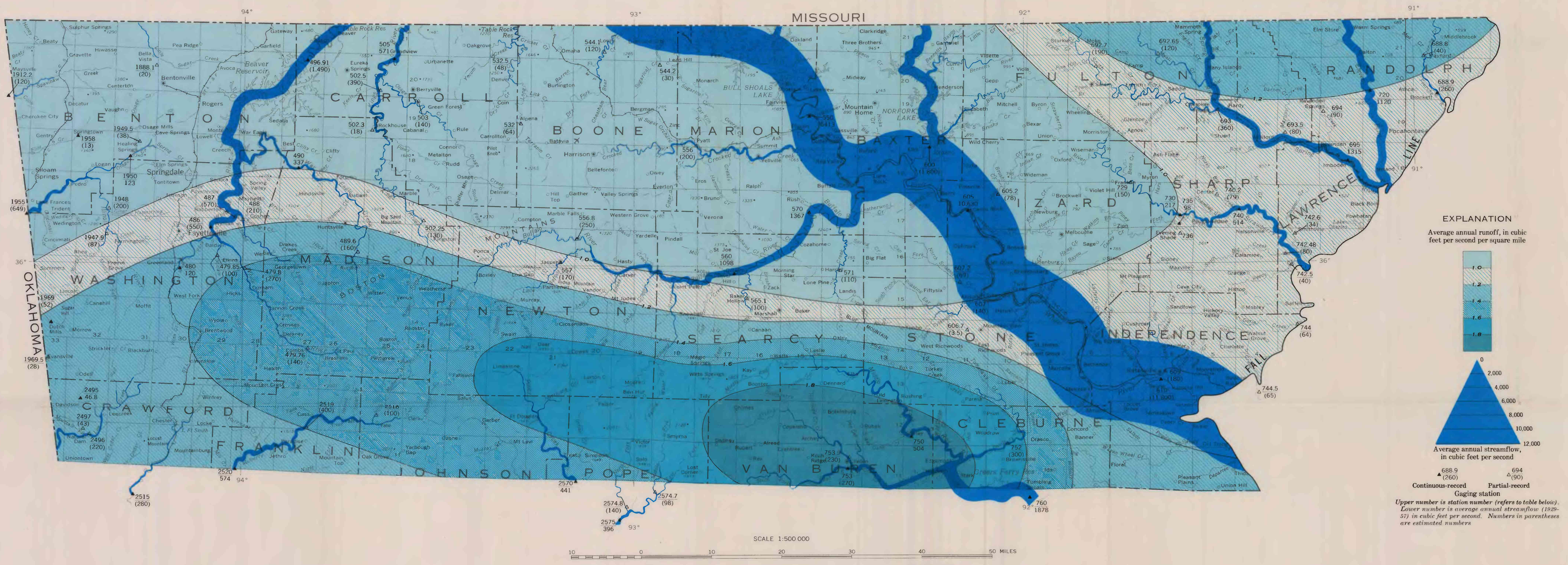
SURFACE-WATER RESOURCES



MAP SHOWING PATTERNS OF RUNOFF

SURFACE WATER IN THE OZARK PLATEAUS

PATTERNS OF RUNOFF

The Ozark Plateaus in Arkansas are drained by the White River, its tributaries, and tributaries of the Arkansas River. The White River, the largest stream in the plateaus, and its tributaries drain about 8,895 square miles in the area. Tributaries of the Arkansas River drain about 3,350 square miles in the western and southwestern parts of the area.

Discharge values used in this report are given in cubic feet per second (cfs); but these values may be converted to millions of gallons per day (mgd) by the conversion factor 1 cfs=0.646 mgd.

Average annual runoff for streams in the plateaus ranges from less than 1.0 cfs per sq mi (cubic feet per second per square mile) to more than 1.8 cfs per sq mi. The rates are shown on the runoff map. The average annual flow at any point on a stream may be estimated by multiplying the drainage area above the site by the average annual runoff as obtained from the runoff map.

The highest runoff occurs in the Boston Mountains and is the result of heavy precipitation and steep gradients. The lowest runoff occurs in the Springfield and Salem Plateaus where the average annual precipitation and gradients are lower.

LOW FLOWS

The natural ability of streams to supply water is measured by the magnitude, frequency, and duration of low flows. Low-flow data determined for gaging stations on streams, which drain the plateaus, are given in the table summarizing low-flow characteristics. This summary includes the minimum average 7-day and 30-day low flows that may be expected to recur at average intervals of 2 and 10 years, and the magnitude of flows that were exceeded 90 and 95 percent of the time.

Interpretation of the table can be illustrated by using the data for Bear Creek near Marshall, station number 565.1. The table shows that the average low flow of Bear Creek will be less than 3.4 cfs for a 7-day period at intervals averaging 2 years in length, and will be less than 1.6 cfs for a 30-day period at intervals averaging 10 years in length. The table also indicates that the flow of Bear Creek will equal or exceed 3.0 cfs 95 percent of the time, and will be less than 3.0 cfs an average of about 5 percent of the time (18 days a year). These values, however, are long-term averages and not regular occurrences.

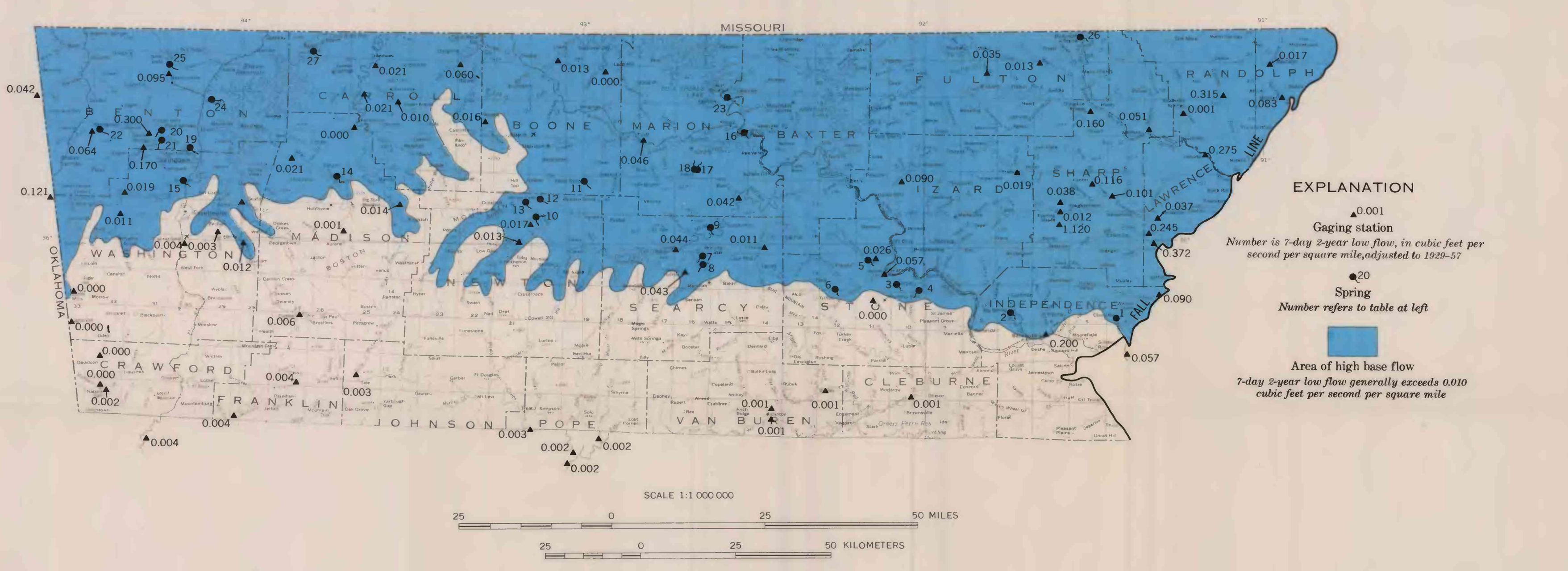
The 7-day 2-year low flow in cubic feet per second per square mile is an index often used to compare low-flow yields of streams or that flow which is composed mostly of ground-water runoff. Low-flow indicies for gaging stations on unregulated streams in the area of this report are shown on the base-flow map. Also shown is the area of relatively high ground-water runoff, which approximates the area underlain by hydrologic units D, E, and F. (See hydrogeologic map, sheet 1.) The high runoff from streams in these hydrologic units is maintained by water from springs. Discharge measurements made on several of the larger springs in the Ozark Plateaus are given in the table summarizing spring discharge. The low-flow characteristics of streams underlain by hydrologic units D, E, and F make possible the development of water supplies from many of these streams with little or no storage.

Because of the low permeability of the sandstones and shales of units B and C, streams in the southern part of the plateaus are "flashy" and have high precipitation runoff but relatively little ground-water discharge.

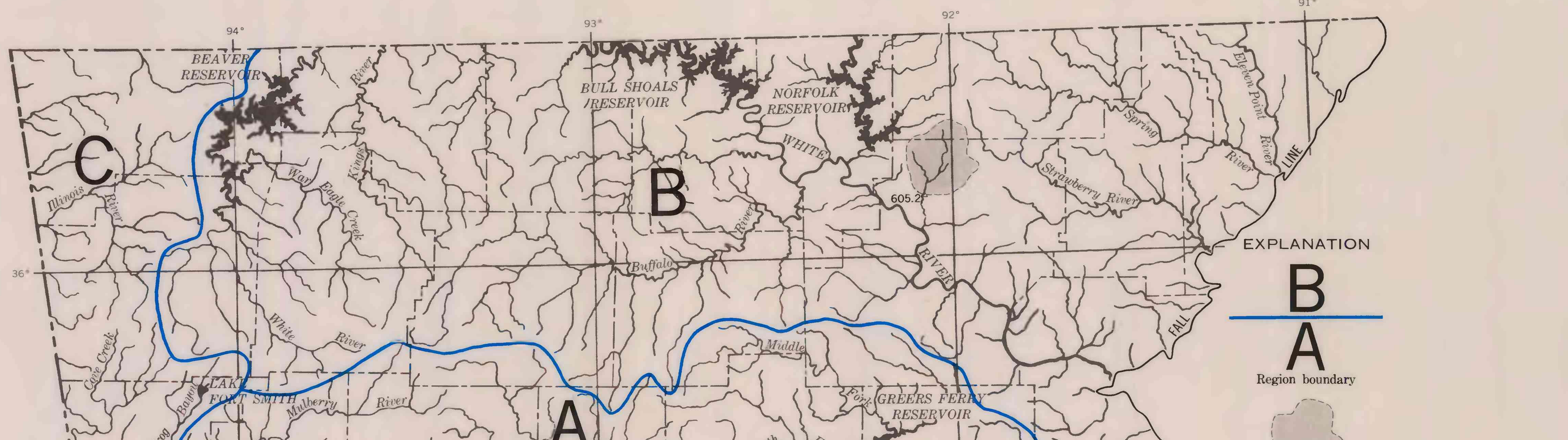
DISCHARGE OF SELECTED SPRINGS

Number	Name	Location	Number of measurements	Maximum measured discharge (cfs)	Date	Minimum measured discharge (cfs)	Date	Average discharge (cfs)
1	Charlotte Springs	14N-4W-32abc	1	[1] 2.6	8-28-68	[1] 2.6	8-28-68	
2	Big Spring	14N-7W-27adc	2	4.34	8-28-68	3.70	7-26-64	4.02
3	Hell Creek Cave Spring.	15N-10W-30aa	2	4.71	5-17-67	1.02	7-29-64	2.86
4	Nesbitt Spring	15N-10W-35caa	2	2.56	8-29-68	2.13	6-15-67	2.34
5	Blanchard Spring	15N-11W-5cda	3	231	3-21-68	3.37	10-3-61	79.6
6	Big Spring	15N-12W-33bd	1	[1] .9	8-4-61	[1] .9	8-4-61	
7	Hughes Spring	15N-16W-3bc	9	7.89	5-12-66	.59	9-9-65	2.55
8	Zack Spring	15N-16W-10acd	2	1.11	8-29-68	.70	8-17-65	.90
9	Unknown	16N-16W-13bba	1	[1] 2.2	4-12-61	[1] 2.2	4-12-61	
10	do	16N-20W-6dcd	1	1.27	5-2-68	1.27	5-2-68	
11	Valley Springs	17N-19W-3bbc	1	.67	8-21-68	.67	8-21-68	
12	Marble Falls Spring	17N-20W-20cad	1	8.42	5-2-68	8.42	5-2-68	
13	Unknown	17N-21W-25aad	1	2.61	5-2-68	2.61	5-2-68	
14	Withrow Spring	17N-26W-10abd	2	[1] .7	8-21-68	[1] .7	7-18-60	[1] .7
15	Johnson Spring	17N-30W-15ccc	2	1.65	8-26-47	1.48	1-14-53	1.56
16	Cotter Spring	18N-15W-1	1	27.6	10-19-42	27.6	10-19-42	
17	Abwatt Spring	18N-16W-28b	18	2.78	4-13-61	.12	9-12-60	.83
18	Gray Spring	18N-16W-28d	38	17.4	5-22-61	1.10	10-4-63	4.18
19	Springdale Spring	18N-30W-23cbc	1	[1] 3.5	6-28-68	[1] 3.5	6-28-68	
20	Keith Lake Spring	18N-31W-1dba	22	10.2	9-15-59 8-10-61	.31	8-15-62	4.10
21	Unknown	18N-31W-13	1	1.79	5-27-58	1.79	5-27-58	
22	Big Spring	18N-32W-5ccb	22	8.84	7-18-62	.93	8-27-56	4.99
23	Dew Spring	19N-15W-4d	[2] 27	54.7	6-21-57	22.4	10-14-54	39.8
24	Lake Atlanta Springs	19N-29W-8bbb	1	1.34	1-15-53	1.34	1-15-53	
25	Ford Spring	20N-30W-7db	24	29.2	5-23-62	.13	8-27-56	9.77
26	Mammoth Spring	21N-5W-8d	11	309	6-11-26	225	8-29-56	250
27	Blue Spring	21N-27W-25b	22	12.9	5-22-62	.91	9-1-54	5.89

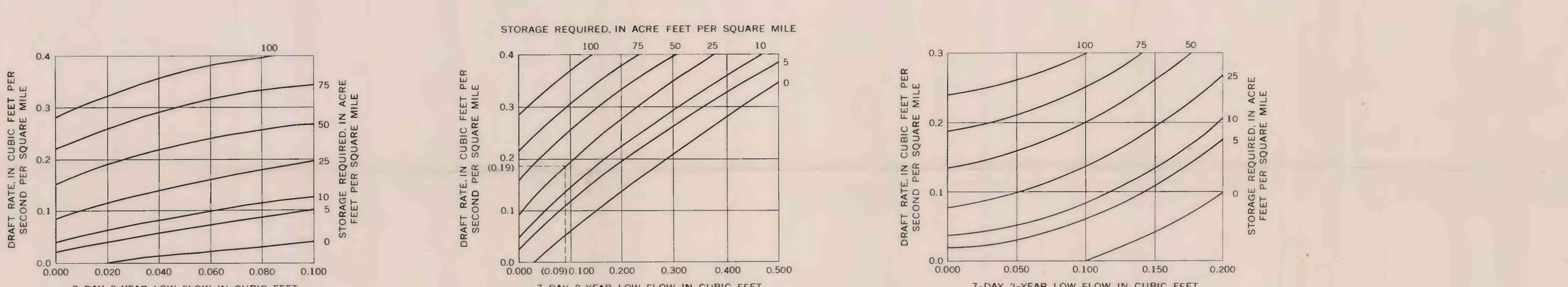
[1] Estimated.
[2] 25 discharge measurements made by U.S. Army Corps of Engineers.



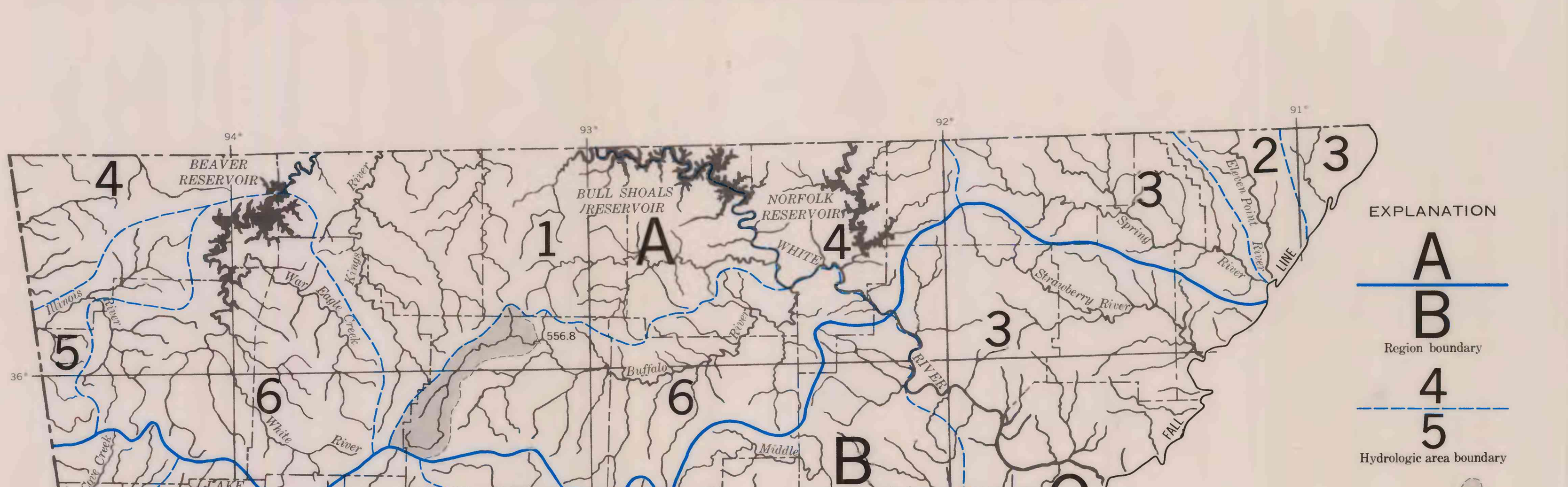
MAP SHOWING BASE FLOW OF STREAMS



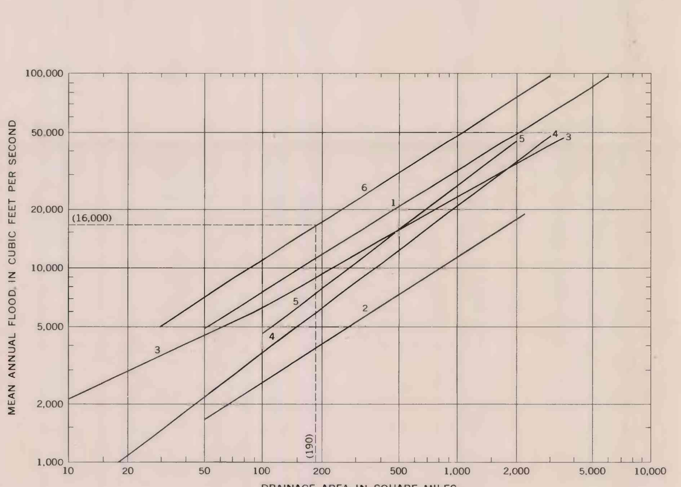
MAP SHOWING DRAFT-STORAGE REGIONS



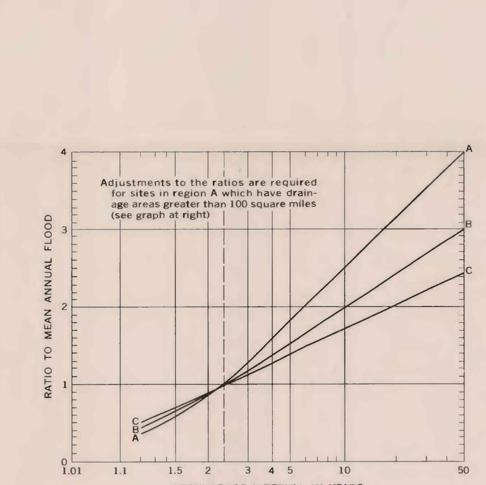
GRAPHS SHOWING DRAFT-STORAGE RELATIONS FOR DROUGHT OF 20-YEAR RECURRENCE INTERVAL AS A FUNCTION OF THE 7-DAY 2-YEAR LOW FLOW FOR SELECTED STORAGE VALUES. NOT ADJUSTED FOR EVAPORATION OR SEEPAGE



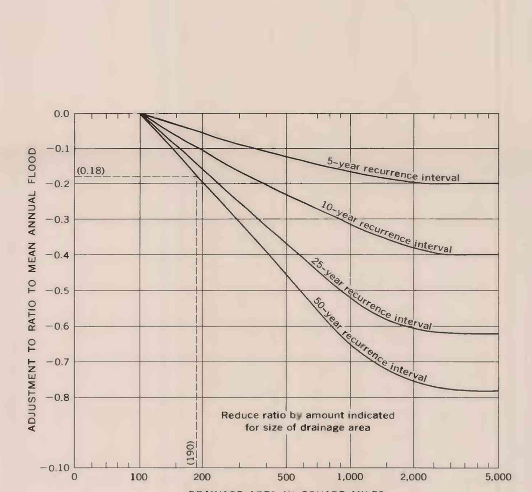
MAP SHOWING FLOOD-FREQUENCY REGIONS AND HYDROLOGIC AREAS



GRAPH SHOWING VARIATIONS OF MEAN ANNUAL FLOOD WITH DRAINAGE AREA IN HYDROLOGIC AREAS 1-6 (FROM PATTERSON, 1961)



GRAPH SHOWING FREQUENCY OF ANNUAL FLOODS IN REGIONS A, B AND C FOR THE PERIOD 1921-58. (FROM PATTERSON, 1961)



GRAPH SHOWING ADJUSTMENT TO RATIO TO MEAN ANNUAL FLOOD FOR REGION A ON THE BASIS OF DRAINAGE AREA SIZE (FROM PATTERSON 1961)

DRAFT-STORAGE RELATIONS

When water-supply needs exceed the natural flow of streams, dependable surface-water supplies can be obtained only by the construction and use of storage reservoirs. The storage required to insure dependable draft (withdrawal) rates is dependent upon the low flow of the stream and the frequency with which a deficient supply can be tolerated. Regionalized draft-storage relations for droughts of various recurrence intervals were related to the 7-day 2-year low flow of Arkansas streams in a report by Patterson (1967). Regionalized draft-storage relations for a drought having a 20-year recurrence interval are shown on the draft-storage graphs.

The Ozark Plateaus province is divided into three draft-storage regions, which are shown on the map below. Use of the draft-storage relations can best be illustrated by an example. Suppose a water supply or a draft rate of 15 cfs is desired from Piney Creek at the station near Calico Rock (605.2), and an inadequate supply can be tolerated an average of once in 20 years. A study of the low-flow characteristics table will indicate that a reservoir must be constructed in order to maintain this selected draft rate. To determine the size of the reservoir or the storage required to supply this need, it is necessary to know (1) the draft-storage region in which the site is located, (2) the drainage area above the site, and (3) the 7-day 2-year low flow at the site. The draft-storage region map shows that the stream is in region B; therefore, draft-storage curves for region B should be used to determine the required storage. The drainage area (78.5 square miles) and the 7-day 2-year low flow (7.1 cfs) can be obtained from the low-flow characteristics table. When expressed in cubic feet per second per square mile of drainage area (cfs per sq mi), the 7-day 2-year low flow and the desired draft rate become 0.09 and 0.19 cfs per sq mi, respectively. Entering these values in the draft-storage curves for region B indicates that Piney Creek will require 25 acre-feet per square mile, or about 2,000 acre-feet of storage to supply a draft rate of 15 cfs. This storage will be inadequate on the average of about once in 20 years. Additional storage would be necessary to allow for evaporation and seepage losses.

Storage requirements can be estimated for sites on streams where few data are available, provided the drainage area and the 7-day 2-year low flow can be determined. Drainage areas at ungaged sites on streams can be determined from topographic maps. The 7-day 2-year low flow can be estimated by correlating base flow, determined from several discharge measurements, with concurrent flows at nearby continuous-record gaging stations whose low-flow characteristics have been determined.

MAGNITUDE AND FREQUENCY OF FLOODS

The mountainous terrane in the plateaus enchances both high precipitation and rapid runoff, and most streams in the area are subject to frequent flooding. Floods may be caused by storms at any time, but they occur most frequently from January to May. Because a large part of the agricultural and urban development in the plateaus is concentrated on, or adjacent to, the flood plains of streams, a knowledge of the magnitude and frequency of floods is necessary to minimize property losses from floods. Also, proper design of bridges and other structures in the flood plains requires that the magnitude and frequency of future floods be determined. The magnitude and frequency of floods in the plateaus may be determined by the use of (1) regional curves relating mean annual floods to drainage areas (six such relationships, applicable to separate "hydrologic areas," have been developed for the Ozark Plateaus) and (2) regional curves showing the ratio of discharge of floods of given recurrence intervals to the mean annual flood (three such relationships define the "flood-frequency regions"). Because the frequency curve for region A was affected by the size of the drainage area, the ratio to the mean annual flood must be adjusted downward for streams in this region that have a drainage area greater than 100 square miles. The graph showing adjustment to mean annual flood for region A presents curves showing the amount of downward adjustment necessary for floods of 5-,10-,25-, and 50-year recurrence intervals.

The map showing flood-frequency regions and hydrologic areas delineates three regions and six areas in the plateaus. The curves described are shown in graphs below the map. To illustrate the use of the curves, assume that the magnitude of the 50-year flood for Buffalo River at Pruitt, Ark. (556.8), must be determined. The steps to be followed are:

1. Determine the drainage area above the site. The drainage area for Buffalo River at Pruitt is 190 square miles (low-flow characteristics table).

2. Determine the flood-frequency region and the hydrologic area in which the site is located (map showing flood-frequency regions and hydrologic areas). The site at Pruitt is in region A and in hydrologic area 6.

3. Determine the mean annual flood for the site. With a drainage area of 190 square miles, the mean annual flood of a stream in hydrologic area 6 is about 16,000 cfs (graph showing variations of mean annual flood).

4. The ratio of the mean annual flood to floods of different recurrence intervals is determined from the graph showing frequency of annual floods. In region A the ratio of the 50-year flood to the mean annual flood is 4.0.

5. Because the site is in region A and the drainage area is greater than 100 square miles, the ratio of the 50-year flood to the mean annual flood must be adjusted downward by the amount shown on the adjustment graph. For a drainage area of 190 square miles, the ratio of the 50-year flood to the mean annual flood must be reduced by 0.18.

6. The magnitude of the 50-year flood is then determined by multiplying the discharge of the mean annual flood (16,000 cfs) by the adjusted ratio of 3.82 (4.00-0.18). The 50-year flood for Buffalo River at Pruitt has a discharge of about 61,000 cfs (16,000 X 3.82).

The curves are useful for determining the magnitude and frequency of floods only on streams that are not significantly affected by regulation. Four major multiple-purpose reservoirs (Beaver, Bull Shoals, Norfork, and Greers Ferry) have been constructed on streams in the area of this report. These reservoirs collectively have a normal storage capacity of about 7,861,000 acre-feet. They serve as major sources of surface water for power generation, municipal and industrial supplies, and for various recreational uses. The reservoirs have a combined flood-control storage capacity of about 4,326,000 acre-feet, and have greatly reduced the magnitude of floods in the lower White, North Fork, and Little Red Rivers.

QUALITY OF SURFACE WATER

The chemical type and prevalent dissolved-solids content of surface water in the Ozark Plateaus during periods of low flow are shown on the surface-water quality map. Surface water in the plateaus generally is of the same chemical type but has a lower dissolved-solids content than ground water. (Compare the ground-water and surface-water quality maps.) The dissolved-solids content of water in unregulated streams is highest during periods of low flow, when streamflow consists largely of water discharged from the ground-water reservoir by springs, and is lowest when this water is diluted by rainfall and by overland runoff.

During periods of low flow, reservoirs and streams that are affected by regulation generally contain water having a lower dissolved-solids content than that of unregulated streams. Water released from large storage reservoirs, such as Beaver, Bull Shoals, Norfork, and Greers Ferry Reservoirs, generally has a low concentration of sediment and suspended material and ranges in temperature from 45°F (7°C) to 50°F (10°C).

Surface water through the Ozark Plateaus is chemically suitable for most municipal and industrial uses. The natural quality of surface water is excellent, and pollution is not a serious problem at present (1969). The concentrations of chemical constituents in the water generally are well within the limits recommended by the U.S. Public Health Service (1962) for drinking water on interstate carriers. Where surface water is used for municipal supplies, the primary treatment is for removal of sediment and suspended solids, and for bateriological purification.

SUMMARY OF LOW-FLOW CHARACTERISTICS AT GAGING AND PARTIAL-RECORD STATIONS ON SELECTED STREAMS

[Frequency and duration figures were computed from discharge records adjusted to a standard reference period, 1929-57]

Station number	Name	Drainage area, in square miles	Annual low flow, in cubic feet per second, for indicated period of consecutive days and indicated recurrence interval, in years: 7-day, 2-year	7-day, 10-year	30-day, 2-year	30-day, 10-year	Flow, in cubic feet per second, which was equaled or exceeded for indicated percentage of time: 90	95
479.76	White River at Combs, Ark.[1]	90.9	0.5	0			0.5	0.2
479.8	White River near Elkins, Ark.[1]	181	2.1	.2	3.1	0.2	2.1	.9
479.85	Middle Fork White River near Fayetteville, Ark.[1]	[2] 72	.2	0			.3	.1
480	West Fork White River at Greenland, Ark.	83	.3	0	.5	0	.3	.1
487	White River near Goshen, Ark.[1]	408	1.9	0	3.4	0	1	.3
488	Richland Creek at Goshen, Ark.[1]	147	.6	0	.8	.1	1	.4
489.6	War Eagle Creek near Huntsville, Ark.[1]	[2] 110	.1	0			.8	0
490	War Eagle Creek near Hindsville, Ark.	262	5.6	1.5	7.1	2.3	8.1	4.1
502.25	Kings River near Kingston, Ark.[1]	[2] 100	1.4	.2			2.2	1.2
502.3	Warm Fork Creek at Rockhouse, Ark.[1]	19	0	0			0	0
502.5	Kings River near Pleasant Valley, Ark.[1]	351	7.3	.5			14	8.0
503	Osage Creek near Berryville, Ark.[1]	139	1.4	0	2.8	.1	3.7	1.6
505	Kings River near Berryville, Ark.	532	11	.8	17	1.4	21	12
532	Long Creek at Alpena, Ark.[1]	67.3	1.1	.1	1.7	.2	2.0	1.3
532.5	Yocum Creek near Oak Grove, Ark.[1]	[2] 50	3.0				4.2	2.9
544.1	Bear Creek near Omaha, Ark.[1]	[2] 130	1.7		3.1		4.0	2.0
544.2	West Sugarloaf Creek near Lead Hill, Ark.[1]	[2] 32	0	0	0	0	0	0
550	White River near Flippin, Ark.	6,067	[3] 1,360	[3] 510	[3] 2,050	[3] 720	[3] 750	[3] 300
556	Crooked Creek at Pyatt, Ark.[1]	207	9.5	3.2	12	4.6	13	7.4
556.8	Buffalo River at Pruitt, Ark.[1]	[2] 190	3.3		4.6		5.0	3.2
557	Little Buffalo River at Jasper, Ark.[1]	124	1.6	.3	2.1	.4	2.8	1.3
560	Buffalo River near St. Joe, Ark.	825	36	14	41	17	48	32
565.1	Bear Creek near Marshall, Ark.[1]	78.3	3.4	1.3	3.9	1.6	4.5	3.0
570	Buffalo River near Rush, Ark.	1,091	46	22	64	30	71	51
571	Big Creek near Big Flat, Ark.[1]	90.3	1.0	0	1.5	.1	2.3	.5
605	White River at Calico Rock, Ark.	9,965	[3] 2,800	[3] 1,000	[3] 3,400	[3] 1,370	[3] 2,400	[3] 1,700
605.2	Piney Creek near Calico Rock, Ark.[1]	78.5	7.1	6.0	7.7	6.3	8.6	7.6
606.7	Lick Fork tributary near Mountain View, Ark.[1]	2.9	0	0	0	0	0	0
607	South Sylamore Creek at Allison, Ark.[1]	126	7.2	5.1	8.3	5.9	9.0	7.5
607.2	North Sylamore Creek near Allison, Ark.[1]	[2] 69	1.8	1.3	2.0	1.5	2.4	2.0
609	Polk Bayou at Batesville, Ark.[1]	165	33	29	35	30	38	34
610	White River at Batesville, Ark.	11,062	[3] 3,200	[3] 1,300	[3] 3,800	[3] 1,800	[3] 2,700	[3] 2,000
688.8	Mud Creek near Ingram, Ark.[1]	[2] 35	.6	.4	.8	.5	1.0	.8
688.9	Fourche Creek above Pocahontas, Ark.	228	19	13	21	16	25	21
692.65	Myatt Creek near Salem, Ark.[1]	102	1.3	.8	1.6	1.0	1.8	1.4
692.7	South Fork Spring River near Salem, Ark.[1]	[2] 170	6.0	4.3	6.9	4.8	7.4	6.4
693	South Fork Spring River near Hardy, Ark.[1]	326	52	44	56	47	63	55
693.5	Martins Creek near Williford, Ark.[1]	66.6	3.4	2.5	3.9	2.8	4.4	3.6
694	Janes Creek near Ravenden Springs, Ark.[1]	78.5	.1	0	.1	0	.4	.1
695	Spring River at Imboden, Ark.	1,162	320	265	340	280	345	311
720	Eleven Point River near Ravenden Springs, Ark.	1,123	352	268	410	286	361	316
729	Strawberry River near Franklin, Ark.[1]	153	2.9	2.0			4.0	3.2
730	Strawberry River near Evening Shade, Ark.	225	8.5	5.6	10	6.6	11	8.9
735	Piney Fork at Evening Shade, Ark.	99	1.2	.2	2.2	.5	2.8	1.5
736	Mill Creek at Evening Shade, Ark.[1]	12.5	14	13	14	13	14	13
740	Strawberry River near Poughkeepsie, Ark.	476	48	41	52	43	58	51
740.2	North Big Creek near Evening Shade, Ark.[1]	75.1	8.7	7.4			10	9.0
742.48	South Big Creek near Strawberry, Ark.[1]	69.4	17	13			20	18
742.5	Reeds Creek near Strawberry, Ark.[1]	34.9	13	12			14	13
742.6	Cooper Creek near Smithville, Ark.[1]	[2] 30	1.1	.5			1.6	1.3
744	Curia Creek near Dowdy, Ark.[1]	55.7	5.0	4.2			6.2	5.4
744.5	Dota Creek near Newark, Ark.[1]	56.3	3.2	2.4			4.0	3.4
750	Middle Fork Little Red River at Shirley, Ark.	294	.3	0	.7	0	1.3	.1
752	Devils Fork Little Red River near Brownsville, Ark.[1]	193	.1	0	.4	0	.4	.1
753	South Fork Little Red River at Clinton, Ark.	145	.1	0	.4	0	.6	.1
753.9	Archey Fork Little Red River at Clinton, Ark.[1]	122	.1	0	.3	0	.5	0
1888.1	McKisic Creek near Bella Vista, Ark.[1]	[2] 22	2.1	.5	2.6	.8	2.0	1.1
1912.2	Spavinaw Creek near Sycamore, Okla.	133	5.6	.9	6.9	1.8	5.0	2.5
1947.9	Muddy Fork Illinois River near Savoy, Ark.[1]	[2] 72	.8		1.1		.7	.2
1948	Illinois River at Savoy, Ark.[1]	167	3.2	.8	3.8	1.2	4.5	2.8
1949.5	Little Osage Creek near Healing Springs, Ark.[1]	40	12	2.2	12.8	8.8	12	9.6
1950	Osage Creek near Elm Springs, Ark.	129	22	11	24	14	21	16
1955	Illinois River near Watts, Okla.	635	77	2.5	94	3.4	56	28
1958	Flint Creek at Springtown, Ark.[1]	14	.9	.3	1.1	.5	.9	.6
1969	Barren Fork at Dutch Mills, Ark.[1]	43	0	0	.2	0	.3	0
1969.5	Evansville Creek at Evansville, Ark.[1]	23.5	.2	0	.5	0	.1	0
2495	Cove Creek near Lee Creek, Ark.	36.9	0		.1		.2	.1
2496	Lee Creek at Natural Dam, Ark.[1]	168	.3	0	.8	0	.3	0
2497	Mountain Fork Creek at Natural Dam, Ark.[1]	36	0	0	.1	0	.2	.1
2515	Frog Bayou at Rudy, Ark.	217	.9	0	2.2	0	1.4	0
2518	Little Mulberry Creek near Oark, Ark.[1]	[2] 66	.2	0	.5	0	.5	0
2519	Mulberry River near Cass, Ark.[1]	[2] 270	1.0	0	2.5	0	2.5	.2
2520	Mulberry River near Mulberry, Ark.	372	1.5	0	3.7	0	3.7	.3
2570	Piney Creek near Dover, Ark.	274	.7	0	2.4	0	1.5	.9
2574.7	Middle Fork Illinois Bayou near Hector, Ark.[1]	57.4	.1	0	.2	0	.1	0
2574.8	North Fork Illinois Bayou near Scottsville, Ark.[1]	87.0	.2	0	.4	0	.3	.1
2575	Illinois Bayou near Scottsville, Ark.	242	.4	0	1.1	0	.9	.2

[1] Partial-record gaging station. [2] Approximately. [3] For regulated conditions.

SELECTED REFERENCES

Albin, D. R., Hines, M. S., and Stephens, J. W., 1967, Water resources of Jackson and Independence Counties, Arkansas: U.S. Geol. Survey Water-Supply Paper 1839-G, 29 p.

Arkansas Geological Survey, 1929, Geologic map of Arkansas: scale 1:500,000.

Arkansas State Department of Health, 1965, Arkansas municipal water supplies, chemical data: Bureau of Sanitary Eng. Bull.

Baker, R. C., 1955, Arkansas' ground-water resources: Arkansas Geol. and Conserv. Comm. Water Resources Circ. 1, 16 p.

Caplan, W. M., 1957, Subsurface geology of northwestern Arkansas: Arkansas Geol. and Conserv. Comm. Inf. Circ. 19, 14 p.

———1960, Subsurface geology of pre-Everton rocks in northern Arkansas: Arkansas Geol. and Conserv. Comm. Inf. Circ. 21, 17 p.

Cordova, R. M., 1963, Reconnaissance of the ground-water resources of the Arkansas valley region: U.S. Geol. Survey Water-Supply Paper 1669-BB, 33 p.

Fenneman, N. M., 1938, Physiography of Eastern United States: New York, McGraw-Hill Book Co., Inc., 714 p.

Frezon, S. E., and Glick, E. E., 1959, Pre-Atoka rocks of northern Arkansas: U.S. Geol. Survey Prof. Paper 314-H, p. 171-189.

Halberg, H. N., and Stephens, J. W., 1966, Use of water in Arkansas, 1965: Arkansas Geol. Comm. Water Resources Summ. 5, 12 p.

Hem, J. D., 1959, Study and interpretation of the chemical characteristics of natural water: U.S. Geol. Survey Water-Supply Paper 1473, 269 p.

Hines, M. S., 1965, Water-supply characteristics of selected Arkansas streams: Arkansas Geol. Comm. Water Resources Circ. 9, 43 p.

Lamonds, A. G., Hines, M. S., and Plebuch, R. O., 1969, Water resources of Randolph and Lawrence Counties, Arkansas: U.S. Geol. Survey Water-Supply Paper 1879-B, 45 p.

Patterson, J. L., 1961, Floods in Arkansas, magnitude and frequency: U.S. Geol. Survey open-file report, 128 p.

———1967, Storage requirements for Arkansas streams: Arkansas Geol. Comm. Water Resources Circ. 10, 35 p.

Patterson, J. L., and others, June 1968, Geohydrology, Appendix D to Comprehensive basin study, White River basin, Arkansas and Missouri: White River Basin Coordinating Comm. rept., 29 p.

Rainwater, F. H., and Thatcher, L. L., 1960, Methods for collection and analysis of water samples: U.S. Geol. Survey Water-Supply Paper 1454, 301 p.

U.S. Army Corps of Engineers, June 1968, Hydrology, Appendix C to Comprehensive basin study, White River basin, Arkansas and Missouri: White River Basin Coordinating Comm. rept., 117 p.

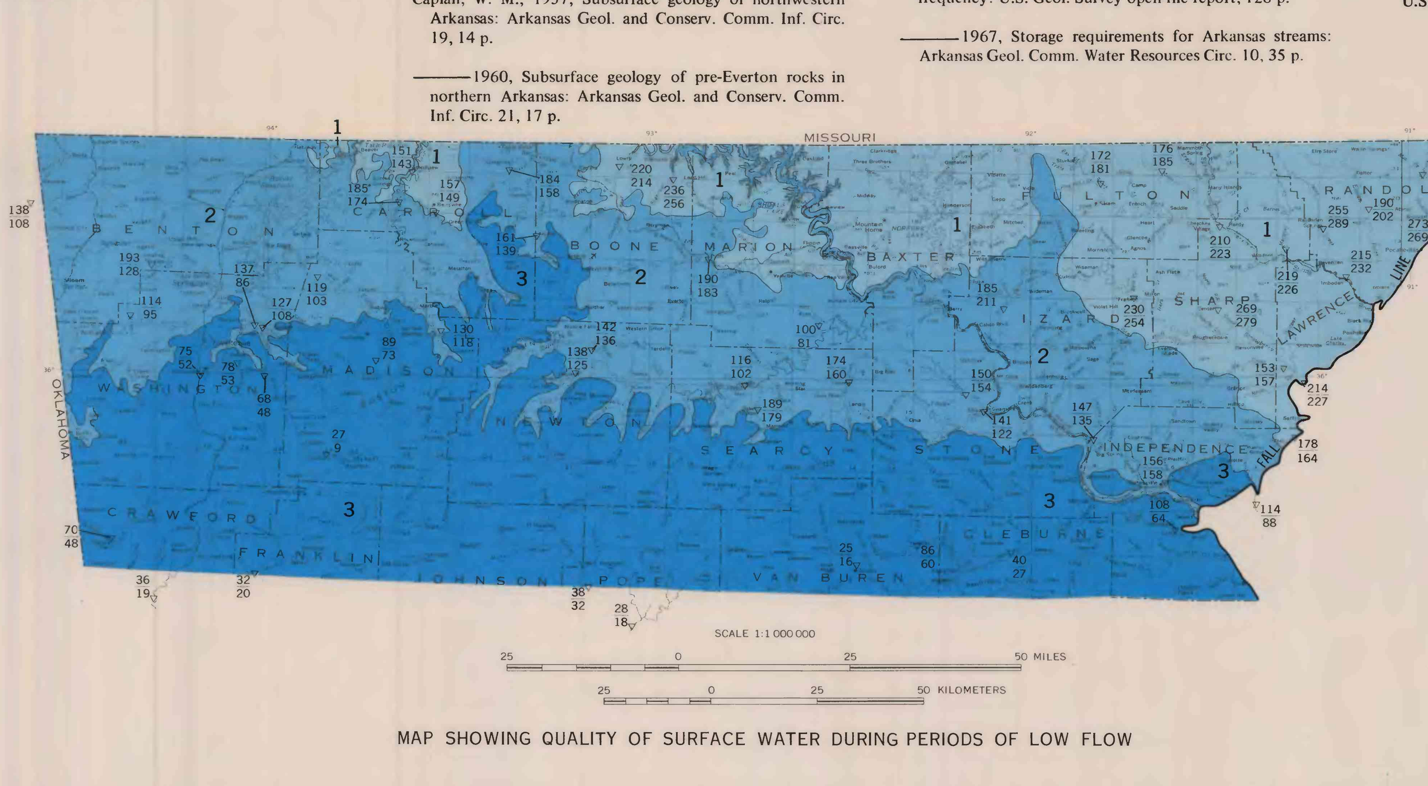
U.S. Geological Survey, 1961, 1962, 1963, 1964, Surface water records of Arkansas: U.S. Geol. Survey open-file reports.

———1964, Water quality records of Arkansas: U.S. Geol. Survey open-file report.

———1965, 1966, Water resources data for Arkansas, Part 1, Surface water records: U.S. Geol. Survey open-file reports.

———1965, 1966, Water resources data for Arkansas, Part 2, Water quality records: U.S. Geol. Survey open-file reports.

U.S. Public Health Service, 1962, Drinking water standards: U.S. Public Health Service pub.



EXPLANATION

269
279
Sampling station

Upper number is dissolved solids, in milligrams per liter; lower number is hardness as $CaCO_3$*, in milligrams per liter*

1

Calcium magnesium bicarbonate water with a dissolved-solids range of 100-300 mg/l. Moderately hard to very hard water with a hardness range of 100-300 mg/l. Generally coincides with hydrologic unit F on sheet 1

2

Calcium bicarbonate water with a dissolved-solids range of 100-200 mg/l. Moderately hard to very hard water with a hardness range of 80-220 mg/l. Generally coincides with hydrologic units D, E, and A on sheet 1

3

Calcium bicarbonate water with a dissolved-solids range of 25-125 mg/l. Soft to moderately hard water with a hardness range of 0-80 mg/l. Generally coincides with hydrologic units B and C on sheet 1

1
2
Area boundary

MAP SHOWING QUALITY OF SURFACE WATER DURING PERIODS OF LOW FLOW

Base from U.S. Geological Survey, 1:500 000
State base map, 1965

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WATER-RESOURCES RECONNAISSANCE OF THE OZARK PLATEAUS PROVINCE, NORTHERN ARKANSAS

By
A. G. Lamonds

1972