--	--	--	--	--	--	0.33
350040110384401	6/13/1966	--	--	105	49	920*	300	1,360	283	--	sodium-chloride	--	--	--	--	--	0.3
350042110425601	2/8/1979	4,400	--	70	38	773.9	100	1,200	200	2,290	sodium-chloride	--	--	--	--	--	0.2
350050110424801	1/21/1954	--	7.6	53	38	630	120	920	260	2,040	sodium-chloride	--	--	--	--	--	0.2

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USGS site number	Sample date	SC (µS/cm)	pH	Ca^{2+} (mg/L)	Mg^{+} (mg/L)	Na^{+} + K^{+} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)	HCO- (mg/L)	TDS (mg/L)	Water type	Arsenic (µg/L)	Uranium (µg/L)	Barium (µg/L)	Lead (µg/L)	Copper (µg/L)	Fluoride (mg/L)
350050110424801	8/12/1992	3,500	8.1	58	37	572.4	98	920	--	1,820	--	--	--	--	--	--	0.1
350051110430001	1/9/1979	4,500	7.9	64	36	854.5	110	1,300	230	2,490	--	--	--	--	--	--	0.2
350051110430001	8/12/1992	4,550	8	70	38	802.9	130	1,200	227	2,360	sodium-chloride	--	--	--	--	--	0.1
350124110450901	11/2/1978	2,750	--	92	34	412.3	170	670	230	1,500	sodium-chloride	--	--	--	--	--	0.2
350125110450801	11/28/1967	2,760	7.5	84	40	430	155	665	244	1,500	--	--	--	--	--	--	0.4
350125110450801	1/21/1972	2,500	7.8	80	38	373*	110	750	192	--	sodium-chloride	--	--	--	--	--	--
350150111040001	6/22/1966	652	7.2	50	49	17	154	12	230	417	calcium-bicarbonate	--	--	--	--	--	0.1
350158110403601	2/27/1979	6,650	7.7	79	60	1212	300	1,800	190	3,550	sodium-chloride	--	--	--	--	--	0.2
350205110513301	11/11/1933	--	--	79	47	240	135	392	264	--	--	--	--	--	--	--	0
350205110513301	5/11/1966	1,890	7.3	73	47	260	135	413	265	--	--	--	--	--	--	--	0.1
350205110513301	10/5/1978	1,880	7.3	76	42	241.9	150	390	250	1,030	calcium-bicarbonate	--	--	--	--	--	0.2
350210110560001	6/18/1966	512	8	--	--	--	--	--	--	309	--	--	--	--	--	--	0.2
350210110560001	11/28/1967	814	7.4	80	38	27*	123	60	248	465	calcium-bicarbonate	--	--	--	--	--	0.4
350210111011001	11/1/1966	992	7.7	103	54	46	358	34	194	706	--	--	--	--	--	--	0.3
350210111011001	6/22/1978	950	7.4	110	49	38.8	320	37	190	660	--	--	--	--	--	--	0.2
350210111011001	8/10/1992	1,000	7.8	110	47	39.6	340	37	181	674	calcium-sulfate	--	--	--	--	--	<0.1
350400111004001	11/20/1933	--	--	94	44	16	226	21	224	512	--	--	--	--	--	--	0
350400111004001	6/10/1966	778	7.5	91	40	18	205	21	230	502	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.2
350400111004001	8/2/1995	720	7.9	72	35	23.3	200	20	--	435	--	--	--	--	--	--	0.1
350407110332101	5/2/1966	12,100	11.1	--	--	--	--	--	--	6,580	--	--	--	--	--	--	0.5
350414110412201	4/30/1965	3,390	7.4	57	26	620	200	840	254	2,200	sodium-chloride	--	--	--	--	--	0.7
350417110413301	4/30/1965	3,370	7.6	51	27	620	190	840	246	2,190	sodium-chloride	--	--	--	--	--	0.6
350420110590001	6/18/1966	805	7.5	101	34	28	212	29	236	537	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.3
350427110512501	3/8/1954	1,420	--	76	42	160	132	250	258	798	sodium-chloride	--	--	--	--	--	0.6
350428110484901	10/11/1965	3,400	7.9	100	42	584.9	224	898	231	1,970	--	--	--	--	--	--	0.1
350428110484901	9/21/1966	3,800	7.2	158	50	574*	328	930	238	2,170	sodium-chloride	--	--	--	--	--	0.2
350428110484901	8/16/1995	3,300	7.6	70	44	551.8	160	840	--	1,800	--	--	--	--	--	--	0.2
350440110411801	4/30/1965	2,560	7.6	78	25	430	160	595	272	--	sodium-chloride	--	--	--	--	--	0.6
350446110502501	8/22/2006	2,870	8.1	75.5	35.6	429.99	145	698	239	1,510	sodium-chloride	1.2	--	28.8	1.28	2.3	0.19
350447110502301	10/25/1978	2,850	7.5	84	38	462.6	160	760	240	1,640	sodium-chloride	--	--	--	--	--	0.2
350450110522001	8/19/1966	1,340	7.5	78	40	160	153	227	264	801	--	--	--	--	--	--	--
350450110522001	10/30/1978	1,300	--	68	37	161.8	140	240	250	783	sodium-chloride	--	--	--	--	--	0.2
350451110494901	8/21/1954	2,800	7.8	74.4	41.8	550	175	830	244	--	--	--	--	--	--	--	0.1

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USGS site number	Sample date	SC (µS/cm)	pH	Ca^{2+} (mg/L)	Mg^{+} (mg/L)	Na^{+} + K^{+} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)	HCO- (mg/L)	TDS (mg/L)	Water type	Arsenic (µg/L)	Uranium (µg/L)	Barium (µg/L)	Lead (µg/L)	Copper (µg/L)	Fluoride (mg/L)
350451110494901	11/3/1958	2,810	7.3	76	39	460	152	705	241	1,560	--	--	--	--	--	--	0.4
350451110494901	11/13/1958	2,810	7.6	76	38	460	146	705	243	1,560	sodium-chloride	--	--	--	--	--	0.3
350518110554801	11/20/1933	750	--	78	43	33	157	63	232	488	--	--	--	--	--	--	0
350518110554801	3/12/1953	808	--	78	40	33	143	64	233	--	--	--	--	--	--	--	0.2
350518110554801	5/12/1966	799	7.6	76	40	36	147	62	236	490	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.1
350538110560401	12/5/1978	750	7.5	88	34	38.7	170	62	210	508	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.2
350600111015001	7/8/1946	891	--	105	45	31	280	26	225	600	--	--	--	--	--	--	0
350600111015001	5/1/1966	890	7.5	106	44	30	281	24	224	608	calcium-sulfate	--	--	--	--	--	0.2
350618111015601	8/10/1992	880	7.8	110	42	22.5	270	25	206	584	calcium-sulfate	--	--	--	--	--	< 0.1
350637110485401	2/26/1934	3,510	--	87	46	720	176	1,120	262	2,280	--	--	--	--	--	--	0
350637110485401	12/5/1978	3,600	7.8	36	23	643.9	170	1,000	40	1,890	sodium-chloride	--	--	--	--	--	0.2
350653110573801	5/11/1966	975	7.6	87	42	63	193	100	223	--	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.1
350700111054001	9/18/1967	407	7.6	55	20	2.3	7	2.5	264	231	calcium-bicarbonate	--	--	--	--	--	0.1
350700111054001	8/2/1995	410	7.7	49	21	4.8	10	1.4	--	225	--	--	--	--	--	--	0.1
350706111014701	11/20/1933	--	--	108	50	25	295	26	226	--	--	--	--	--	--	--	0
350706111014701	3/3/1953	859	--	98	47	20	269	22	207	--	--	--	--	--	--	--	0.3
350706111014701	10/12/1978	850	7.6	89	41	26.7	240	23	200	529	--	--	--	--	--	--	0.2
350706111014701	2/28/2005	860	7.5	107	45.5	27.84	265	21.7	217	587	--	0.5	--	12.6	0.101	1.1	0.23
350706111014701	2/28/2005	856	7.5	106	44.9	27.78	265	21.6	207	E 582	calcium-sulfate	0.5	--	12.4	E 0.075	1	0.22
350756111154001	9/18/1967	607	7.4	56	33	16	126	23	178	354	--	--	--	--	--	--	0.2
350756111154001	7/12/1978	600	7.8	58	31	23	120	22	170	352	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.2
350810111105001	9/18/1967	1,080	7.2	101	58	35	345	51	164	692	calcium-sulfate	--	--	--	--	--	0.2
350816110531001	1/3/1979	1,220	7.8	95	47	112.5	190	180	240	755	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.1
350839111005301	5/12/1966	832	7.5	86	45	36	253	36	198	565	calcium-sulfate	--	--	--	--	--	0.1
350845110540101	5/11/1966	1,360	7.5	98	50	110	225	189	236	800	--	--	--	--	--	--	0
350845110540101	12/5/1978	1,300	7.5	79	46	122.5	250	220	170	806	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.1
350909111165401	9/18/1967	454	7.5	48	27	3.9	32	8	236	251	--	--	--	--	--	--	0.2
350909111165401	7/12/1978	450	7.4	44	27	9.7	45	7.6	210	254	calcium-bicarbonate	--	--	--	--	--	0.2
350957110562601	2/9/2005	1,230	8.3	88.6	43.5	120.15	267	125	217	767	--	1.3	--	25.3	0.082	2.5	0.32
350957110562601	2/24/2005	1,160	7.9	102	52.8	77.53	250	123	232	E 734	--	0.4	--	16.9	E 0.04	1.3	0.25
350957110562601	2/24/2005	1,160	7.8	104	53.5	79.87	251	123	220	734	calcium-magnesium-chloride sulfate	0.5	--	19.1	<0.08	1.1	0.26

Table 2. Selected field parameters and water-chemistry data for Coconino aquifer groundwater sites included in this study, northeastern Arizona (U.S. Geological Survey, 2023).—Continued

[**Sample date:** MM/DD/YYYY, month/day/year. **Water type:** Water type refers to major ion distribution and is only listed if used in the analysis (most recent complete sample). **Abbreviations:** SC, specific conductance; µS/cm, microsiemens per centimeter; Ca^{2+} , calcium; Mg^{+}, magnesium; mg/L, milligrams per liter, Na^{+} + K^{+}, sodium+potassium; SO_4^{2-}, sulfate; Cl, chloride; HCO-, bicarbonate; TDS, total dissolved solids; --, no data available; E, estimate; <, less than]

USGS site number	Sample date	SC (µS/cm)	pH	Ca^{2+} (mg/L)	Mg^{+} (mg/L)	Na^{+} + K^{+} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)	HCO- (mg/L)	TDS (mg/L)	Water type	Arsenic (µg/L)	Uranium (µg/L)	Barium (µg/L)	Lead (µg/L)	Copper (µg/L)	Fluoride (mg/L)
350957110562601	3/23/2005	1,180	7.3	106	55.1	75.08	247	121	--	E 742	--	<2	2.45	16.5	E 0.052	<2	0.25
350958110562201	2/9/2005	1,200	7.7	107	50.7	82.6	253	129	216	742	calcium-magnesium-chloride sulfate	1	--	15	0.08	2.4	0.23
351001110562601	5/11/1954	1,170	--	100	45	85	260	130	220	736	--	--	--	--	--	--	0.2
351001110562601	6/6/1973	1,180	7.9	100	44	82.4	280	130	200	760	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.35
351022111061801	2/21/2005	1,180	8.1	122	56.7	58.82	385	64.9	194	797	--	0.2	--	14.3	0.108	1.6	0.21
351022111061801	2/25/2005	1,180	7.6	125	59.2	61.6	386	65.4	186	803	--	0.5	--	15.7	0.346	1.5	0.22
351022111061801	2/25/2005	1,190	7.6	127	59.5	61.51	386	65.4	188	808	calcium-sulfate	0.6	--	14.8	0.66	1.8	0.23
351023111062002	2/13/2005	1,170	8	110	51.6	57.03	385	65.2	193	E 779	--	0.2	--	19.4	E 0.071	3.1	0.2
351023111062002	2/19/2005	1,160	7.6	124	57.8	60.67	384	66.1	172	E 793	--	0.3	--	14.9	E 0.054	1.4	0.24
351023111062002	2/19/2005	1,170	7.6	124	58.1	60.06	383	62.7	176	E 789	calcium-sulfate	0.4	--	15.8	E 0.064	3	0.22
351023111062002	3/15/2005	1,150	7.3	127	59.2	59.61	379	64.6	--	E 791	--	<2	4.6	11.8	0.177	<2	0.21
351052110491701	10/12/1955	8,340	7.2	130	52	1,700	450	2,510	300	5,010	--	--	--	--	--	--	0.6
351052110491701	6/6/1973	8,620	8	100	44	1,706.30	380	2,600	220	5,030	sodium-chloride	--	--	--	--	--	0.53
351053110332501	4/7/1964	8,330	7.8	190	10	1,800	1,470	1,960	82	5,470	sodium-chloride	--	--	--	--	--	1.3
351122111101301	9/7/1950	1,160	--	--	--	--	--	--	--	753	--	--	--	--	--	--	0.2
351142110563401	9/7/1950	1,470	--	98	53	140	246	218	235	881	--	--	--	--	--	--	0.2
351142110563401	9/8/1965	1,530	8.1	98.2	49.9	144.32	232	220	192	944	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.15
351144111161201	9/18/1967	633	7.4	54	34	20	135	30	166	368	--	--	--	--	--	--	0.3
351144111161201	3/7/1979	610	7.7	51	35	26.5	180	28	150	422	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.3
351214111022101	4/22/2005	841	7.4	98.3	42.6	29.41	255	21.6	200	E 561	--	E 0.2	--	16.2	E 0.061	1	0.25
351214111022101	4/22/2005	842	7.4	100	43.5	29.32	255	21.7	201	E 563	calcium-sulfate	0.2	--	14.8	0.13	1.1	0.26
351215111021701	9/7/1950	840	--	90	48	23	264	22	202	--	calcium-sulfate	--	--	--	--	--	0.2
351238111084101	4/22/1955	1,020	7.3	67	40	100	312	48	190	--	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.4
351442110581601	9/8/1965	1,190	8	102	43	77.6	222	107	198	744	--	--	--	--	--	--	0.2
351442110581601	4/19/1973	1,120	7.9	104	41.3	68.7	203	112	196	752	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.25
351448111012701	9/8/1965	1,020	8	98.2	38	57.9	249	76	177	676	--	--	--	--	--	--	0.2
351448111012701	10/11/1978	990	7.7	91	40	59	250	72	210	629	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.2
351519111120701	11/20/1953	346	--	41	20	4.1	11	4.5	211	199	calcium-bicarbonate	--	--	--	--	--	0.4
351525111035801	11/2/1953	846	--	94	44	26	235	34	217	555	--	--	--	--	--	--	0.6

Table 2. Selected field parameters and water-chemistry data for Coconino aquifer groundwater sites included in this study, northeastern Arizona (U.S. Geological Survey, 2023).—Continued

[**Sample date:** MM/DD/YYYY, month/day/year. **Water type:** Water type refers to major ion distribution and is only listed if used in the analysis (most recent complete sample). **Abbreviations:** SC, specific conductance; µS/cm, microsiemens per centimeter; Ca^{2+} , calcium; Mg^{+}, magnesium; mg/L, milligrams per liter, Na^{+} + K^{+}, sodium+potassium; SO_4^{2-}, sulfate; Cl, chloride; HCO-, bicarbonate; TDS, total dissolved solids; --, no data available; E, estimate; <, less than]

USGS site number	Sample date	SC (µS/cm)	pH	Ca^{2+} (mg/L)	Mg^{+} (mg/L)	Na^{+} + K^{+} (mg/L)	SO_4^{2-} (mg/L)	Cl^{-} (mg/L)	HCO- (mg/L)	TDS (mg/L)	Water type	Arsenic (µg/L)	Uranium (µg/L)	Barium (µg/L)	Lead (µg/L)	Copper (µg/L)	Fluoride (mg/L)
351525111035801	9/8/1965	880	8.2	90.2	40.1	36.34	253	29.4	167	590	calcium-sulfate	--	--	--	--	--	0.25
351739111001501	9/7/1965	1,430	--	98.2	49.9	132.64	226	194	205	906	--	--	--	--	--	--	0.25
351739111001501	3/17/1966	--	--	96.2	47.4	129.98	239	198	197	880	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.15
351748110592301	9/8/1965	1,740	7.6	110	51	183.8	245	280	240	1,080	--	--	--	--	--	--	0.3
351748110592301	3/17/1966	1,680	--	98	50	182	260	290	220	1,040	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.3
351749111003401	4/5/1959	1,400	7.4	100	46	120	240	200	230	847	--	--	--	--	--	--	0.4
351749111003401	9/7/1965	1,470	7.8	96	50	133.3	240	200	210	908	--	--	--	--	--	--	0.2
351749111003401	6/25/1969	1,390	7.8	93	45	142	190	200	230	860	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.1
351758111000901	3/5/1958	--	8.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--
351758111000901	7/11/1960	--	9.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
351758111000901	3/17/1966	1,380	--	96	49	132	240	200	200	890	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.2
351804111060301	8/19/1951	1,840	--	102	49	210	258	340	209	1,080	--	--	--	--	--	--	0.2
351804111060301	9/8/1965	1,900	8.1	92.2	46.2	218.93	251	339	141	1,130	--	--	--	--	--	--	0.2
351804111060301	3/3/1967	1,840	--	77.2	44.4	227.74	288	345	188	1,160	--	--	--	--	--	--	0.2
351804111060301	11/2/1972	1,750	8.1	72.1	47.4	211.35	237	345	118	1,090	sodium-chloride	--	--	--	--	--	0.18
351815110505001	5/30/1959	8,350	7.6	430	130	1,500	910	2,600	276	5,800	--	--	--	--	--	--	--
351815110505001	5/31/1959	8,500	7.7	450	110	1,500	900	2,600	246	5,800	sodium-chloride	--	--	--	--	--	--
351818110054901	4/14/1953	1,030	--	94	44	63	230	100	208	646	--	--	--	--	--	--	0.2
351818110054901	9/7/1965	1,380	8	102	46.2	111.05	236	185	204	870	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.2
351831111054501	9/7/1965	1,100	8	90.2	42.6	71.58	216	107	206	702	calcium-magnesium-chloride sulfate	--	--	--	--	--	0.2
351930111184801	7/18/1965	756	7.5	49	53	33	221	25	182	--	calcium-sulfate	--	--	--	--	--	0.3
351930111184801	7/31/1995	740	8	54	43	34.9	210	20	--	455	--	--	--	--	--	--	0.2
352117111132901	7/6/1972	2,710	8.5	106	48.6	371.65	301	597	161	1,710	sodium-chloride	--	--	--	--	--	0.3
352119111132901	6/10/1951	2,610	--	104	59	360	275	598	201	1,510	sodium-chloride	--	--	--	--	--	0.2
352226111081401	4/7/1955	2,020	7.8	83	62	260	262	395	235	1,190	sodium-chloride	--	--	--	--	--	0.2

*Sodium only is reported.

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