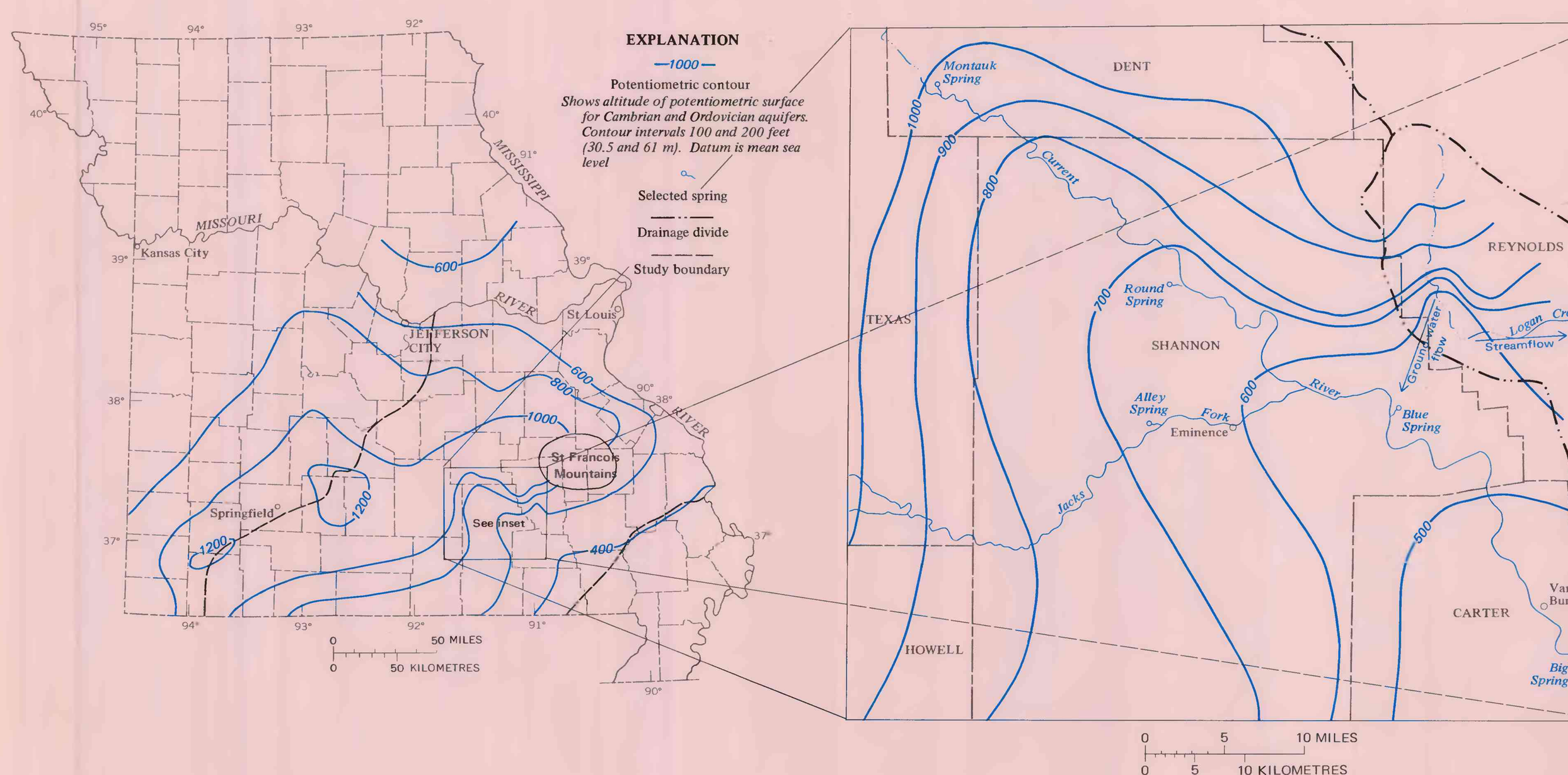
GROUND-WATER AVAILABILITY



Ground water is abundant in most parts of south-central Missouri. This abundance is reflected in the large number of big springs located along major streams in the area. Bedrock aquifers range from dense rock with poorly connected, microscopic openings to highly permeable rocks with enlarged, interconnected solution openings several feet in diameter. For practical purposes, the entire section of dolomite and sandstone rocks from the surface down to the Davis Formation (base of Elvins Group) may be considered as one aquifer although ground water may be more plentiful at a given depth at any particular location. Annual recharge to aquifers is sufficient to replenish seasonally depleted storage and a general lowering of the potentiometric surface has not occurred. Locally, however, the installation of deep, large-capacity wells may interfere with other wells in the vicinity, especially with the more shallow wells.

Rapid recharge to aquifers occurs locally, especially in areas where sinkholes and losing streams exist. Although rapid recharge insures continued availability of water to springs and wells, the good hydraulic connection existing between surface and subsurface in many areas is highly conducive to aquifer contamination. Tracing data in the accompanying table, for example, indicate subsurface movement of water for distances as great as 40 miles (64.4 km) at indicated velocities ranging from 0.1 to 7 miles (0.16 to 11.3 km) per day. Clearly, any pollutant either intentionally or accidentally introduced into a sinkhole or losing stream may enter the aquifer, and although possibly diluted, be subsequently discharged at a spring or pumped from a well.

To reduce chances of contamination, the upper part of the geologic section, which is highly permeable in some areas, is usually cased off and sealed during well construction. As a result, the production capability of most wells is largely determined by that part of the aquifer left open to the well. Aquifer characteristics data on this sheet, in general, do not reflect the upper part of the aquifer which is sealed off from the well.

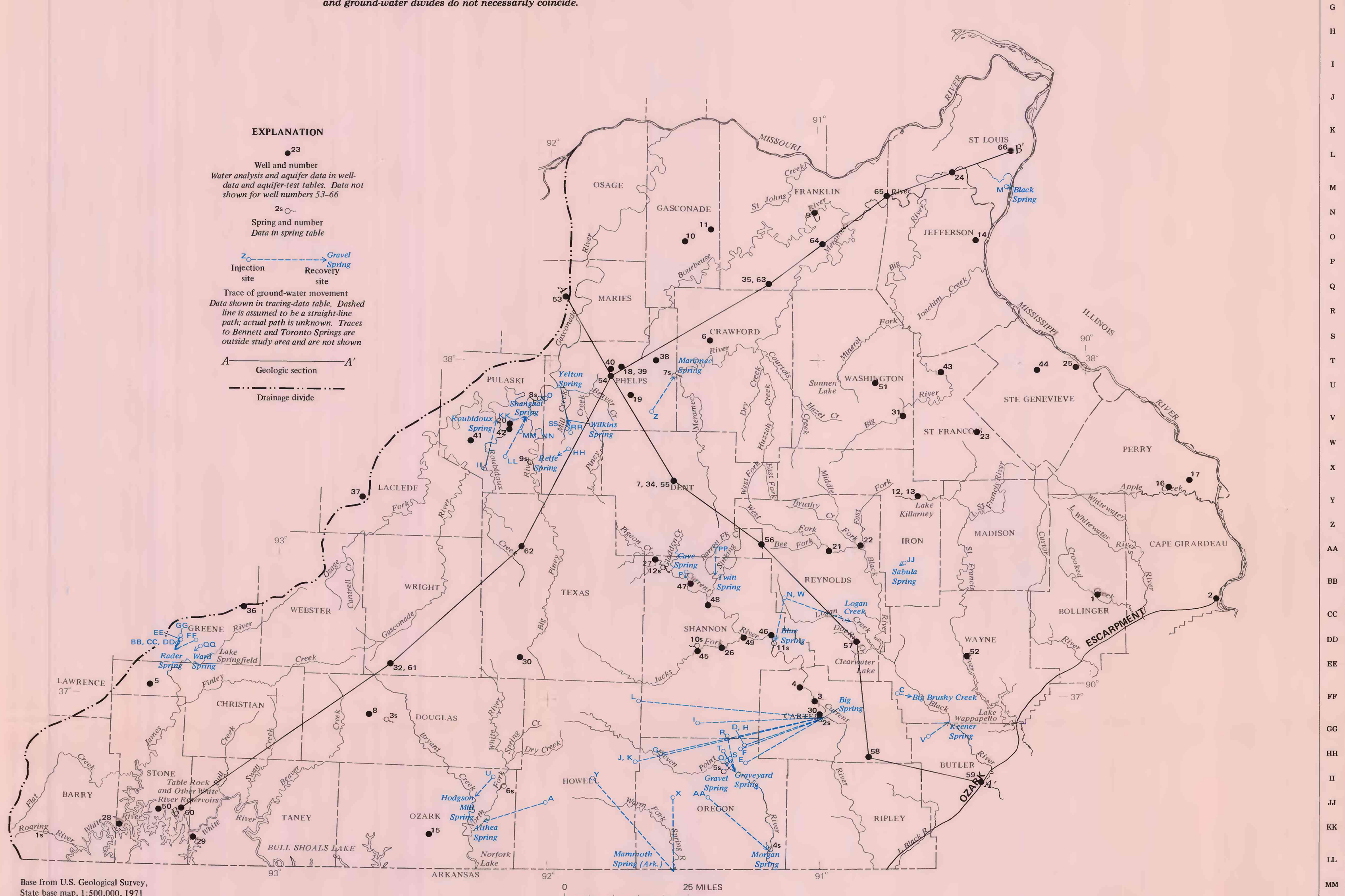
GROUND-WATER LEVELS IN CAMBRIAN AND ORDOVICIAN AQUIFERS STAND AT THEIR HIGHEST LEVELS IN AN AREA THAT EXTENDS SOUTHWEST FROM THE ST. FRANCOIS MOUNTAINS.—*The potentiometric surface slopes away from this central ridge in all directions with reentrant contours occurring along the principal streams which serve as ground-water drains.*

Detailed water-level data, where available, alter the gross potentiometric surface as demonstrated by the inset map of Logan Creek and Current River. Logan Creek, in the Black River basin, is a source of recharge to Blue Spring in the Current River basin. As much as 200 ft³/s (5.66 m³/s) of flow sinks into the sand and gravel streambed of Logan Creek and resurges toward the southeast at Blue Spring (see tracing-data table). This example of interbasin flow, undoubtedly a common occurrence in the area, suggests that drainage divides and ground-water divides do not necessarily coincide.

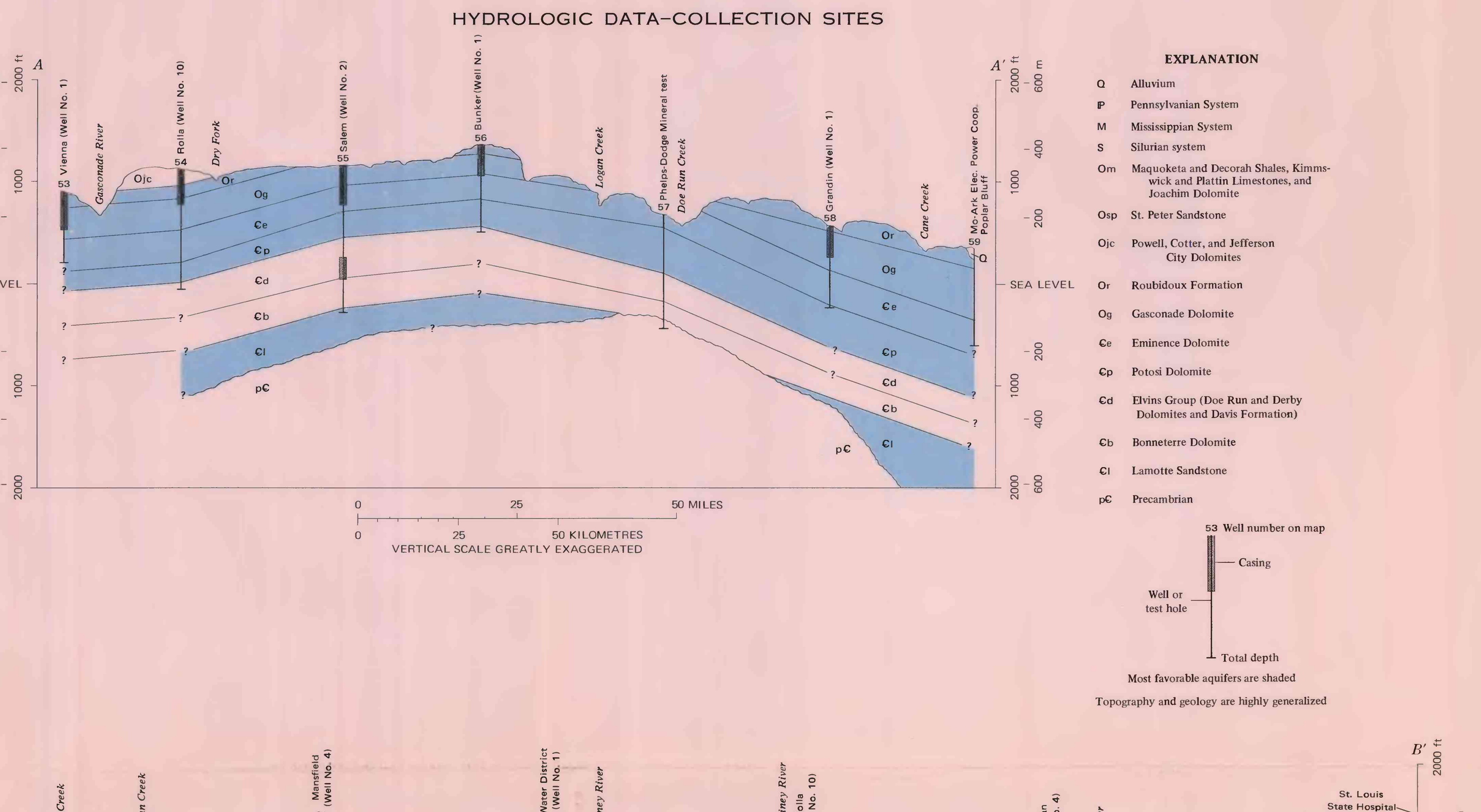
SUMMARY OF GROUND-WATER TRACING EXPERIMENTS IN MISSOURI
[Listed chronologically by recovery site]

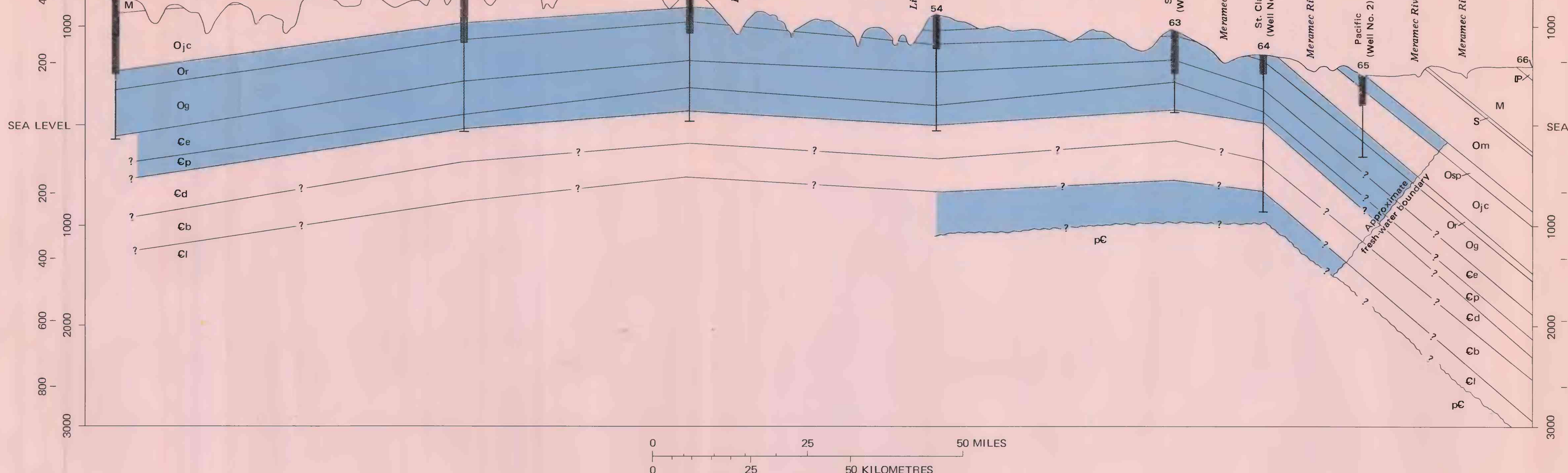
Map letter	Injection date	Tracer	Recovery method	Injection site: Location Sec.-T.-R.	Injection site: Altitude (ft)	Injection site: Geologic system[1]	Recovery site: Location Sec.-T.-R.	Recovery site: Altitude (ft)	Recovery site: Geologic system[1]	Straight-line distance (mi)	Mean slope (ft/mi)	Leading edge: Approximate elapsed time (days)	Leading edge: Approximate velocity (ft/min)	Source
A	July 24, 1972	Fluorescein dye	Activated charcoal packets	Cureall Spring 1-23N-10W	850	Ojc	Althea Spring 25-23N-12W	605	Og	8.75	28.0	7-15	4.59-2.14	Forest Service[2]
B	Fall 1968	......do......	....do....	Goodwin Hollow 4-34N-16W	≈1,140	Og	Bennett Spring 1-34N-18W	870	Og	9.0	30.0	13	2.54	Mo. G. S.[3]
C	Summer 1968	......do......	....do....	Big Brushy Creek 2-27N-3E	475	Og	Big Brushy Creek 8-27N-4E	415	Og	3.3	18.2	7-14	1.73-.86	Forest Service[4]
D	June 11, 1968	......do......	....do....	Blowing Spring Estavelle 3-25N-3W	630	Og	Big Spring 6-26N-1E	433	Єep	17.0	11.6	7-14	8.92-4.46	Do.[5]
E	Aug. 29, 1969	......do......	....do....	Johnson Spring 22-25N-3W	530	Og	........do........	433	Єep	18.0	5.4	17	3.89	Do.[5]
F	Nov. 18, 1970	......do......	....do....	Leslie Spring 4-25N-3W	620	Or	........do........	433	Єep	17.5	10.7	6-13	10.7-4.94	Do.[5]
G	Aug. 26, 1971	......do......	....do....	Stillhouse Spring 14-25N-6W	820	Ojc	........do........	433	Єep	33.5	11.6	57-75	2.16-1.64	Do.[5]
H	Oct. 22, 1971	Lycopodium spores	Nylon net	Blowing Spring Estavelle 3-25N-3W	630	Og	........do........	433	Єep	17.0	11.6	11.2-13.0	5.59-4.81	Do.[5]
I	Dec. 10, 1971	Fluorescein dye	Activated charcoal packets	Paul Dowler Sinkhole 12-26N-5W	975	Or	........do........	433	Єep	25.3	21.4	7-14	13.3-6.64	Do.[5]
J	Jan. 18, 1972	......do......	....do....	Middle Fork Eleven Point River 25-25N-7W	835	Or	........do........	433	Єep	39.5	10.2	13-17	11.1-8.52	Do.[5]
K	Feb. 9, 1972	Lycopodium spores	Nylon net	........do........	835	Or	........do........	433	Єep	39.5	10.2	5-14	29.0-10.4	Do.[5]
L	Apr. 17, 1972	Fluorescein dye	Activated charcoal packets	Jam Up Creek 24-27N-7W	1,090	Ojc	........do........	433	Єep	38.1	17.2	8-15	17.5-9.32	Do.[2]
M	Oct. 13, 1971	......do......	....do....	Sinkhole near Jefferson Barracks	440	Mm	Black Spring near Jefferson Barracks	400	Mm	.45	88.9	< 8.9	> .19	Mo. G.S.[17]
N	Oct. 7, 1969	Rhodamine WT dye	....do....	Logan Creek 11-30N-2W	880	Єep	Blue Spring 21-29N-2W	550	Єep	9.5	34.7	3-10	11.6-3.48	U.S.G.S.[6]
O	July 8, 1970	Fluorescein dye	....do....	Slaughter Sink 34-37N-10W	850	Or	Boiling Spring 33-37N-10W	675	Og	.95	184	< 2	> 1.74	Mo. G.S.[17]
P	Dec. 10, 1961	......do......	....do....	Devils Well 16-31N-5W	870	Og	Cave Spring 21-31N-5W	750	Єep	1.1	109	< 7	> .58	Do.[17]
Q	Mar. 29, 1972	Fluorescein dye	....do....	McCormack Hollow 24-25N-4W	570	Og	Gravel Spring 25-25N-4W	530	Og	.5	80.0	< 6.09	> .30	Forest Service[5]
R	Apr. 30, 1969	......do......	....do....	Hurricane Creek 25-26N-4W	730	Or	Graveyard Springs 32-25N-3W	510	Og	7.6	28.9	55-62	.51-.45	Do.[4]
S	Apr. 1, 1970	......do......	....do....	Davis Pond Sinkhole 18-25N-3W	900	Or	........do........	510	Og	3.5	111	<8	> 1.60	Do.[5]
T	June 14, 1972	......do......	....do....	Horsetail Spring 11-25N-4W	750	Or	........do........	510	Og	5.25	45.7	<9	> 2.14	Do.[2]
U	July 22, 1971	......do......	....do....	Dora Sinkhole Dump 8-24N-11W	890	Ojc	Hodgson Mill Spring 34-24N-12W	660	Og	5.6	41.1	12-20	1.71-1.03	Do.[5,7]
V	July 20, 1972	......do......	....do....	Cane Creek 23-26N-4E	470	Og	Keener Spring 4-26N-5E	360	Og	4.9	22.4	< 20	> .90	Mo. G.S.[17]
W	Oct. 7, 1969	Rhodamine WT dye	....do....	Logan Creek 11-30N-2W	880	Єep	Logan Creek 31-30N-2E	590	Єep	14.0	20.7	3-10	17.1-5.14	U.S.G.S.[6]
X	Dec. 16, 1970	Fluorescein dye	....do....	Granny Meyers Spring 29-24N-5W	690	Ojc	Mammoth Spring 5-21N-5W	510	Ojc	14.5	12.4	15-24	3.55-2.22	Forest Service[5]
Y	June 14, 1972	......do......	....do....	Renfrow Spring Sink 10-24N-8W	1,000	Ojc	........do........	510	Ojc	25.0	19.6	8-21	11.5-4.37	Do.[2]
Z	Aug. 23, 1972	Rhodamine WT dye	....do....	Norman Creek 7-36N-6W	930	Og	Maramec Spring 1-37N-6W	785	Og	8.7	16.7	68-75	.47-.42	U.S.G.S.
AA	May 28, 1969	Fluorescein dye	....do....	Alton Sinkhole Dump 28-24N-4W	770	Ojc	Morgan Spring 16-22N-2W	390	Or	15.5	24.5	75-89	.76-.64	Forest Service[5,8]
BB	June 20, 1967	Rhodamine BA dye	Grab samples	Rader Estavelle 18-28N-22W	1,120	Mo	Rader Spring 18-28N-22W	1,115	Mo	.2	25.0	.052	14.1	U.S.G.S.[9]
CC	July 7, 1967	......do......	....do....	Wilson Creek 7-28N-22W	1,135	Mo	Rader Estavelle 18-28N-22W	1,120	Mo	1.25	12.0	.188	24.4	U.S.G.S.[9]
DD	July 7, 1967	......do......	....do....	........do........	1,135	Mo	Rader Spring 18-28N-22W	1,115	Mo	1.35	14.8	.233	21.2	U.S.G.S.[9]
EE	Oct. 29, 1968	Fluorescein dye	Activated charcoal packets	South Creek Sinkhole 5-28N-22W	1,145	Mo	........do........	1,115	Mo	1.8	16.7	1.62	4.06	Mo. G.S.[10]
FF	Nov. 15, 1968	......do......	....do....	Subdivision Sinkhole 2-28N-22W	1,275	Mo	........do[11]......	1,115	Mo	4.8	33.3	< 3.00	> 5.86	Mo. G.S.[10]
GG	Nov. 22, 1968	......do......	....do....	Pfaff Cave 32-29N-22W	1,140	Mo	........do[11]......	1,115	Mo	3.4	7.4	< 3.21	> 3.88	Mo. G.S.[10]
HH	Mar. 13, 1973	......do......	....do....	Sinkhole 21-35N-9W	1,120	Or	Relfe Spring 36-35N-10W	825	Og	2.8	104	8-16	1.31-.65	Forest Service[16]
II	Oct. ?, 1970	......do......	....do....	Roubidoux Creek 3-34N-12W	900	Og	Roubidoux Spring 25-36N-12W	780	Og	10.5	11.4	5	7.70	Mo. G.S.[12]
JJ	July 28, 1970	......do......	....do....	Stream 2-31N-3E	730	Єep	Sabula Cave 3-31N-3E	700	Єep	.57	52.6	< 13	> .16	Mo. G.S.[17]
KK	May 10, 1971	......do......	....do....	Dry Creek Tributary 28-36N-11W	1,000	Or	Shanghai Spring 24-36N-11W	750	Og	2.8	89.3	14	.73	Mo. G.S.[13]
LL	June 9, 1971	......do......	....do....	Sediment Basin 32-35N-11W	1,000	Or	........do........	750	Og	9.2	27.2	23-30	1.47-1.12	Forest Service[13]
MM	Aug. 25, 1971	......do......	....do....	Dry Creek 2-35N-11W	900	Og	........do........	750	Og	3.2	46.9	28	.42	Do.[13]
NN	Oct. 27, 1971	......do......	....do....	........do........	900	Og	........do........	750	Og	3.2	46.9	19	.62	Do.[13]
OO	1963	......do......	....do....	Carroll Cave Siphon 11-37N-15W	760	Og	Toronto Spring 30-38N-14W	710	Og	3.0	16.7	14-21	.79-.52	Mo. G.S.[14]
PP	1968	......do......	....do....	Hodge Creek 21-32N-4W	1,020	Єep	Twin Spring 21-31N-4W	780	Єep	5.0	48.0	17	1.08	Forest Service[15]
QQ	Fall 1968	......do......	....do....	Parkcrest Subdivision Sinkhole 12-28N-22W	1,240	Mo	Ward Spring 14-28N-22W	1,170	Mo	1.1	63.6	2.5-7	1.61-.58	Mo. G.S.[10]
RR	Feb. 23, 1973	......do......	....do....	Mill Creek 4-35N-9W	960	Og	Wilkins Spring 20-36N-9W	815	Og	3.5	41.4	10-17	1.28-.76	Forest Service[16]
SS	Jan. 24, 1973	......do......	....do....	Deep Hollow Creek 32-36N-9W	895	Og	Yelton Spring 29-36N-9W	850	Og	1.35	33.3	6-12	.83-.41	Do.[16]

[1]Mm, MISSISSIPPIAN, Meramecian Series; Mo, MISSISSIPPIAN, Osagean Series; Og, ORDOVICIAN, Gasconade Dolomite; Ojc, ORDOVICIAN, Jefferson City Dolomite; Or, ORDOVICIAN, Roubidoux Formation; Єep, CAMBRIAN, Eminence and Potosi Dolomites.
[2]T. Aley, written commun., September 18, 1972.
[3]Missouri Geological Survey and Water Resources (1969).
[4]C. Tryon, oral commun., June 22, 1972.
[5]T. Aley, written commun., July 24, 1972.
[6]Feder and Barks (1972).
[7]Aley (1972).
[8]Aley (1969).
[9]Harvey and Skelton (1968).
[10]U.S. Environmental Protection Agency (1969).
[11]Dye also recovered in Rader Estavelle.
[12]T. Dean, oral commun., June 8, 1972.
[13]C. Tryon, written commun., June 28, 1972.
[14]Helwig (1965).
[15]Tryon (1972).
[16]C. Tryon, written commun., 1973.
[17]J. Vineyard, written commun., 1974.



HYDROLOGIC DATA-COLLECTION SITES





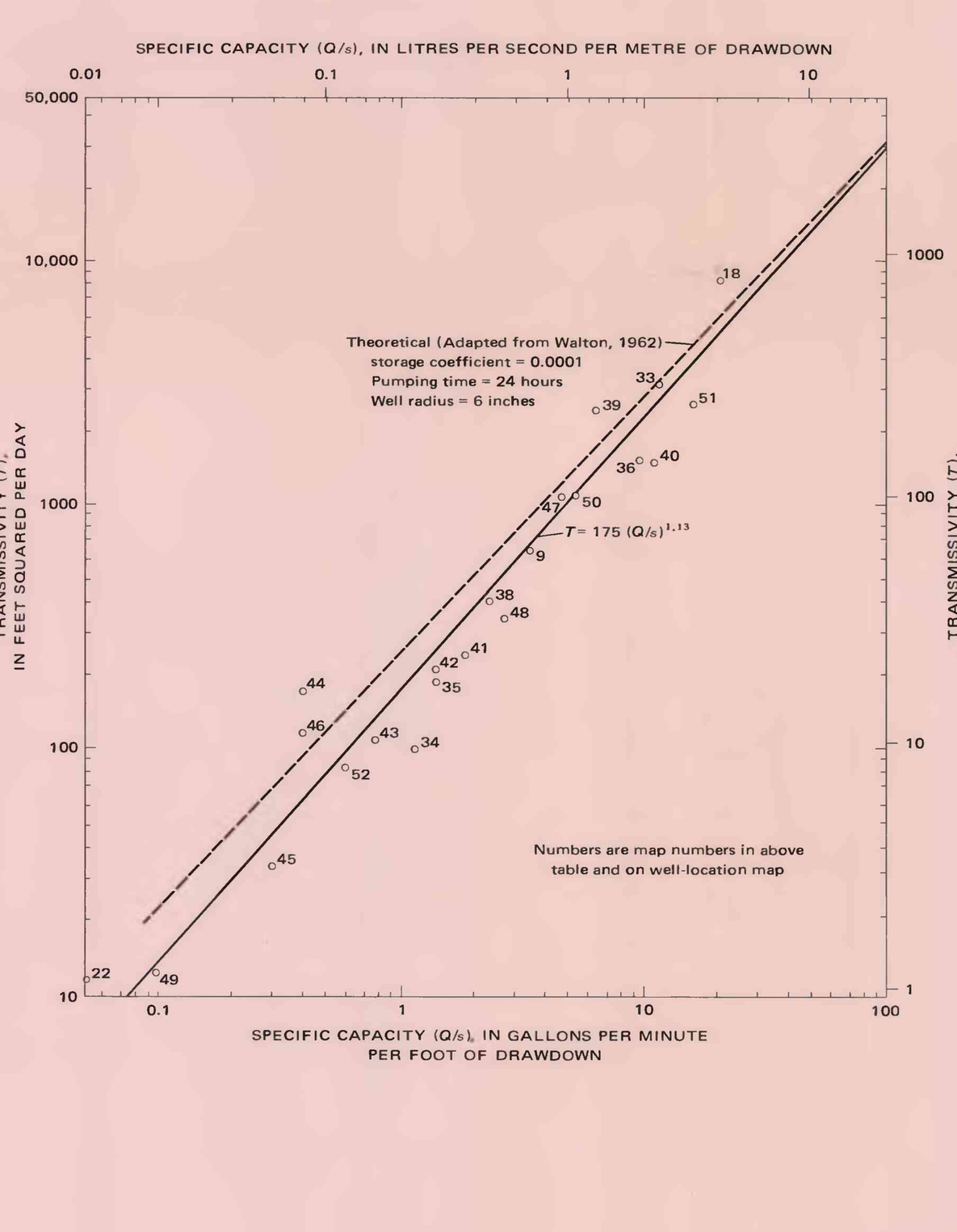
AQUIFER EVALUATION
[Most favorable aquifers are shaded]

System	Series	Thickness (ft)	Lithology	Water-bearing characteristics
Quaternary	Holocene Pleistocene	0-135	Alluvium-sand, clay, silt, and gravel	Important aquifer in northern part of study area along Missouri River and at eastern margin adjacent to Mississippi River. Yields in excess of 1,000 gal/min are available. Meramec River alluvium downstream from Times Beach is capable of yields as great as 600 gal/min. Other stream valleys important only where deposits of sufficient thickness and permeability are present.
Pennsylvanian, Mississippian, Devonian, and Silurian	——	0-3,000	Limestone, sandstone, and shale	Occurs principally in the St. Louis area, along the Mississippi River, and in the southwestern part of the area. Yields range from 1-3 gal/min from Pennsylvanian sandstones to as much as 50 gal/min from limestones of Mississippian age. Water quality poor in some areas.
Ordovician	Upper	0-200	Limestone, shale, and sandstone	Data insufficient to judge water-bearing characteristics. Yields of 10 gal/min may be possible.
	Middle	0-1,100	Limestone, shale, dolomite, and sandstone	Yields adequate for domestic supplies (10-15 gal/min). Locally yields as high as 50 gal/min are available from rocks above St. Peter Sandstone in the eastern part of the area. Yields of 10-140 gal/min are possible from the St. Peter. This unit yields mineralized water locally.
	Lower	0-1,200	Dolomite and sandstone	Upper part of sequence yields only small (10 gal/min) amounts of water to wells. Lower two formations (Roubidoux Formation and Gasconade Dolomite) yield 30-500 gal/min. Yields mineralized water at depth in extreme eastern part of study area.
Cambrian	Upper	0-1,700	Dolomite, shale, and sandstone	Upper two units (Eminence and Potosi Dolomites) yield 50 to 600 gal/min in combination. Middle units (Elvins Group) not important as aquifers. Lower two units (Bonneterre Dolomite and Lamotte Sandstone) have variable yields. Lamotte yields 10-100 gal/min. Bonneterre generally yields sufficient water for domestic supplies (10-15 gal/min). Cambrian aquifers yield mineralized water in extreme eastern part of study area and in other local areas.
Precambrian	——	——	Igneous and metamorphic rock	Not important as an aquifer. Yields water only locally from fractured and weathered zones.

AQUIFER CHARACTERISTICS

Map number	Well identification	County	Section	Township	Range	Total depth (ft)	Geologic unit[1]	Static water level (ft)	Pumping water level (ft)	Drawdown (ft)	Pumping rate (gal/min)	Specific capacity (gal/min per foot of drawdown)	Transmissivity (ft²/d)	Storage coefficient	Length of test (hours)	Remarks
33	National Park Service, Big Spring	Carter	6	26N	1E	475	Єe-Єp	53	73	20	230	12	3,300	....	14.0	Drawdown curve flattens.
34	City of Salem, No. 5	Dent	24	34N	6W	880	Єp	90	257	167	200	1.2	100	....	4.0	
35	City of Sullivan, No. 6	Franklin	7	40N	2W	850	Єe-Єp	157	334	177	240	1.4	190	....	4.0	
9	East Central Jr. College	Franklin	36	43N	1W	1,055	Og-Єp	156	191	35	120	3.4	670	0.0018	4.0	
36	Village of Strafford	Greene	4	29N	20W	1,100	Or-Єe	242	289	47	450	9.6	1,670	....	2.7	Reported test.
37	Laclede Co. Water District 3, No. 2	Laclede	9	33N	16W	1,215	Єe-Єp	405	438	33	115	3.5	....	....	5.0	Drawdown curve flattens.
38	City of St. James, No. 2b	Phelps	20	38N	6W	1,100	Og-Єp	224	366	142	330	2.3	410	....	3.3	
18	Hy-Point Industrial Park, No. 3	Phelps	30	38N	7W	1,155	Og-Єp	269	303	34	665	20	8,800	....	4.0	Reported test.
39	Hy-Point Industrial Park, Well D	Phelps	32	38N	7W	1,100	Og-Єp	295	374	79	500	6.3	2,500	....	2.8	
40	Loughridge Trailer Park	Phelps	35	38N	8W	750	Og-Єe	269	283	14	150	11	1,600	....	7.2	
41	Pulaski Co. Water District 1	Pulaski	18	35N	12W	885	Єe-Єp	275	320	45	83	1.8	240	.0001	3.3	
42	Wood Village Mobile Home Park	Pulaski	33	36N	11W	750	Єe-Єp	340	412	72	100	1.4	210	....	1.5	
22	Reynolds Co. Water District 1	Reynolds	17	32N	2E	605	Єb	125	380	255	14	.05	12	....	1.2	
43	St. Francois State Park	St. Francois	36	38N	4E	785	Єl	82	199	117	92	.8	110	....	4.2	
44	Ste. Genevieve Co. Water District 1, No. 2	Ste. Genevieve	30	38N	8E	1,025	Or-Єe	65	282	217	96	.4	170	....	19.0	
45	National Park Service, Alley Spring	Shannon	36	29N	5W	650	Og-Єe	55	269	214	59	.3	33	....	24.0	
46	National Park Service, Owls Bend	Shannon	16	29N	2W	303	Єe-Єp	45	157	112	50	.4	120	....	6.0	
47	National Park Service, Pulltite Spring	Shannon	34	31N	5W	310	Єe-Єp	32	58	26	120	4.6	1,200	....	8.0	
48	National Park Service, Round Spring	Shannon	20	30N	4W	400	Єe-Єp	79	123	44	120	2.7	360	....	3.0	
49	National Park Service, Two Rivers	Shannon	16	29N	3W	350	Єe-Єp	100	228	128	11	.1	13	....	24.0	Located near igneous knobs.
50	Stone Co. Water District 1	Stone	33	23N	23W	1,325	Or-Og	452	491	39	203	5.2	1,200	.001	25.0	Reported test.
51	City of Potosi, No. 5	Washington	14	37N	2E	1,425	Єb-Єl	487	510	23	370	16	2,700	....	2.0	
52	City of Greenville, No. 1	Wayne	1	28N	5E	769	Єe-Єp	38	212	174	110	.6	84	....	8.5	

[1]Or, Roubidoux Formation; Og, Gasconade Dolomite; Єe, Eminence Dolomite; Єp, Potosi Dolomite; Єb, Bonneterre Dolomite; Єl, Lamotte Sandstone.

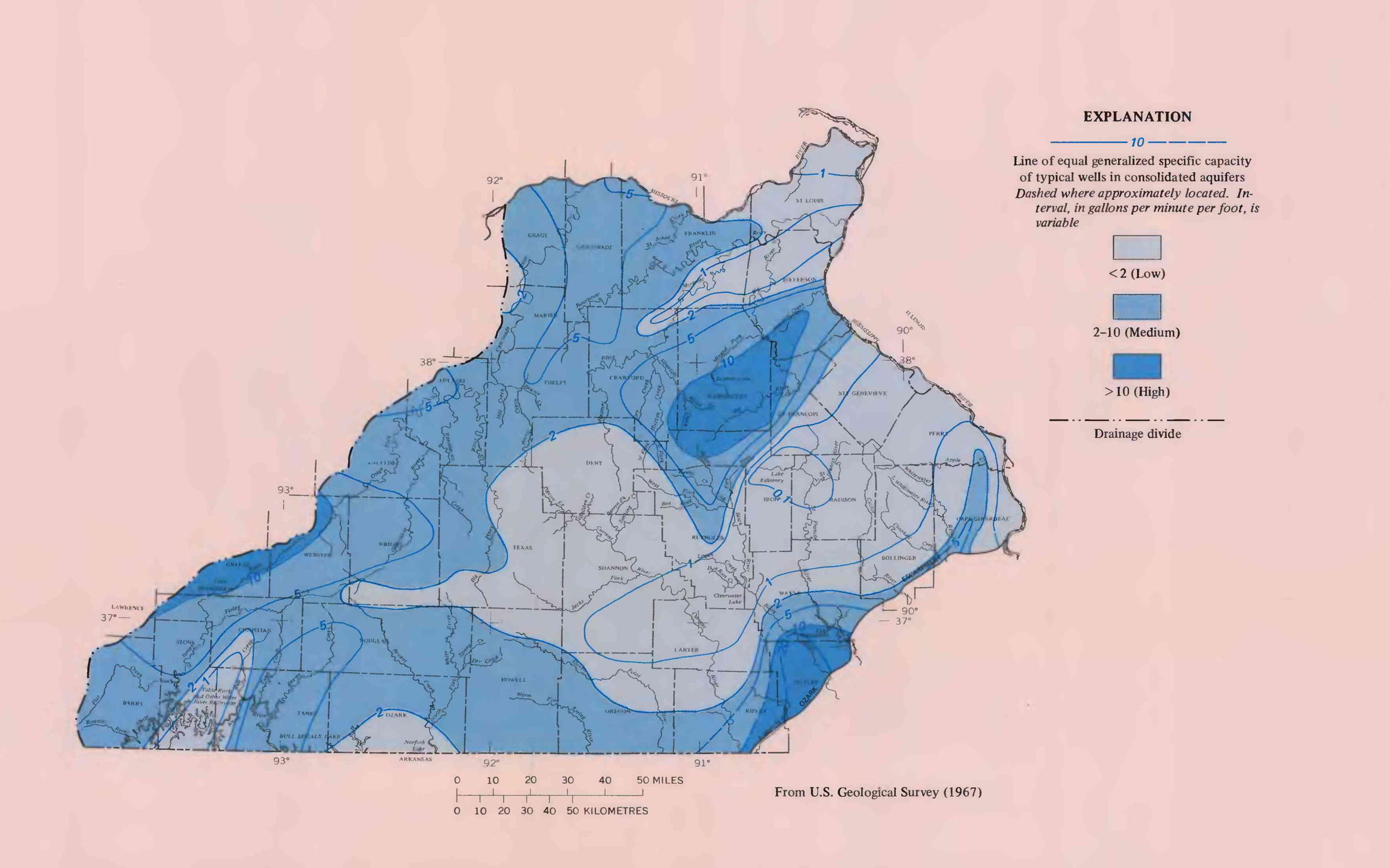


HYDRAULIC CHARACTERISTICS OF BEDROCK AQUIFERS ARE HIGHLY VARIABLE IN THE AREA.—*Specific-capacity data in the tables on this sheet suggest that the specific capacity of wells in Cambrian and Ordovician aquifers ranges from 0.05 to 22 (gal/min)/ft or 0.01 to 4.6 (l/s)/m of drawdown with a median of 1.7 (gal/min)/ft or 0.35 (l/s)/m of drawdown. The generalized specific-capacity map below indicates that specific capacity ranges from less than 0.1 to greater than 20 (gal/min)/ft or <0.02 to >4.1 (l/s)/m of drawdown. Aquifer test data in the above table indicate that the transmissivity of Cambrian and Ordovician aquifers ranges from 12 to 8,800 ft²/d (1.1 to 818 m²/d), with a median of 385 ft²/d (36 m²/d). Limited storage coefficient data suggest that the storage coefficient ranges from 0.0001 to 0.0018.*

The specific capacity of a well is related to the transmissivity of the aquifer or aquifers which the well penetrates and to other factors such as storage coefficient, pumping rate, length of test, well diameter, and screen size. Assuming that the aquifer transmissivity is the primary factor affecting the specific capacity of a bedrock well, the adjacent graph plotted from data in the above table may be used to estimate transmissivity when specific capacity is known. A theoretical relation adapted from Walton (1962) is shown on the graph for comparison.

The generalized specific-capacity map below shows the areal variation of specific capacity for typical wells in the area. Owing to the extreme variation of aquifer characteristics in local areas, however, the specific capacity of an individual well may differ significantly from values estimated from this map. For example, the well at Big Spring (33 in above table) has a specific capacity of 12 (gal/min)/ft or 2.5 (l/s)/m of drawdown although the well is located in an area of about 1 (gal/min)/ft or 0.21 (l/s)/m of drawdown as estimated from the generalized map. The deviation in this particular instance probably reflects higher permeability in the vicinity of Big Spring.

For preliminary estimates, the specific capacity map may be used in conjunction with the adjacent graph to estimate aquifer transmissivity. Owing to the variability of aquifer characteristics, however, aquifer tests provide more reliable data for the final design of wells.



CALCIUM MAGNESIUM RATIOS FOR LIMESTONE AND DOLOMITE SPRINGS

Spring	Number of springs	Number of analyses	Ca/Mg ratio[1]: Maximum	Ca/Mg ratio[1]: Minimum	Ca/Mg ratio[1]: Median	Type of rock
Roaring River Spring ...	1	11	27.0	8.8	14.0	Limestone
Chesapeake Spring[2].....	1	13	2.56	1.79	2.22	Limestone and dolomite
Salem Plateau Springs	12	138	1.55	.99	1.10	Dolomite

[1]Computed from milliequivalents per litre.
[2]Located outside of study area in Lawrence County.

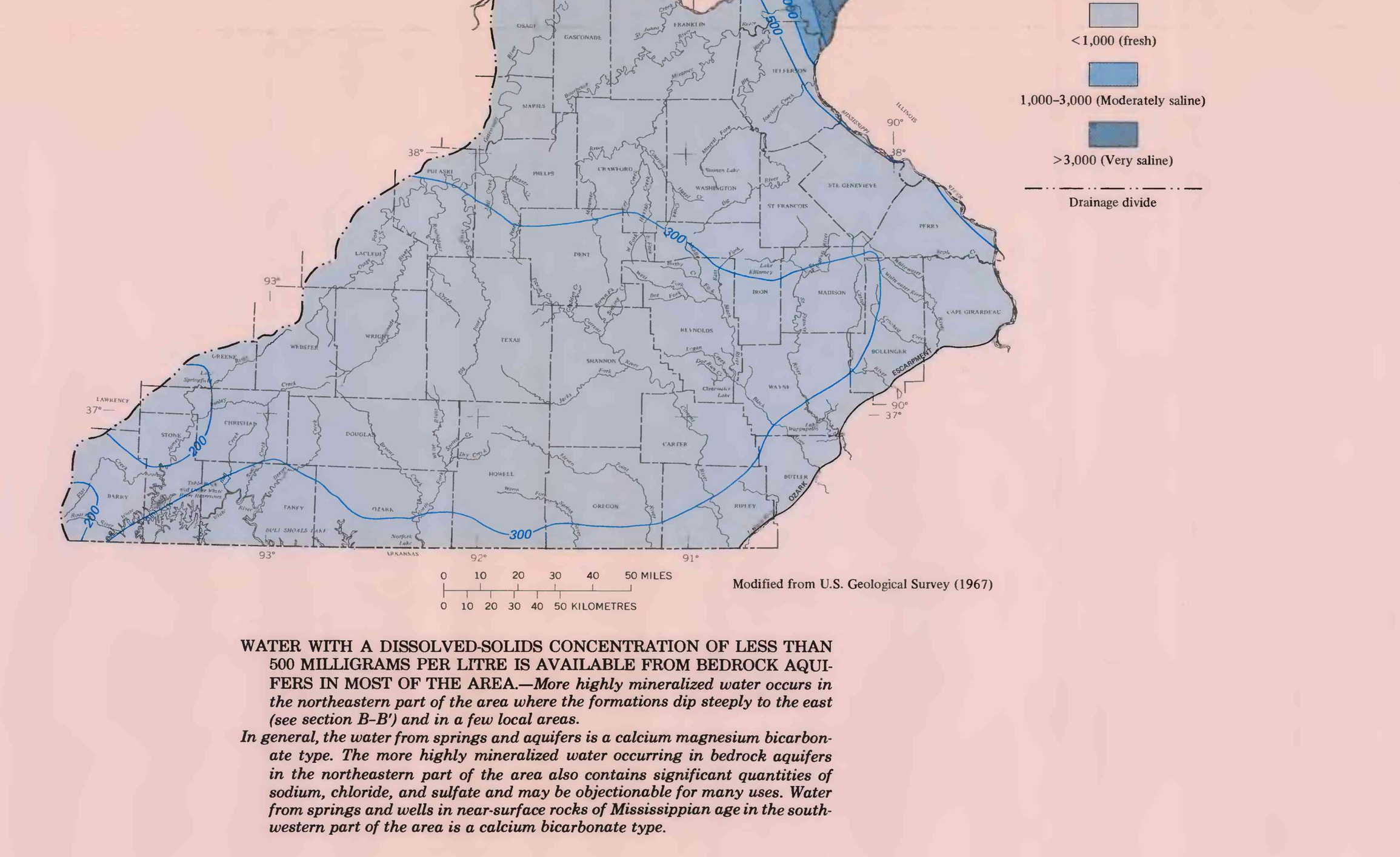
CALCIUM MAGNESIUM RATIOS FOR ORDOVICIAN AND CAMBRIAN AQUIFERS

System	Springfield Plateau[1]: Number of analyses	Springfield Plateau[1]: Median[2] Ca/mg ratio	Salem Plateau: Number of analyses	Salem Plateau: Median[2] Ca/mg ratio	Weighted median Ca/mg ratio
Ordovician.............	248	1.26	174	1.05	1.17
Cambrian...............	60	1.20	271	1.03	1.06
Ordovician and Cambrian.............	308	1.24	445	1.04	1.12

[1]Ordovician and Cambrian aquifers (dolomite) overlain by rocks of Mississippian age (limestone). Most analyses are for wells north and west of study area.
[2]Computed from milliequivalents per litre.

THE CALCIUM MAGNESIUM RATIO IS AN INDICATOR OF THE TYPE OF ROCK THROUGH WHICH WATER HAS MOVED IN A LIMESTONE AND DOLOMITE TERRANE.—*Ratios greater than about 5, computed from milliequivalents per litre, suggest that the water is derived from limestone (Hem, 1959, p. 82; Meisler and Becker, 1967). As indicated by the spring and well data in the above tables, Ca/Mg ratios less than about 1.5 suggest that dolomite is the source of water. Ratios between about 1.5 and 5 suggest a mixture of water from limestone and dolomite. The Ca/Mg ratios of water from wells in dolomite aquifers is normally very near 1.0. Corresponding ratios in water from dolomite springs range from about 1.0 to about 1.5 with the higher values normally occurring during high flows in the spring of the year.*

Water having calcium magnesium ratios greater than about 1.1 from Cambrian and Ordovician aquifers in the western part of the area surrounds a mound on the potentiometric surface in the vicinity of Webster County. This suggests probable recharge to the dolomite aquifers of that area through the overlying limestone of Mississippian age along the numerous faults in southern Webster County associated with the Bolivar-Mansfield fault system. (See McCracken, 1971.)



WATER WITH A DISSOLVED-SOLIDS CONCENTRATION OF LESS THAN 500 MILLIGRAMS PER LITRE IS AVAILABLE FROM BEDROCK AQUIFERS IN MOST OF THE AREA.—*More highly mineralized water occurs in the northeastern part of the area where the formations dip steeply to the east (see section B-B′) and in a few local areas.*

In general, the water from springs and aquifers is a calcium magnesium bicarbonate type. The more highly mineralized water occurring in bedrock aquifers in the northeastern part of the area also contains significant quantities of sodium, chloride, and sulfate and may be objectionable for many uses. Water from springs and wells in near-surface rocks of Mississippian age in the southwestern part of the area is a calcium bicarbonate type.

GROUND-WATER QUALITY

SELECTED WELL DATA
[Analyses by Missouri Geological Survey and Water Resources]

Map number on above map	Well owner	County	Section	Township	Range	Sampling depth or total depth (ft)	Depth of casing (ft)	System[1]	Rate of pumping (gal/min)	Specific capacity (gal/min per foot of drawdown)	Date of collection	Dissolved silica (SiO_2)	Dissolved iron (Fe)	Dissolved manganese (Mn)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium (Na)	Dissolved potassium (K)	Bicarbonate (HCO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Dissolved fluoride (F)	Dissolved nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as ($CaCO_3$): Calcium, magnesium	Hardness as ($CaCO_3$): Noncarbonate	pH
1	City of Marble Hill	Bollinger	5	30N	10W	600	37	O	125	2.1	10-11-68	12	0.06	0.0	49	34	1.5	0.5	333	1.6	2.2	0.1	1.6	293	263	0	7.3
2	Southeast Missouri State University No. 1	Cape Girardeau	31	31N	14E	1,725	700	O	122	1.5	9-14-61	7.3	1.3	.08	120	36	[2]70	...	297	110	160	.7	0	781	240	210	7.4
3	City of Van Buren	Carter	24	27N	1W	16	14	Q	150	...	2-17-71	8.0	.04	0	39	23	3.2	3.0	230	5.8	6.7	<.1	4.2	275	189	3	7.5
4	National Park Service, Austin House	Carter	4	27N	1W	250	150	Є	23	.5	8-19-69	6.2	...	...	73	39	3.7	2.0	396	9.2	4.8	.1	4.1	351	343	18	7.7
5	City of Clever, No. 2	Christian	20	27N	23W	1,300	405	O	200	22	3-18-70	8	.02	.0	31	17	.8	.9	168	13	2	.1	0	207	148	10	7.9
6	City of Cuba, No. 2	Crawford	31	39N	4W	1,005	300	Є	233	3.3	3-24-69	8	.02	.0	39	30	7.8	.2	272	16	7.6	<.1	.3	301	220	0	7.5
7	City of Salem, No. 3	Dent	18	34N	5W	1,500	550	Є	40	.4	5-11-65	2	1.4	0	46	27	[2]3.5	...	266	1.6	2.7	0	0	228	218	5	7.5
8	City of Ava, No. 5	Douglas	11	26N	16W	805	400	O	400	...	5-14-70	9.8	1.7	.07	54	24	1.8	1.2	295	15	5.7	.1	2.3	318	236	0	7.8
9	East Central Jr. College	Franklin	36	43N	1W	1,055	375	Є	120	3.4	11- 5-70	12	.22	.01	37	31	3.8	2.0	243	7.2	4.7	.3	.0	245	217	4	7.2
10	City of Owensville, No. 2	Gasconade	29	42N	5W	962	430	Є	79	.4	11-25-68	8	.1	...	40	35	6	.9	287	18	3	.1	0	307	236	8	7.3
11	City of Rosebud, No. 1	Gasconade	17	42N	5W	508	213	O	35	.6	11-21-67	6	.09	.0	33	22	1.9	.5	209	7	4	.1	.2	218	171	3	7.9
12	City of Ironton, No. 4	Iron	32	34N	4E	424	70	pЄ	46	...	6-18-45	...	.4	...	45	17	[2]9.1	...	219	13	6.5	...	.8	295	180	2	...
13	City of Ironton, No. 6	Iron	32	34N	4E	300	...	Є	36	.4	5-28-51	9	.14	...	47	21	[2]12	...	240	18	7.6	.8	.2	337	198	7	7.4
14	Jefferson County Water District 8, No. 1	Jefferson	25	42N	3E	1,015	450	Є	200	...	4-28-71	8	.17	.0	61	31	3.2	.4	367	15	2.6	.1	.2	359	280	3	7.7
15	City of Gainesville, No. 2	Ozark	7	22N	13W	1,220	425	Є	310	2.6	7-29-68	8	.14	0	54	36	1.1	.2	361	1.4	3.1	.1	.4	339	285	0	7.2
16	E. L. Boehme	Perry	28	34N	13E	870	...	O	10	.2	1940?	11	...	...	100	66	[2]32	...	439	190	12	.6	...	868	360	170	...
17	City of Frohna	Perry	20	34N	13W	1,092	810	O	54	2.2	4-28-70	9	.12	0	98	24	12	2.2	383	27	20	.3	0	452	320	31	7.7
18	Hy-Point Industrial Park, No. 3	Phelps	30	38N	7W	1,155	400	Є	665	20	2- 4-71	15	1.6	.01	78	43	2.5	.9	340	60	41	.4	.0	446	370	92	7.6
19	Sharon Thorpe	Phelps	21	37N	7W	250	30	O	30	1.5	2- 2-71	11	.08	0	126	57	4.4	1.4	432	220	8.8	0	0	694	354	196	8.1
20	Tulane Trailer Court	Pulaski	28	36N	11W	417	130	O	22	2.2	1-23-70	8	.01	.0	48	39	1.3	1.4	339	0	5.7	.1	3.4	385	278	4	7.7
21	Village of Centerville, No. 1	Reynolds	29	32N	1E	800	517	Є	130	.7	5-29-68	.6	.15	0	24	15	32	3.2	162	28	38	.9	0	218	119	0	7.8
22	Reynolds County Water District No. 1	Reynolds	17	32N	2E	605	210	Є	14	.05	6- 1-66	6	.14	...	45	24	68	2.8	217	60	76	.6	0	432	178	34	7.8
23	City of Farmington, No. 8	St. Francois	36	36N	5E	622	150	pЄ	160	.6	3-31-69	8	.2	.0	53	32	5	.3	315	8	4.9	<.1	2.4	320	260	6	8.0
24	City of Valley Park	St. Louis	18	44N	5E	62	54	Q	504	70	8-27-69	13	.00	.33	57	16	26	2.2	158	88	32	.0	4.2	331	208	78	7.5
25	City of Ste. Genevieve, No. 1	Ste. Genevieve	...	38N	9E	65	40	Q	250	17	8-18-48	14	.08	...	170	33	[2]44	...	484	140	50	...	4.2	978	400	150	6.9
26	City of Eminence	Shannon	26	29N	4W	26	11	Q	213	200	3-20-64	6.0	.01	...	40	21	1.4	1.0	208	5.1	6.5	.1	.7	222	171	5	7.2
27	National Park Service, Cedar Grove	Shannon	4	31N	6W	500	250	Є	60	.3	9-24-71	11	.21	.01	58	30	1.2	.6	341	1.2	2.7	0	.3	300	268	0	7.8
28	U. S. Forest Service	Stone	18	22N	24W	360	225	O	16	.1	10- 7-64	2.8	18	.61	46	39	[2]7.5	...	267	29	13	.2	0	302	238	39	7.5
29	Mo. State Park, No. 2	Taney	27	22N	22W	437	284	O	120	2.0	4- 1-64	6	1.5	...	64	35	1.4	1.5	332	29	6.5	.1	.1	323	272	32	7.6
30	City of Cabool, No. 4	Texas	12	28N	11W	1,350	400	Є	289	1.1	1-27-62	10	.25	...	48	30	[2]2.2	...	289	2.3	5.2	.1	.4	268	233	9	7.3
31	City of Irondale, No. 1	Washington	14	36N	3E	1,030	139	Є	100	6.7	5-31-71	9	<.1	.04	64	43	[2]1.9	...	412	6.7	2.9	<.1	1.6	449	340	0	7.7
32	City of Mansfield, No. 2	Wright	29	28N	15W	1,200	475	Є	127	1.7	9- 1-61	8	.17	...	44	28	[2]1.9	...	261	6.4	4.1	.1	...	243	211	13	7.4
Maximum						1,725	700	...	665	200	......	15	18	.61	170	66	68	3.2	484	220	160	.9	4.2	978	400	210	8.1
Minimum						16	11	...	10	.05	......	.6	.00	.0	24	15	.8	.2	158	0	2	.0	.0	207	119	0	6.9
Median						800	284	...	122	1.7	......	8	.14	0	49	31	3.2	1.2	295	15	6.5	.1	.3	318	238	7	7.5
Recommended maximum concentration for drinking water[3]						...	...	...	...	...	......	...	.30	.05	...	...	...	...	...	250	250	[4]1.7	45	500	...	...	...

[1]Є, Cambrian; O, Ordovician; pЄ, Precambrian; Q, Quaternary.
[2]Sodium plus potassium. Not included in statistical summary.
[3]U.S. Public Health Service, (1962).
[4]Varies with annual average of maximum daily air temperatures and ranges downward from 1.7 mg/l at 10.0°C to 0.8 mg/l at 32.1°C. The optimum concentration is from 1.2 to 0.7 mg/l.

SELECTED SPRING DATA
[Analyses by U.S. Geological Survey and Missouri Geological Survey and Water Resources]

Map number	County	Section	Township	Range	Spring name	Geologic system[1]	Range of observed discharges (ft³/s)	Use	Date of collection	Discharge (ft³/s)	Temperature (°C)	Dissolved silica (SiO_2)	Dissolved iron (Fe)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium (Na)	Dissolved potassium (K)	Bicarbonate (HCO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Dissolved fluoride (F)	Dissolved nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Colonies per 100 millilitres: Fecal coliform	Colonies per 100 millilitres: Fecal streptococci
1s	Barry	27	22N	27W	Roaring River	O	8.0-177	State park	4-28-71	54	13.0	9.8	0.100	61	2.0	2.0	0.7	172	3.0	5.2	......	6.9	176	160	19	305	7.4	< 1	3
2s	Carter	6	26N	1E	Big	Є	236-1,300	National park	4-27-71	493	14.0	8.7	.110	40	18	1.3	.7	220	1.5	2.7	0.0	1.0	188	173	0	340	7.5	< 1	5
3s	Douglas	22	26N	15W	Crystal	O	9.7-17	Fish hatchery	11-67	14	14.4	9.1	.01	48	27	1.5	1.1	284	5.0	2.2	.0	3.5	242	231	0	437	7.7	......	......
4s	Oregon	16	22N	2W	Blue	O	52-100	Aquatic farming	4-27-71	67	14.0	9.8	.130	54	23	1.0	.8	284	3.0	6.2	.0	4.4	254	232	0	440	7.3	1	1
5s	Oregon	36	25N	4W	Greer	O	104-903	Private lodge	4-27-71	387	14.0	9.2	.130	40	18	1.1	.9	216	3.0	4.7	.0	1.8	194	172	0	340	7.6	8	8
6s	Ozark	23	24N	11W	Double	O	47-232	Recreation, fishing	4-28-71	197	13.0	9.1	.330	47	20	1.2	1.0	240	3.6	4.7	......	3.5	222	200	3	385	7.5	< 1	17
7s	Phelps	1	37N	6W	Maramec	O	56-650	Trout fishing	4-26-71	149	13.0	8.9	.280	30	13	1.8	1.0	146	5.5	4.2	......	3.1	140	127	7	260	7.3	3	52
8s	Pulaski	33	37N	10W	Boiling	O	56-70	Camping	8-65	......	13.9	2.8	.06	33	19	3.2		190	2.3	3.5	0	2.1	169	161	6	......	7.9	......	......
9s	Pulaski	6	34N	10W	Miller[2]	O	4.4-41	Stock water	8-53	......	14.4	10.0	.08	41	24	2.8		238	4.5	2.3	.1	1.4	213	202	7	......	8.4	......	......
10s	Shannon	25	29N	5W	Alley	O	54-1,060	National park	4-27-71	119	13.5	8.0	.270	31	15	1.2	.7	172	1.5	4.7	.0	2.4	156	138	0	280	7.4	3	10
11s	Shannon	21	29N	2W	Blue	Є	62-236	National park	4-27-71	122	13.0	6.9	.060	29	14	4.3	.7	156	8.8	8.2	.0	1.1	161	128	0	280	7.7	< 1	6
12s	Shannon	10	31N	6W	Welch	Є	70-331	National park	4-26-71	169	13.5	9.5	.050	35	16	1.4	.6	192	3.0	3.2	.0	2.7	180	154	3	315	7.5	<1	8

[1]Є, Cambrian; O, Ordovician.
[2]Ebb and flow spring.

THE SPRINGS OF THE OZARKS ARE AMONG THE LARGEST IN THE WORLD.—*The average flow of Big Spring alone (276 Mgal/d or 12.1 m³/s) is sufficient to supply a city of approximately 2 million people. The average flow of the 15 largest springs in Missouri (about 1,400 Mgal/d or 61.3 m³/s) is nearly three times the total average municipal withdrawal in the State (about 500 Mgal/d or 21.9 m³/s). Small springs are common along many Ozark streams and the occurrence of watercress, mint, and other spring flora usually indicates a perennial spring.*

Many of the springs are noted for their scenic features and most of the large springs are included in State or national parks, Forest Service camping areas, or privately owned fishing and hatchery developments. Spring products include fish, watercress, and aquatic plants for aquariums. A few springs are still used for grinding meal and for generating electric power.

Although most springs are usually clear except after heavy rains, the water generally should not be used for drinking without treatment because of the possibility of pollution from surface sources. Owing to the relatively free access of surface contaminants to the springs (see tracing data), great care must be exercised in recharge areas to prevent contamination of this vital resource.

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WATER RESOURCES OF SOUTH-CENTRAL MISSOURI

By
E. E. Gann and E. J. Harvey
U.S. Geological Survey
and
D. E. Miller
Missouri Geological Survey and Water Resources
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