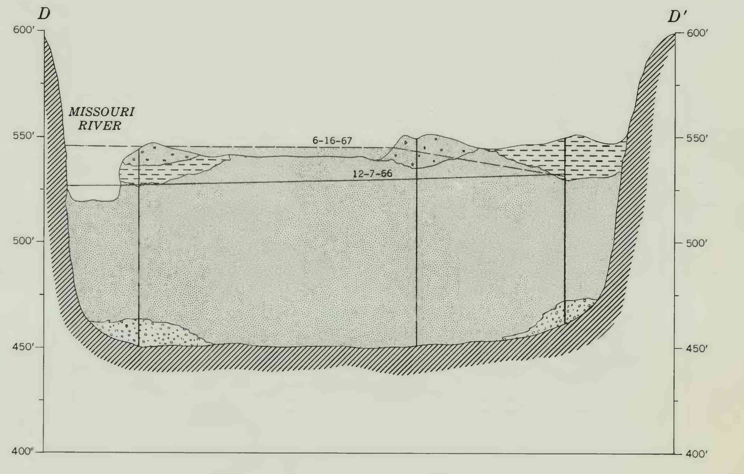
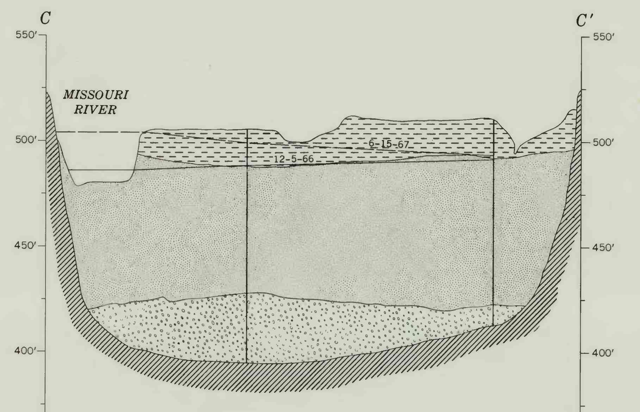
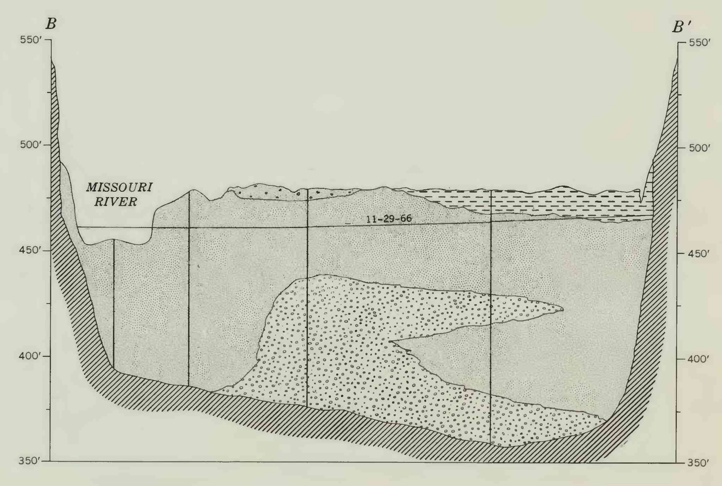
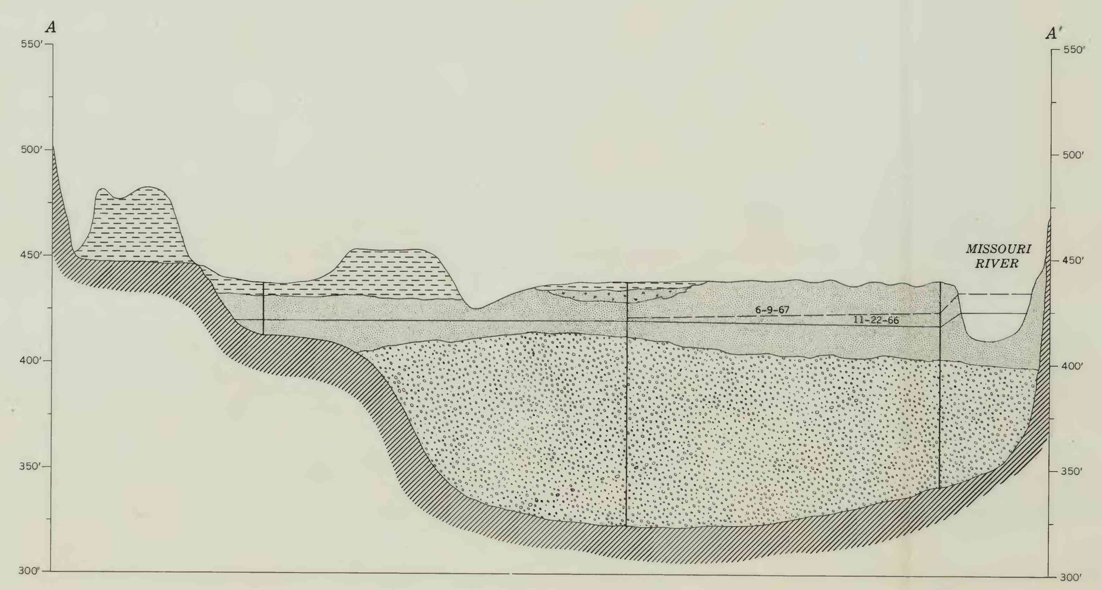
PREPARED IN COOPERATION WITH THE
MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES
WILLIAM C. HAYES, DIRECTOR AND STATE GEOLOGIST









0 1000 2000 3000 4000 5000 FEET
DATUM IS MEAN SEA LEVEL
VERTICAL EXAGGERATION × 40

HYDROGEOLOGIC MAP AND GENERALIZED GEOLOGIC SECTIONS

SCALE 1:125 000

2 1 0 2 4 6 8 10 MILES

2 0 2 4 6 8 10 KILOMETERS

DATUM IS MEAN SEA LEVEL

1968 MAGNETIC DECLINATION FROM TRUE NORTH FOR THIS SHEET VARIES FROM CENTER OF THE EAST EDGE 6° EASTERLY FOR THE CENTER OF THE WEST EDGE TO 5° EASTERLY FOR THE CENTER OF THE EAST EDGE

EXPLANATION

Well, number is depth to water, in feet below land surface

Test boring, number is depth to bedrock, in feet below land surface

Seismic sounding, number is depth to bedrock, in feet below land surface

530 Piezometric Contour
Shows altitude to which water would have risen in wells in December 1966. Contour interval 10 feet

12-7-66
12-5-67
Water level profiles for date given
Shown in sections only

Boundary between alluvium and bedrock

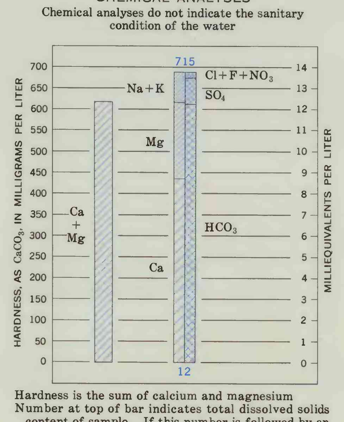
WELL LOGS AND GEOLOGIC SECTIONS

FEET 0, 50, 100

Clay
Silt
Sand
Sand, some gravel (sand is predominant)
Sand and gravel (equal amounts)
Alluvium
Bedrock

CHEMICAL ANALYSES

Chemical analyses do not indicate the sanitary condition of the water



Hardness is the sum of calcium and magnesium. Number at top of bar indicates total dissolved solids content of sample. If this number is followed by an "e" the content has been estimated from specific conductance.
Number at bottom of bar indicates well referred to in table

INTRODUCTION

The sand and gravel underlying the Missouri River flood plain between St. Charles and Jefferson City, Mo. contain an abundant amount of water, which for the most part is unused. At present (1967) there are no municipal well fields in the area. The only large capacity wells in use are a few industrial and irrigation wells in the flood plain areas of St. Charles and St. Louis Counties, and an irrigation well on the penal farm near Jefferson City in Callaway County. Some of the industrial wells in St. Charles County are capable of yielding as much as 3,000 gpm (gallons per minute). This does not mean large capacity wells can be developed at random anywhere in the valley. However, geologic logs of test holes bored in the vicinity of St. Charles, Augusta, Washington, and Hermann indicate large capacity wells may be feasible in these areas. There undoubtedly are many other areas in this reach of the valley where the thickness and permeability of the saturated sand and gravel could support large capacity (1,000 to 3,000 gpm) wells.

Purpose and Scope.—The purpose of this hydrologic atlas is to describe the thickness, areal extent, and lithology of the alluvial deposits along the Missouri River between Jefferson City and St. Charles, Mo., and to provide information on the occurrence, availability, use, and chemical quality of the water contained in the alluvial aquifer.

Cooperation and Acknowledgments.—This investigation was done in cooperation with the Missouri Geological Survey and Water Resources, Dr. William C. Hayes, Director and State Geologist. The assistance and information provided by his staff is greatfully acknowledged. The authors also thank the many residents in the area and the representatives of other State and Federal agencies who provided information and assistance.

GEOLOGIC SETTING

Bedrock.—The steep bluffs which border the Missouri River flood plain are composed predominantly of dolomite with lesser amounts of limestone and sandstone. Rocks of the same type also underlie the alluvium and form the bedrock surface. Areal distribution of these rocks is shown on the geologic map of Missouri (McCracken, and others, 1961). A description of each formation can be found in Howe and Koenig (1961). Well yield and quality of water from bedrock formations in Missouri are shown on maps by Robertson (1962), Fuller (1962), and Knight (1962).

Alluvium.—The river responsible for carving the Missouri valley has also partially filled this trough with alluvium consisting of sand, gravel, silt, and clay. In general, the lower part of the alluvium is made up of coarse sand and gravel, while the upper part is composed of fine sand, silt, or clay. Thickness of the alluvium is controlled by irregularities in the bedrock surface. Based on available test-hole data the maximum thickness of alluvium in this reach is about 120 feet. Average thickness one-half mile from the valley wall is about 100 feet. The average saturated thickness is about 80 feet.

Lithologic character and thickness of the alluvium are shown on the map by strip logs and geologic sections.

GROUND-WATER HYDROLOGY

Recharge, Discharge, and Occurrence of Ground Water.—Ground water available to wells occurs in the openings between individual sand and gravel particles making up the alluvium. Some of this water comes from direct penetration by downward percolation of rainfall; some is the result of overbank flooding or sustained high river stage. A still smaller amount may be due to underflow from bedrock aquifers.

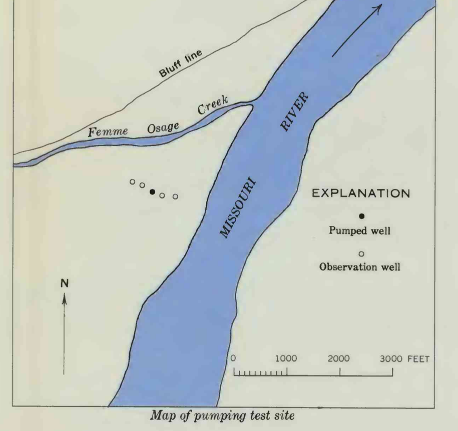
The main ground-water discharge is seepage from the alluvium into the Missouri River when river stage is low. Other discharge may be attributed to evapotranspiration, downward movement of water into the bedrock, and pumping from wells.

Ground water in the alluvial aquifer occurs under water table (unconfined) and artesian (confined) conditions. These conditions vary geographically and in time. In many instances confinement is marginal; that is, the water level is at or near the base of the confining layer. In these areas the water level may be above the base of the confining layer during wet seasons and below the base of the confining layer during dry seasons. Consequently, in referring to the map, reference will be made to the piezometric surface (the surface to which water in the aquifer will rise under its full head) rather than the water table (the upper surface of the zone of saturation).

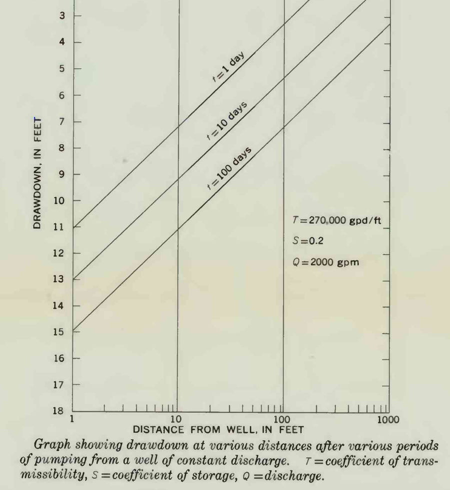
Movement of Ground Water.—Arrows drawn at right angles to the piezometric contours and pointed in direction of decreasing altitude would show the direction of movement of the ground water. At this particular time (December 1966) the Missouri River was acting as a drain throughout most of its length, except in the vicinities of Labadie and St. Charles. At other times, such as during periods of prolonged high river stage, the direction of movement may be reversed, at least in the area close to the river. The relation of the water level in the aquifer to river stage is shown by the water level profiles drawn on the geologic sections.

Water Level Fluctuations.—The Missouri Geological Survey and Water Resources has maintained a continuous water-level recorder on a well in the Jefferson City area since 1956. Its location is shown as the middle well on the Jefferson City geologic section (D-D'). The maximum range in water-level fluctuation in this well between 1956 and 1966, was 11 feet and was due to changes in river stage and variations in precipitation. Periodic water-level measurements are made in eight other observation wells shown on the four geologic sections. As would be expected, the water levels in wells closest to the river exhibit the greatest range in fluctuation.

Aquifer Characteristics.—An aquifer test was made in March 1967 using one of the wells in the Weldon Springs Ordnance well field (see map of pumping test site). The well was pumped for 47 hours at a rate of 2,650 gpm and water-level drawdowns were measured in observation wells 244 feet, 261 feet, 484 feet, and 502 feet from the pumping well. Results of the test show the coefficients of transmissibility and storage of the aquifer in the vicinity of the test are about 270,000 gpd per foot (gallons per day per foot) and 0.2 respectively. The average permeability is about 3,000 gpd per square foot. The values obtained from the test were used to construct the graph which shows the amount of drawdown at various distances from a pumping well that will be caused by a steady pumping rate of 2,000 gpm if there is no recharge. For instance, the drawdown 100 feet from a well pumping 2,000 gpm continuously for 10 days will be about 5.1 feet. Such high yield wells should be placed at least 1,000 feet apart to lessen the affect of interference between wells. If this is impractical then more wells with smaller discharge rates should be used. Pumping at a rate less than developed capacity may also prolong the life of the well.



Map of pumping test site



Graph showing drawdown at various distances after various periods of pumping from a well of constant discharge. T = coefficient of transmissibility, S = coefficient of storage, Q = discharge.

WELL SCREEN ENCRUSTATION

The precipitation of calcium and iron carbonates probably is the major cause of well screen encrustation problems in the area. Where well screen encrustation is a problem, it is likely that the drop in pressure which occurs around the well screen during pumping causes some carbon dioxide to leave solution, thus permitting some carbonates to precipitate. The accumulation of these precipitates eventually lessens the well yield.

Although well encrustation cannot be completely eliminated its effects can be delayed or minimized by controlling the methods of well operation. Since the decrease in pressure as water moves into the well is indirectly the principal cause of encrustation, well operating practices which cause the least pressure drop will delay the rate of encrustant accumulation. These practices are (1) developing the well to its maximum capacity then pumping it at a rate somewhat less than its developed capacity (2) by reducing the pumping rate and pumping more continuously or, (3) increasing the number of wells pumped and pumping them at a lower rate.

GROUND-WATER USE

Ground water withdrawal from the alluvium bordering this reach of the Missouri River represents only a small fraction of the water available to wells. The only areas where ground water is used for other than rural household or stock watering are in western St. Louis County, and a small area in St. Charles County near Weldon Springs. It is reported that less than 70,000 gpd is being withdrawn from the Weldon Springs well field. The amount of water being withdrawn for irrigation from the alluvium in western St. Louis County is approximately 200,000 gpd during the irrigation season. Water-level measurements made in wells in the area indicate that pumping has had no long-term effect on water levels.

GROUND-WATER POTENTIAL AND INDUCED RECHARGE

It was not possible to measure the water level in the pumped well during the aquifer test at the Weldon Springs site; therefore the exact specific capacity cannot be computed. However, a very conservative estimate can be made knowing the setting of the pump bowls, the discharge, static water level, and the fact the well did not go dry. Using these figures specific capacity would be about 65 gpm per foot. A group of 100 such wells spaced so as not to interfere with each other would yield about 374 mgd (million gallons per day) or about 580 cfs (cubic feet per second).

The old Weldon Springs Ordnance well field is an example of the tremendous ground water potential of the Missouri River alluvium. According to Searcy, Baker, and Durum (1952, p. 48) this well field, which consisted of 13 large capacity wells in a 344 acre tract, supplied water from the Missouri River alluvium at a rate of more than 44 mgd, or about 68 cfs. Undoubtedly those wells closest to the Missouri River induced recharge from the river when heavily pumped. "This principle of locating large capacity wells in permeable material near large streams and inducing infiltration from the stream has been used successfully at many places and has been particularly successful in the Ohio River Valley" (Searcy and others, 1952, p. 43). Similar large yields could undoubtedly be obtained elsewhere in the Missouri River valley by inducing recharge from the river.

Rorabaugh (1963, p. 52, 55-56) cites several advantages of a water supply developed through streambed percolation over a supply directly from the stream. The chief advantages are a more nearly uniform chemical quality, a temperature range less than that of a stream, and the apparent removal or dilution of most objectionable odors and tastes. Rorabaugh (1963, p. 51) further states the planning of a water supply that is to be dependent on induced percolation through a streambed requires extensive knowledge of not only the hydrology of the basin, but also the geologic and ground-water conditions in the vicinity of the proposed installation.

CHEMICAL QUALITY OF GROUND WATER

Water in alluvial deposits in this reach of the Missouri River is predominantly a calcium bicarbonate type with significant amounts of magnesium and sulfate. The water is characterized by a high hardness and iron content and a variable dissolved-solids content. Areal variations in the chemical characteristics and dissolved-solids content are shown graphically by bar diagrams on the map. Selected chemical analyses, along with the maximum, median, and minimum values, based on all of the available analyses, and the U.S. Public Health Service drinking water standards recommended maximum limit for potable water, are shown in the table of analyses.

Suitability for Domestic, Municipal, and Industrial Use.—Water from the alluvium is used for domestic and irrigation supplies and has been used for industrial purposes (Weldon Springs Ordnance). In evaluating the suitability of water for domestic and municipal uses, the concentrations of iron, manganese, fluoride, dissolved solids, and the hardness of the water are important characteristics. A high iron and manganese content is objectionable because it imparts an unpleasant taste and also stains fabrics, and porcelain and enamel fixtures. A small amount of fluoride is desirable because it reduces the incidence of tooth decay, but excessive amounts cause mottling of the tooth enamel. Hardness of water is caused principally by the calcium and magnesium salts in the water. A high hardness is undesirable in water for domestic use because it causes an excessive consumption of soap, and it causes scale formation in hot water pipes and in vessels in which the water is boiled.

A comparison of the maximum, minimum, and median values with the recommended limits for some constituents (see table) shows that the amounts of iron and manganese generally exceed the recommended maximum limit for these constituents. The maximum amounts of sulfate, chloride, fluoride, and nitrate are well below the maximum or optimum limits for these constituents.

Limits have not been established for hardness of water but according to the U.S. Geological Survey classification, water having a hardness of less than 60 mg/l (milligrams per liter) is rated as soft and is suitable for most purposes; hardness ranging from 61 to 120 mg/l is considered moderate, but it does not seriously interfere with the use of water except in high pressure boilers and in some industrial processes; hardness ranging from 121 to 180 mg/l is hard, and, in the upper ranges, the water could be softened profitably for some uses; water having a hardness in excess of 180 mg/l is very hard and usually is softened before being used. The minimum value for hardness of water in this area indicates that the water is very hard and softening of the water would be desirable for domestic or municipal use

Suitability of Water for Irrigation.—Rainfall is generally sufficient to maintain crop growth so irrigation is not widely practiced in this reach of the Missouri River valley. During periods when rainfall is not sufficient to maintain the desired soil moisture, water from the alluvial deposits could be used as a supplementary supply. According to classifications developed by the U.S. Salinity Laboratory (1954) water from the alluvium has a low sodium hazard and a medium to high salinity hazard (see diagram). Corn, soybeans, and alfalfa are the principal crops grown in this area and water of the above classification would be suitable for supplemental irrigation of these crops on almost all soils.

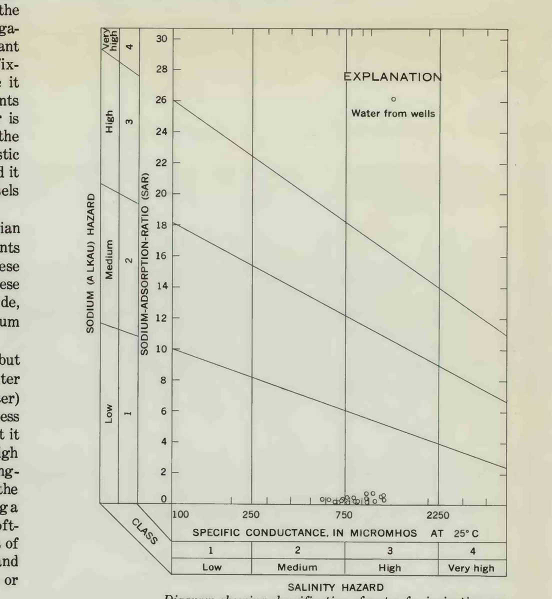


Diagram showing classification of water for irrigation use

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AREA OF THIS REPORT

CHEMICAL ANALYSES OF WATER FROM SELECTED WELLS

Well number	Depth, feet	Date of collection	Temperature, °C	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180° C)	Hardness as $CaCO_3$: Calcium Magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25° C)	pH	Color
				Milligrams per liter																			
1	41	2-3-67	17	26	2.9	0.70	160	31	18	6.1	625	50	6.7	0.0	0.0	609	527	14	6.8	0.3	959	7.1	0
2	108	11-4-64	—	24	5.1	.00	61	32	14	5.0	372	15	2.8	.2	.9	343	284	0	10	.4	575	7.9	6
3	46	2-3-67	15	26	2.8	2.7	172	38	11	5.3	662	55	2.4	.2	.0	641	586	42	3.9	.2	1,020	7.1	0
4	46	2-3-67	15	30	2.8	.76	110	33	6.6	5.3	527	18	1.9	.4	.0	468	410	0	3.6	.1	780	7.2	5
5	40	2-2-67	14	32	2.8	.20	142	39	34	5.8	719	3.2	3.3	.2	.0	616	515	0	12	.7	959	7.1	5
6	46	2-2-67	15	28	2.6	.52	120	25	4.6	5.0	495	22	1.0	.4	.0	452	403	0	2.4	.1	744	7.6	5
7	45	2-2-67	14	26	3.0	4.4	172	46	26	6.7	856	.8	5.4	.2	.0	711	619	0	8.1	.4	1,180	7.2	2
8	27	11-5-64	—	25	—	.00	70	42	23	3.9	317	77	46	.2	11	489	347	87	12	.5	770	7.9	5
9	51	2-2-67	16	23	3.2	.61	152	39	9.4	8.2	570	96	22	.2	.1	651	540	72	3.6	.2	1,030	7.1	2
10	56	2-2-67	16	30	2.7	.52	101	26	6.4	5.8	400	59	1.6	.5	.0	433	359	31	3.7	.1	690	7.3	4
11	46	2-1-67	18	16	.26	.57	89	22	7.5	3.3	332	58	2.8	.3	13	386	313	40	5.0	.2	633	7.4	0
12	40	2-1-67	15	32	3.4	2.3	172	46	23	6.2	753	62	7.5	.3	.0	725	619	1	7.4	.4	1,150	7.1	5
Maximum for area			18	32	5.2	4.4	172	46	38	8.2	856	117	46	.5	13	794	820	239	—	—	1,280	7.9	6
Median for area			16	26	3.4	.59	131	36	9.4	5.6	542	45	3.4	.2	.0	530	488	31	—	—	854	7.2	5
Minimum for area			14	16	.26	.00	61	22	1.1	3.3	317	.4	1.0	.0	.0	343	284	0	—	—	575	7.0	0
Recommended limits drinking water standards[1]			—	—	.30	.05	—	—	—	—	—	250	250	[2]1.7	45	500	—	—	—	—	—	—	20

[1] Public Health Service Drinking Water Standards, revised 1962.
[2] Varies with the 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 32.5° C. The optimum concentration is from 1.2 to 0.7 mg/l.

Base from U.S. Geological Survey, St. Louis, 1947 and Jefferson City, 1955, 1:250,000

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RECONNAISSANCE OF THE GROUND-WATER RESOURCES OF THE MISSOURI RIVER ALLUVIUM BETWEEN ST. CHARLES AND JEFFERSON CITY, MISSOURI

By
L. F. Emmett and H. G. Jeffery
1968

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