Hydrologic Benchmark Network Stations in the Western U.S. 1963-95 (USGS Circular 1173-D)

Wet Bottom Creek near Childs, Arizona (Station 09508300)

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This report details one of the approximately 50 stations in the Hydrologic Benchmark Network (HBN) described in the four-volume U.S. Geological Survey Circular 1173. The suggested citation for the information on this page is:

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All of the tables and figures are numbered as they appear in each circular. Use the navigation bar above to view the abstract, introduction and methods for the entire circular, as well as a map and list of all of the HBN sites. Use the table of contents below to view the information on this particular station.

Table of Contents

Site Characteristics and Land Use

The Wet Bottom Creek HBN Basin is in the Mexican Highland of the Basin and Range physiographic province in central Arizona (Figure 2. *Map showing study area in the Wet Bottom Creek Basin and photograph showing the basin landscape*). The 94 at the HBN

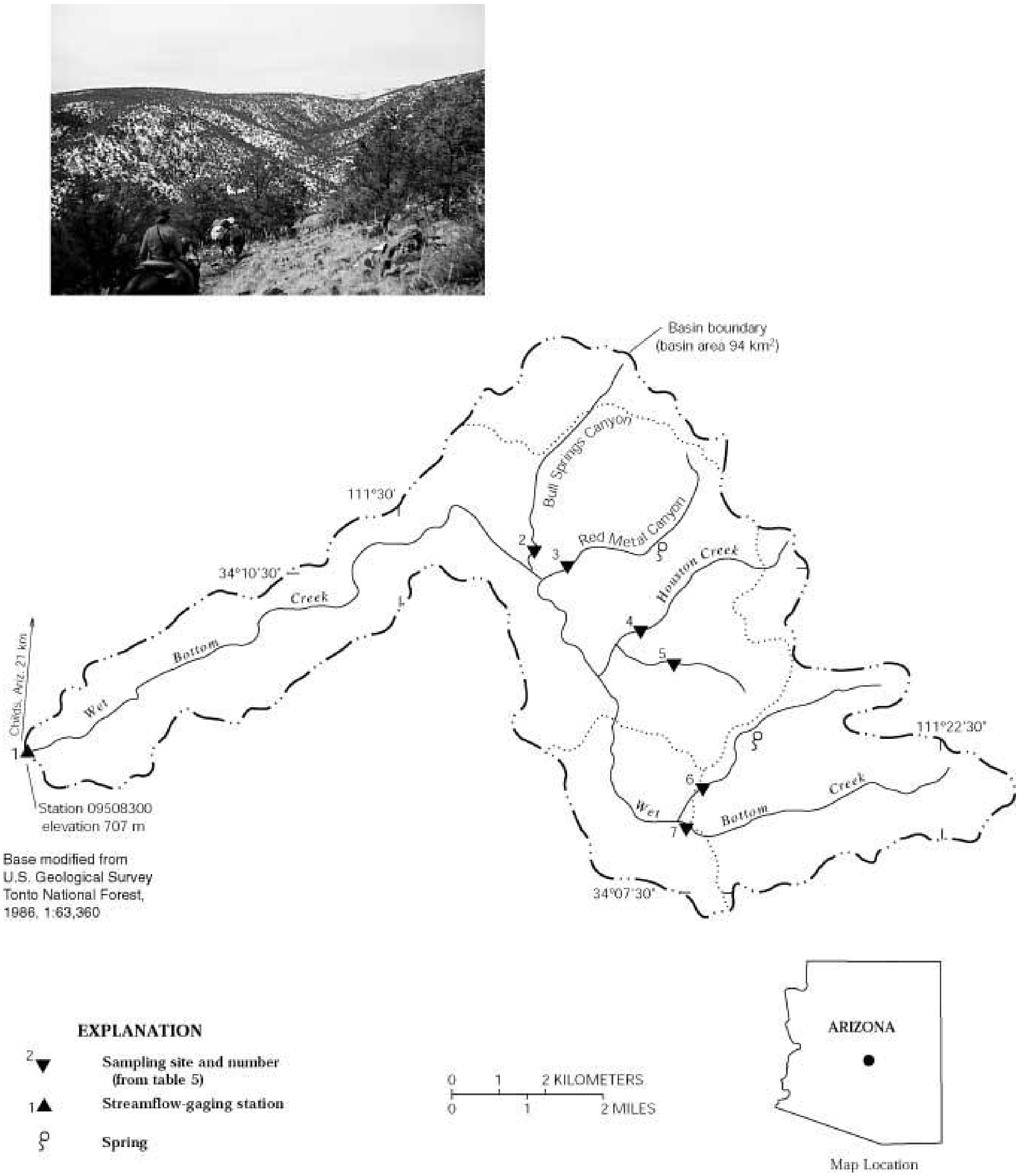

Figure 2. *Map showing study area in the Wet Bottom Creek Basin and photograph showing the basin landscape*

station to 2,271 m along the eastern boundary. Topography consists of west-sloping mesas and ridges separated by steep canyons. The USGS station is located 21 km south of the town of Childs, Ariz., at latitude 34°09'39" and longitude 111°41'32". Wet Bottom Creek flows west into the Verde River, a tributary of the Colorado River, and has a channel length of 28 km upstream from the HBN station and an average stream gradient of 40 m/km. The main channel is ephemeral, often having no flow during June and July. Peak flows usually occur during February and March when spring rains combine with melting snow. Average monthly discharge ranges from 0.003 m3/s in June to 1.4 m3/s in March, and average annual runoff was 15.5 cm from 1968 through 1995 (Smith and others, 1996). The area has a high-elevation desert climate, with substantial diurnal temperature variations. Summers are hot and dry, and winters are cool and wet. Average daily temperatures range from 7.7°C in December to 29.4° C in July (National Weather Service at URL http://www.wrcc.dri.edu/climsum.html, accessed 1998). Snowfall is common at high elevations during the winter months; however, a seasonal snowpack seldom persists through the winter. Average annual precipitation is 63.5 cm and varies seasonally from 1 cm in June to 6.6 cm in August when thunderstorms are most common.

The basin is located in the Colorado Plateau Semidesert ecoregion (Bailey and others, 1994). Vegetation grows in zones defined by temperature and soil-moisture regimes, which are in turn dictated by elevation and aspect (Bailey and others, 1994). Low elevations are dominated by arid grasslands characterized by thin, patchy grass and xeric shrubs; cottonwoods grow along some of the streambanks. The woodland zone, which is above the grasslands, is dominated by low, open stands of pinyon pine and juniper. Groundcover includes grama grass, herbs, and shrubs, such as big sagebrush and alderleaf cercocarpus. The montane zone is on the high plateaus and mountains and is characterized by ponderosa pine and occasionally by Douglas-fir. Soils developed along flood plains of major streams are classified as Entisols, and those covering plateau tops, old stream terraces, and alluvial fans are classified as Aridisols (Bailey and others, 1994). Badlands of broken rock and steep slopewash deposits are extensive in the mountains and on the plateaus.

The geology and mineral resources of the Wet Bottom Creek Basin have been mapped by Wrucke and others (1983) and Wrucke and Conway (1987). The predominant rock type is alkali granite, which crops out in the southern two-thirds of the basin. The mineralogy of the granite includes quartz, feldspar, biotite, with minor amounts of tourmaline and hematite. Locally, the granite contains deposits of tin, although the resource potential is low (Wrucke and others, 1983). Basalt, andesite, graywacke, siltstone, and volcaniclastic rocks are the main rock types in the northeastern part of the basin. Small outcrops of dolomite and limestone also are present in this part of the basin. An area of silver and copper sulfide mineralization is mapped near the northeastern boundary of the study area, which is associated with mafic volcanic rocks.

The Wet Bottom Creek HBN Basin is in the Tonto National Forest and is mostly in the Mazatzal Wilderness Area, which was created in 1964. The HBN station is accessed by flying in a helicopter to a marked landing site near the station. Hiking trails provide access to some of the canyons and plateaus, but much of the basin is relatively inaccessible. The closest access by road is from a trailhead 5 km east of the basin boundary. The basin is protected from human effects except for a minor amount of livestock grazing (Lawrence, 1987). Prospecting has occurred intermittently in the area since the 1870's; however, only one prospect pit is mapped in the Wet Bottom Creek Basin.

Historical Water-Quality Data and Time-Series Trends

The data set for the Wet Bottom Creek HBN station analyzed for this report includes 174 water-quality samples that were collected from August 1968 through July 1995. Sampling frequency ranged from 6 to 11 times per year from 1969 to 1982, then was quarterly from 1983 to 1995. Samples from the early part of the period of record probably were analyzed at a USGS district laboratory in Yuma, Ariz. (Durum, 1978). After establishment of the central laboratory system, samples were analyzed at the Salt Lake City, Utah, laboratory from 1973 to 1975 and at the NWQL in Arvada, Colo., from 1976 through 1995. Daily discharge records for Wet Bottom Creek (station 09508300) are available beginning in June 1967.

Calculated ion balances for 173 samples that have complete major-ion analyses are shown in figures 3a and 3b. *Graphs showing temporal variation of discharge, field pH, major-ion concentrations, and ion balance in Wet Bottom Creek, Arizona.* Ion balances ranged from -12 to +17 percent, and 90 percent of the samples had values within the ±5 determinations, issued February 25, 1983, at URL http://water.usgs.gov/admin/memo/) followed by a change to ion chromatography in 1990 (Fishman and others, 1994). The stepped pattern in the time-series plot for concentrations of nitrite plus nitrate was caused by changes in the analytical reporting limit for this constituent that occurred in 1982 and again in 1991.

The median concentrations and ranges of major dissolved constituents in stream water collected at the HBN station and VWM concentrations in wet-only precipitation measured at the Oliver Knoll NADP station are presented in table 2. Precipitation chemistry at the NADP station, which is about 200 km southeast of the HBN station, is dilute and acidic and has a VWM pH of 4.8 for 15 years of record. The predominant cations in precipitation were hydrogen and calcium, which contributed 38 and 24 percent of the total cation charge, respectively. The predominant anions were sulfate and nitrate, which accounted for 64 and 27 percent of the total anion charge, respectively. The predominance of strong acid anions in precipitation may indicate that the chemistry at the NADP station is affected by industrial emissions of sulfur and nitrogen compounds that cause acid rain.

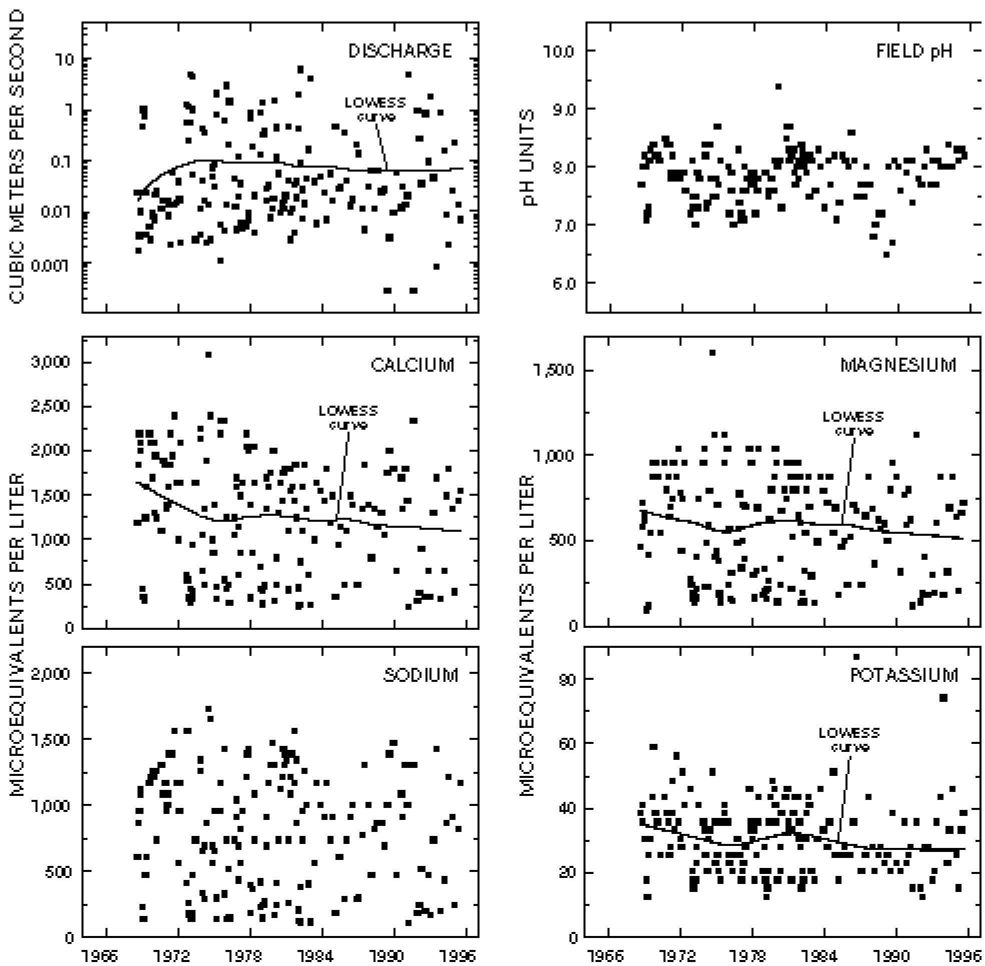

Figure 3a. ***Graphs showing temporal variation of discharge, field pH, major-ion concentrations, and ion balance in Wet Bottom Creek, Arizona.***

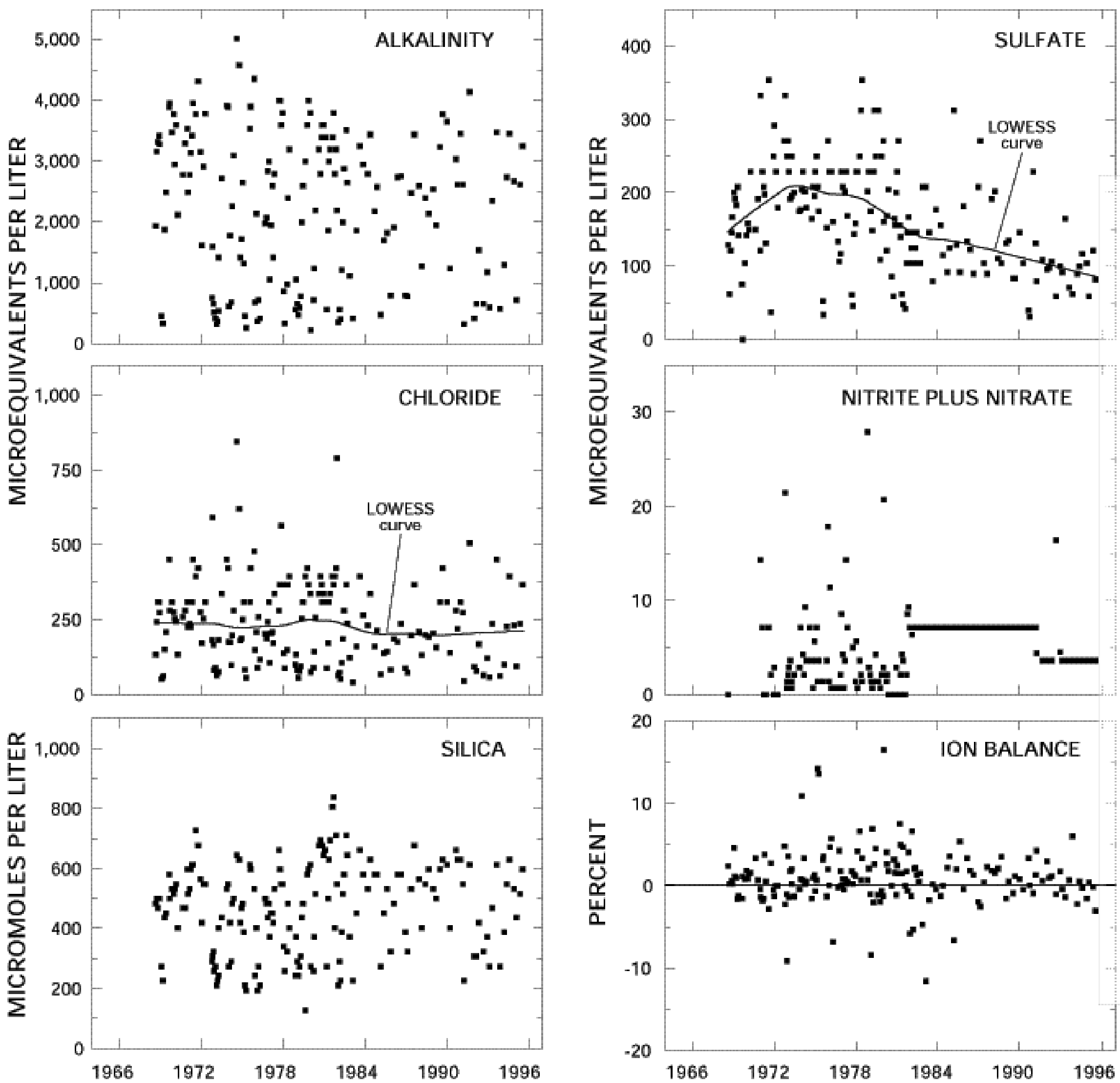

Figure 3b. ***Graphs showing temporal variation of discharge, field pH, major-ion concentrations, and ion balance in Wet Bottom Creek, Arizona - Continued***

Table 2. Minimum, first quartile, median, third quartile, and maximum values of physical properties and major dissolved constituents measured in water-quality samples from Wet Bottom Creek, Arizona, August 1968 through July 1995, and volume-weighted mean concentrations in wet precipitation collected at the Oliver Knoll Station, Arizona

[Concentrations in units of microequivalents per liter, discharge in cubic meters per second, specific conductance in microsiemens per centimeter at 25 degrees Celsius, pH in standard units, and silica in micromoles per liter; n, number of stream samples; VMW, volume-weighted mean; inst., instantaneous; spec. cond., specific conductance; <, less than; --, not reported]

Parameter	Stream Water						Precipitation VMA[a]
	Minimum	First Quartile	Median	Third Quartile	Maximum	n	
Discarge, inst.	0.00028	0.0099	0.025	0.19	6.2	173	--
Spec. cond., field	17	130	280	360	580	172	11
pH, field	6.5	7.6	7.9	8.1	9.4	166	4.8[b]
Calcium	240	610	1,350	1,790	3,100	174	9.9
Magnesium	88	300	620	880	1,600	174	2.4
Sodium	110	410	850	1,170	1,740	174	4.1
Potassium	13	23	31	38	87	174	0.5
Ammonium	<.7	.8	2.1	4.3	13	74	9.3
Alkalinity, laboratory	220	1,000	2,500	3,300	5,020	174	--
Sulfate	31	100	160	210	350	173	28
Chloride	42	140	230	310	850	174	3.9
Nitrite plus nitrate	<.7	1.4	3.6	7.1	28	151	12[c]
Silica	130	350	480	580	840	174	--

[a] Values are volume-weighted mean concentrations for 1981-95.

[b] Laboratory pH.

[c] Nitrate only.

Stream water in Wet Bottom Creek is fairly concentrated and strongly buffered; specific conductance ranged from 17 to 580 mS/cm and alkalinity ranged from 220 to 5,020 meq/L (table 2). The major cations in stream water were calcium and sodium, and the major anion was bicarbonate. The predominance of these solutes in stream water, in addition to relatively high concentrations of silica, is attributed to the weathering of silicate minerals in the alkali granites and volcanic rocks and carbonate minerals in the sedimentary rocks. The median chloride (230 meq/L) and sulfate (160 meq/L) concentrations in stream water were substantially greater than the VWM concentrations of chloride (3.9 meq/L) and sulfate (28 meq/L) in precipitation, indicating that these solutes are derived primarily from sources in the basin. Because land-use activities in the basin are minimal, the most plausible sources of chloride other than wet deposition are wind-blown material from surrounding desert areas (Turk and Spahr, 1991) and weathering of sedimentary rocks in the northeastern part of the basin. Wind-blown material also may be a source of stream-water sulfate; however, most sulfate probably is derived from oxidation of sulfide minerals associated with mineralized areas in the basin. Concentrations of inorganic nitrogen species in stream water were less than the VWM concentrations in precipitation, indicating that most atmospheric nitrogen is retained by vegetation and soils and that livestock grazing in the basin has not substantially affected nutrient concentrations at the HBN station.

Table 3. Spearman rank correlation coefficients (rho values) showing the relation among discharge, pH, and major dissolved constituents, Wet Bottom Creek, Arizona, 1968 through 1995

[Q, discharge; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; Alk, alkalinity; SO4, sulfate; Cl, chloride; N, nitrite plus nitrate; Si, silica]

	Q	pH	Ca	Mg	Na	K	Alk	SO_4	Cl	N
pH	-0.198	--	--	--	--	--	--	--	--	--
Ca	-.888	0.214	--	--	--	--	--	--	--	--
Mg	-.872	.242	0.948	--	--	--	--	--	--	--
Na	-.806	.274	.904	0.943	--	--	--	--	--	--
K	-.632	.295	.723	.751	0.744	--	--	--	--	--
Alk	-.882	.262	.973	.974	.953	0.736	--	--	--	--
SO_4	.339	-.273	-.194	-.206	-.188	-.207	-0.256	--	--	--
Cl	-.800	.215	.887	.896	.923	.736	.901	-0.147	--	--
N	.133	.000	-.111	-.153	-.079	-.115	-.109	-.083	-0.094	--
Si	-.760	.267	.815	.853	.863	.672	.863	-.382	0.780	-0.038

Table 4. Results of the seasonal Kendall test for trends in discharge and unadjusted and flow-adjusted pH and major dissolved constituents, Wet Bottom Creek, Arizona, August 1968 through July 1995

[Trends in units of microequivalents per liter per year, except for discharge in cubic meters per second per year, pH in standard units per year, and silica in micromoles per liter per year; <, less than; --, not calculated]

Parameter	Unadjusted		Flow adjusted	
	Trend	p-value	Trend	p-value
Discharge	0.001	0.001	--	--
pH, field	<.01	.744	0.01	0.169
Calcium	-21.6	.001	-7.8	.006
Magnesium	-8.0	.010	-3.2	.033
Sodium	-7.7	.060	-3.9	.073
Potassium	-.3	.002	-.2	.014
Alkalinity, laboratory	-25.1	.025	4.3	.360
Sulfate	-3.2	.000	-3.4	.000
Chloride	-3.5	.007	-1.0	.111
Nitrite plus nitrate	([a])	--	--	--
Silica	<.1	.608	1.8	.026

[a] Insufficient data to calculate trend.

The solute composition of stream water was further evaluated by analyzing correlations among solutes and stream discharge (table 3). Most weathering-derived solutes had strong inverse correlations with stream discharge, particularly calcium (rho = -0.888) and alkalinity (rho = -0.882). These results are consistent with a hydrologic system where weathering-enriched base flow is diluted by water from shallow or surficial sources during periods of increased discharge, such as spring snowmelt. For the solutes, the strongest correlations were among calcium, magnesium, and alkalinity, which is consistent with the weathering stoichiometry of carbonate minerals. The combination of the strong positive correlations between chloride and the major weathering constituents and the inverse correlation between chloride and discharge may indicate that most stream-water chloride is derived from bedrock weathering rather than from wind-blown dust. The poor correlations between sulfate and other dissolved constituents was unexpected, particularly considering that most sulfate is probably derived from bedrock weathering.

The results of the seasonal Kendall test for trends in discharge and major dissolved constituents are listed in table 4. Statistically significant trends were detected in discharge and in the unadjusted calcium, magnesium, potassium, sulfate, and chloride concentrations at the 0.01 probability level. The trends in magnesium, potassium, and chloride concentrations were not significant using the flow-adjusted data; however, the trends in flow-adjusted calcium and sulfate remained significant, indicating they were not caused by the upward trend in discharge. The LOWESS curves in figure 3 show somewhat different temporal patterns in the calcium and sulfate concentrations during the period of record. Most of the decline in calcium concentrations occurred prior to 1980, whereas most of the decline in sulfate concentrations occurred after 1980. A change in atmospheric deposition is one possible explanation for the declines in stream-water concentrations at this station. Lynch and others (1995), for example, reported significant downward trends in calcium and sulfate concentrations in precipitation at several NADP stations in the Southwestern United States from 1980 to 1992. Although this change in precipitation chemistry is consistent with the downward trend in stream-water sulfate, it cannot account for the decline in stream- water calcium concentrations, which primarily occurred prior to 1980. Alternatively, trends in stream-water chemistry at this station may be caused by method-related factors. For example, the decline in sulfate occurred during a period when there were two changes in the analytical technique for sulfate, one in 1983 and another in 1990 (Fishman and others, 1994). Method-related factors that may have introduced bias into the calcium records include a switch from a district laboratory to the central laboratory system in 1973 and a change in the analytical technique for calcium from atomic absorption (AA) spectroscopy to inductively coupled plasma (ICP) spectroscopy in 1983 (Office of Water Quality Technical Memorandum No. 82.18, National water-quality networks, issued September 28, 1982, at URL http://water.usgs.gov/admin/memo/).

Synoptic Water-Quality Data

Chemical results of the surface-water synoptic sampling of March 23 through 26, 1991, are listed in table 5, and locations of sampling sites are shown in figure 2. During the synoptic sampling, average daily discharge at the HBN station was between 3.2 and 6.3 m3/s compared to the median daily discharge of about 0.2 m3/s for March (Lawrence, 1987), indicating that the basin was sampled during high-flow conditions for that time of year. Because of the flow conditions, most of the solute concentrations measured at the HBN station (site 1) during the sampling period were less than the first-quartile values reported for the station during the entire period of record (table 2). Samples from the upstream sites were similar in composition to the sample at site 1; calcium and bicarbonate were the predominant ions, and their concentrations bracketed the concentrations at site 1. Ion balances for all the synoptic samples were positive (range 1.3 to 15 percent), indicating that unmeasured anions, such as organic anions, may have contributed to the ionic content of stream water during the sampling period. Despite the high-flow conditions in the basin, stream- water chemistry was quite variable, particularly for the weathering-derived constituents. For example, calcium ranged from a minimum of 130 meq/L at site 6 to 650 meq/L at site 2, and alkalinity ranged from 92 meq/L at site 5 to 1,120 meq/L at site 2 (table 5). The observed variation in stream chemistry seems to reflect the distribution of mapped bedrock types in the basin. Sites that had high concentrations (sites 2-4) drain areas underlain by sedimentary and volcanic rocks, whereas sites with more dilute water (sites 5-7) drain areas underlain by granitic bedrock. This relation is demonstrated by comparing the average alkalinity of 800 meq/L at sites 2-4 with the average alkalinity of 100 meq/L at sites 5-7. A similar pattern occurred for calcium concentrations, which averaged 510 meq/L at sites 2-4 compared to 140 meq/L at sites 5-7. This pattern in stream-water concentrations seems to be consistent with the concept that the sedimentary and volcanic rocks contain more weatherable minerals, such as carbonates and mafic silicates, than the chemically resistant granites, which primarily consist of quartz and feldspar.

Table 5. Physical properties and major dissolved constituents from surface-water sampling sites in the Wet Bottom Creek Basin, Arizona, collected March 23-26, 1991

[Site locations shown in fig. 2; Q, discharge in cubic meters per second; SC, specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; Alk, alkalinity; SO4, sulfate; Cl, chloride; NO3, nitrate; Si, silica; concentrations in microequivalents per liter, except silica in micromoles per liter; <, less than; --, not reported]

Site	Station number	Q	SC	pH	Ca	Mg	Na	K	Alk	$S0_4$	Cl	NO_3	Si	Criteria [a]	Remarks
1	09508300	5.07	51	7.4	240	120	110	15	320	79	45	4.4	230	--	--
2	341128111353300	.069	130	8.0	650	500	220	19	1,120	130	99	3.6	330	BG	Sedimentary and volcanic rocks
3	341118111350500	.067	73	7.5	340	220	150	16	480	130	85	<0.7	280	BG	Sedimentary and volcanic rocks
4	341032111340700	.19	100	7.7	550	310	160	13	820	100	73	<0.7	250	BG	Mafic volcanic rocks
5	341011111334200	.13	33	6.7	150	80	83	18	92	92	59	1.4	200	BG	Granite
6	340848111331100	--	27	6.9	130	69	65	14	100	65	37	1.4	170	BG	Granite
7	340819111333600	--	27	6.9	140	62	61	13	120	58	34	0.7	160	BG	Granite

[a] Criterion used in selection of sampling sites: BG = bedrock geology.

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Wrucke, C.T., and Conway, C.M., 1987, Geologic map of the Mazatzal Wilderness and contiguous roadless area, Gila, Maricopa, and Yavapai Counties, Arizona: U.S. Geological Survey Open-File Report 87-664, 22 p.

Wrucke, C.T., Marsh, S.P., Conway, C.M., Ellis, C.E., Kulik, D.M., Moss, C.K., and Raines, G.L., 1983, Mineral resource potential of the Mazatzal Wilderness and contiguous roadless area, Gila, Maricopa, and Yavapai Counties, Arizona: U.S. Geological Survey Miscellaneous Field Studies Map MF-1573-A, 15 p.

Appendix A. List of Map References

a. U.S. Geological Survey Topographic Maps:

- Cypress Butte, Arizona (1:24,000), 1967
- Table Mountain, Arizona (1:24,000), 1967
- Wet Bottom Mesa, Arizona (1:24,000), 1967, HBN gaging station on this quadrangle
- Payson, Arizona (1:100,000), 1981

b. Geologic Maps:

- Wrucke, C.T., and Conway C.M., 1987, Geologic map of the Mazatzal Wilderness and contiguous roadless area, Gila, Maricopa, and Yavapai Counties, Arizona: U.S. Geological Survey Open-File Report 87-664, 22 p., scale 1:48,000.
- Wrucke, C.T., Marsh, S.P., Conway, C.M., Ellis, C.E., Kulik, D.M., Moss, C.K., and Raines, G.L., 1983, Mineral resource potential of the Mazatzal Wilderness and contiguous roadless area, Gila, Maricopa, and Yavapai Counties, Arizona: U.S. Geological Survey Miscellaneous Field Studies Map MF-1573-A, 15 p., scale 1:48, 000.

c. Soil surveys: No soil survey available.

d. Miscellaneous Maps

- U.S. Department of Agriculture, 1985, Tonto National Forest land and resource management planning: Albuquerque, U.S. Department of Agriculture Forest Service, Southwestern Region, scale 1:126,720.
- U.S. Department of Agriculture, 1986, Mazatzal Wilderness, Tonto National Forest: Albuquerque, U.S. Department of Agriculture Forest Service, Southwestern Region, scale 1:63,360.
- U.S. Department of Agriculture, 1991, Tonto National Forest, Arizona: Albuquerque, U.S. Department of Agriculture Forest Service, Southwestern Region, scale 1:126,720.

Appendix B. NWIS Site-Identification Numbers

Table B-1. NWIS site-identification numbers and site names for water-quality sampling sites.

Site	Identification Number	Site Name
1	09508300	WET BOTTOM CR NR CHILDS, AZ
2	341128111353300	BULL SPRING TRIB NR CYPRESS BUTTE, AZ
3	341118111350500	RED METAL CR NR CYPRESS BUTTE, AZ
4	341032111340700	HOUSTON CR NR CYPRESS BUTTE, AZ
5	341011111334200	CHALK SPRING CR NR CYPRESS BUTTE, AZ
6	340848111331100	FULLER SEEP CR NR CYPRESS BUTTE, AZ
7	340819111333600	WET BOTTOM CR NR MIDNIGHT MESA, AZ