1963

Hydrogeology of reservoir sites in the Meramec River basin, Missouri.

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HYDROGEOLOGY OF RESERVOIR SITES IN THE MERAMEC RIVER BASIN, MISSOURI

BY

JOHN H. ANDERSON

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A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

Degree of

MASTER OF SCIENCE, GEOLOGY MAJOR

Rolla, Missouri

1963

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Approved by

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A B S T R A C T

Governmental and private agencies have proposed construction of multiple purpose dams in the Meramec River Basin for flood control, conservation, recreation and possible power development. Evaluation of the effects of reservoirs created by these dams on ground water conditions has not been published. Study of possible effects led to the thesis that prediction of changes in ground water conditions could be made.

Several limited applications of ground water geology techniques to the problem of reservoir-ground water relations were studied; no thorough previous studies were found. Apparently, complete studies have not been undertaken by even the larger agencies.

Inspection of the Meramec Basin disclosed features normally found in a region of temperate, humid climate and karst topography. Evaluation of the Meramec State Park, Virginia Mines and St. Clair reservoir sites, construction of cross sections, geologic maps, reservoir area overlays and study of well logs led to the conclusion that water stored in these reservoirs would leak into adjacent formations. The existence of caves and associated solution cavities, old mine workings, reported joint patterns and a gentle regional dip downstream are factors contributing to leakage. Predictions about anticipated changes in elevation of the ground water table are made. Pumping tests, installation of observation wells and detailed investigation of a power reservoir site are recommended.

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I. INTRODUCTION

Construction of multiple purpose dams, by public and private agencies, as a means of aiding the overall economic development of an area, has been an increasingly popular custom in recent years. Geological problems existing in areas selected for dam and reservoir construction have often been treated only as they affected the engineering design of a particular project. The effect of reservoir construction on the quality and quantity of ground water in a drainage basin has been studied, in most cases, only when specific problems of reservoir leakage, failure, or contamination of ground water occurred.

An area southwest of Saint Louis, Missouri, the basin of the Meramec River and its tributaries, including major areas in Crawford, Franklin, Jefferson and Washington Counties, has been considered for water development by both the Corps of Engineers (under their river and harbor program) and the Meramec Basin Corporation, a private organization interested in water and economic development of the Meramec area. Both agencies have proposed that a series of multiple purpose dams be built in the valley of the Meramec and on other streams in the basin. The problem of investigating and evaluating the effects those dams would have on ground water conditions in the Meramec Basin was suggested to the author in September 1962. Study of this problem led to the thesis that reasonably accurate predictions of changes in ground water conditions, in areas affected by reservoir construction, could be obtained by appropriate geologic study.

The objectives of this dissertation are to:

a. Review the literature on other reservoirs constructed in humid, karst areas and compare conditions existing in those areas with conditions existing or predicted in the Meramec Basin.

b. Describe several of the dam sites proposed by either the Corps of Engineers or the Meramec Basin Corporation, choosing those which appear to have the greatest problem potential to the ground water geologist.

c. Collect and evaluate specific geologic and ground water data for the locations chosen, including information on wells, springs and caves.

d. Describe the anticipated effects on ground water quantity and quality caused by reservoir construction at the locations selected.

The information assembled in the dissertation represents a review of available literature, data obtained from the St. Louis District Engineer, Corps of Engineers, U. S. Army, field work in the dissertation area and analysis of well data. Well data were obtained from the files of the Missouri Division of Geological Survey and Water Resources. Field work was done in the Meramec Basin in several short periods from October 1962 to May 1963. Visits were made to caves in the area with members of the Missouri Speleological Survey. Stratigraphy, lithology and some structural geology were compiled from existing literature, as modified from field investigations. A study of well logs, Corps of Engineers test borings, caves and field work provided information on the occurrence of ground water and the possible effects reservoir construction would have on ground water conditions.

II. ACKNOWLEDGEMENTS

The writer is indebted to Doctor James C. Maxwell, Associate Professor of Geology, Missouri School of Mines and Metallurgy, for suggesting the problem discussed in this thesis, and for advice, constructive criticism and constant encouragement. The Chairman of the Department of Geology, Doctor Paul D. Proctor, in 1960, persuaded the writer to resume long-delayed graduate studies. Valuable advice and assistance was offered by Colonel Alfred J. D'Arezzo, St. Louis District Engineer, Corps of Engineers, U. S. Army, and his staff. Permission to research files and well logs at the Missouri Geological Survey and Water Resources was granted by Doctor Thomas R. Beveridge, State Geologist; he and his staff were most helpful. Colonel Glenn R. Taylor, Professor of Military Science, Missouri School of Mines and Metallurgy, was responsible for allowing the writer to attend classes as a part-time graduate student. Finally, the writer is deeply grateful to his wife, Mary, for her patience, helpfulness and loyal support.

III. REVIEW OF PREVIOUS WORK

Although data are available on much of the geology of the Meramec Basin, only a few writers have presented any information about ground water conditions in the basin. Other areas of humid, temperate climate and semi-karst topography (similar to the Meramec Basin) have been described; geologic problems inherent in reservoir construction in these areas have been investigated by state and federal agencies.

A. Ground Water in Missouri.

The Corps of Engineers, U. S. Army, planned flood control projects in the Meramec River Basin in 1947-1948. Data concerning ground water aspects of the basin began to be published at that time.

General hydrology, flood damage estimation and recommendations for flood control with retarding basin reservoirs in the Meramec Basin were presented by I. K. Ozbilen (1950).

The permeability of algal reef deposits in the Bonne Terre formation in southeast Missouri (lithologically somewhat similar to the Eminence formation in the Meramec Basin) was determined with a helium permeameter by B. L. Perry (1958). He concluded that even minute fracturing would increase rock permeability hundreds of times.

Willard G. Owens (1960) described the occurrence of mineralized ground water in southern St. Louis and Jefferson counties. He included geologic cross sections and subsurface contour maps of the principal water bearing formations and determined that the occurrence of mineralized ground water in the area studied was controlled by lithology and structural features. Although problems of mineralized water were not found in the reservoir sites described in this study, Owen's descriptions were indirectly useful to the writer.

In 1961, Ullman, Boyce and Volk described water supplies, water quality and flood damage reduction in the Meramec Basin as part of an overall study of water development in the basin. This study is the basic document for information on proposals of the Meramec Basin Corporation for reservoir construction.

A ground water investigation of the southern half of Franklin County was reported by Kemal Piskin (1962), who analyzed well log data, stratigraphy, lithology and structures to determine occurrence and availability of ground water. Piskin concluded that the quality of ground water in the area studied was satisfactory for most uses. Information pertaining to water bearing formations, stratigraphy and well locations were used by the writer in evaluating areas surrounding proposed reservoir sites.

The stratigraphy and structure of the north half of the Meramec Spring Quadrangle was studied by Mueller (1951). A similar study of the south half of the same quadrangle was made by Yorston (1954).

B. Reservoirs in Other Areas.

Other areas similar to the Meramec Basin, the Tennessee Valley, in particular, have been described since the mid-1930's. The Tennessee Valley Authority, in a series of technical publications issued from 1939 to 1949, has presented hydrologic and geologic information as part of the data describing flood control projects in the Tennessee Valley, an area similar in many ways to the Meramec Basin.

Major and minor ground water horizons and the relationship of geologic structure and reservoir blocking of underground drainage to a rise in the ground water table near Vaspar, Tennessee, were described by Robert A. Laurence (1937). Vaspar, Tennessee, is near the Tennessee Valley Authority's Norris Reservoir.

G. M. Brune (1957) of the U. S. Soil Conservation Service, in describing methods used by that agency in geologic investigations of dam and reservoir sites, lists specific actions taken to determine movement of underground water in the vicinity of proposed reservoirs. These actions include location and delineation of any pervious formations (cavernous limestones, areas of jointing, buried stream channels), using dyes to trace underground water movement. Exploratory borings are made to determine the depth and extent of aquifers and to plan the location and depth of relief wells or foundation drains.

George A. Kiersch (1958) described the geologic causes for failure of the Lone Pine Reservoir in east central Arizona. He concluded that the failure of the reservoir was due to permeabilities developed when silt-filled sink holes and fissures in limestone formations were breached by the pressure head of water in the reservoir. Such partially and wholly filled sink holes and fissures are common in the areas studied for this thesis. Local joint patterns and regional structure (a gentle dip toward the dam) in the Lone Pine area were mentioned as contributing factors toward the establishment of an integrated underground drainage system.

Preliminary engineering geology reports of dam sites in Scott, Jennings and Jefferson Counties, Indiana, were prepared by John D. Winslow (1960). Winslow described the leakage problem that would probably occur if reservoirs (unless extensively grouted) were constructed in the North Vernon Limestone of southeastern Indiana. The North Vernon Limestone is similar (in the number of springs and solution cavities) to the Gasconade formation of the Meramec Basin.

J. E. Reed and M. S. Bedinger (1961), using electric-analog methods to determine boundary components, developed a technique for projecting the effect of changed stream stages on an aquifer with an impermeable boundary. A similar approach using other boundary conditions might be devised for other hydrologic areas. The same authors also (1962) described a method for estimating the effects of stream impoundment on ground water levels. The technique utilized assumed idealized conditions, i.e.; straight stream channel, flow system in equilibrium, averaging of water table fluctuations and no change in the recharge or discharge rates through the aquifer. An example of their method, using data for the Meramec Park Reservoir, is shown in Figure 11, for illustrative purposes only.

The Chattanooga, Tennessee, office of the Water Resources Division, United States Geological Survey, has participated in intensive gaging of stream flows below dams where leakage is a problem in the Tennessee Valley, (Cragwall 1963).

The Austin, Texas, office of this agency maintains reservoir content records indicating amounts of surface water apparently lost to underground formations. For example, a reservoir built in the pervious Edwards limestone to supply the City of Amarillo has consistently lost so much water that relief wells have been drilled around the perimeter of the reservoir to regain the losses (Twichell 1963).

Ground water data obtained for a sandstone aquifer near Oklahoma City, Oklahoma, have been used by that office of the United States Geological Survey to construct a configuration map of the ground water body. A reservoir was built in the area a few years ago but water level data sufficient to draw a new configuration map have not yet (April 1963) been collected, although personnel of the Oklahoma City office have predicted that the water table would be raised near the reservoir (Leonard 1963). This study is one of the few examples of the effects of reservoir construction on ground water levels which were found while conducting research for this dissertation. Apparently, the study of reservoir - ground water relationships has only recently begun by most private or public agencies (Moneymaker 1963).

Other standard references on ground water, hydrology and reservoir and dam construction were studied by the writer in preparing this dissertation.

IV. DESCRIPTION OF THE MERAMEC BASIN

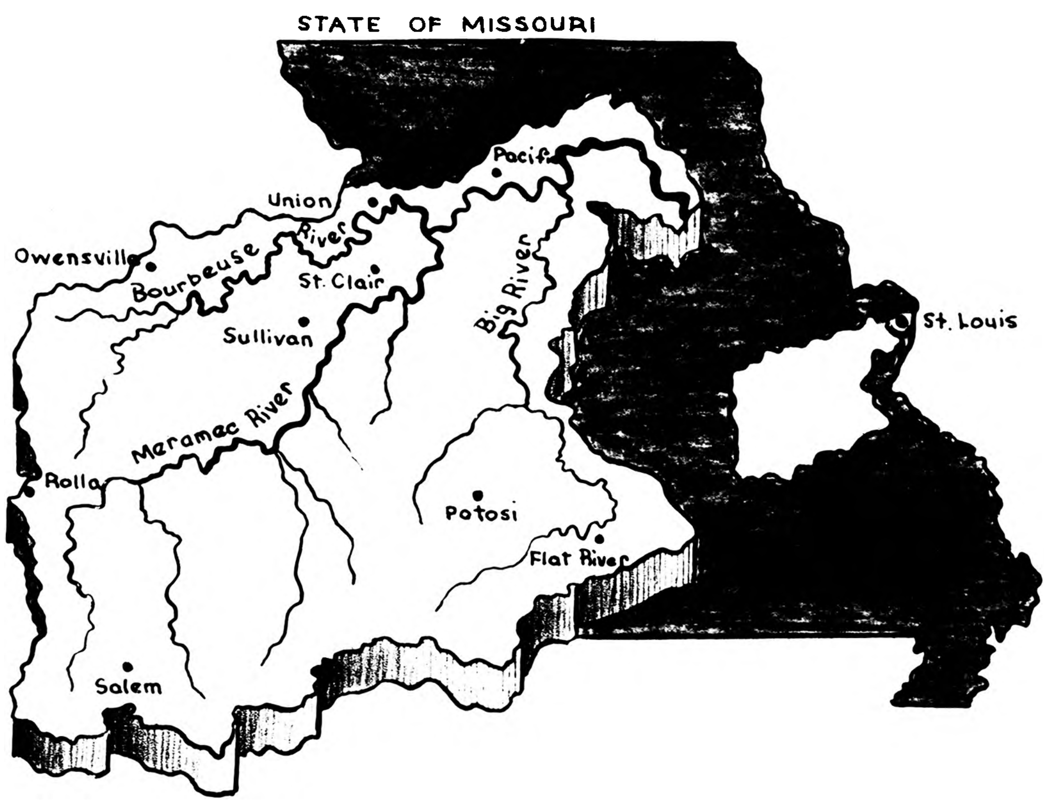
A. Geography.

1. Location and size.

The Meramec Basin extends nearly 100 miles southwest from St. Louis. As shown in Figure 1, it includes all of Crawford and Washington Counties and parts of Dent, Franklin, Gasconade, Iron, Jefferson, Maries, Phelps, St. Francois and St. Louis Counties. Total area of the watershed is about 3,980 square miles; the greatest north-south distance is about 70 miles; the east-west distance is about 80 miles.

2. Culture.

Most towns and transportation routes in the basin have developed along ridge lines. The Frisco Railroad was the original traffic artery; now U. S. Highway 66 (part of which is Interstate 44) also follows the main Ozark ridge from St. Louis to Springfield. There is a fair network of state and county roads connecting communities within the basin. Land use in the northern half of the basin is predominately agricultural; the southern half of the basin has more than 80% forest cover and is one of the more sparsely populated regions in the eastern half of the United States. Total basin population is about 210,000 (1960 census); less than 50 persons per square mile. About one-half of the total population is concentrated in the lower, eastern part of the basin in the St. Louis suburban area. Away from this St. Louis area, employment records indicate that between 25% and 30% of the working force is employed in agriculture, 50% to 55% in mining and manufacturing and about 20% in



LOCATION MAP OF MERAMEC RIVER BASIN

FIGURE I

services. New mineral discoveries, now under development, may eventually be utilized to balance the downward economic trend in some "depressed" areas in the Lead Belt in the southeastern part of the basin and provide additional employment and economic growth. Agricultural products include small grains, corn and soybeans. Livestock raising and the utilization of some forest products are increasing.

3. Climate.

Climate in the basin is temperate, humid continental, long summer phase. Specific climatic data are listed in Table 1.

B. Physiography.

1. Regional Setting.

The Meramec Basin lies entirely within, and occupies about the northeastern quarter of the Ozark Plateau Province (see Figure 2). Dolomites and limestones of Ordovician age, with important sandstone units, are the principal rocks exposed in the basin. Surface elevations range from 400 to 1400 feet above sea level; higher elevations occur in Dent and Iron Counties and lower elevations are found along the valleys of the Bourbeuse, Big and Meramec Rivers.

2. Topography.

Terrain in the northern half of the basin is gently rolling; toward the southern half, the land surface is increasingly rugged. Narrow, sometimes incised, stream valleys (0.2 to 0.5 miles wide) and a

TABLE 1

CLIMATIC DATA

Average Annual and Monthly Precipitation for Meramec River Basin

County	Years of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average Annual
Phelps	40	2.44	2.02	3.45	4.11	4.78	4.48	3.22	4.25	4.23	3.40	2.74	2.23	41.35
Crawford	23	1.89	1.91	2.94	4.47	4.55	3.71	3.25	3.57	3.37	4.04	2.72	2.41	38.83
Franklin	36	2.25	2.01	3.36	4.06	4.88	4.45	3.26	3.97	3.92	3.33	2.73	2.14	40.36
Washington	39	2.74	2.27	3.66	4.83	4.51	4.05	3.33	3.47	4.00	3.63	2.89	2.51	42.39
Jefferson	8	2.29	2.20	3.83	3.20	4.56	4.25	3.76	4.27	3.79	2.28	2.47	2.80	37.70
St. Francois	23	2.70	2.23	3.56	4.42	5.60	4.04	3.70	3.55	4.02	3.28	3.14	2.69	42.93
St. Louis	22	1.89	1.49	3.42	4.17	4.55	3.41	2.29	3.47	3.59	3.38	2.67	2.37	36.70
Dent	35	2.83	2.18	3.70	4.50	4.69	4.63	3.21	4.24	4.24	3.57	2.70	2.46	42.95

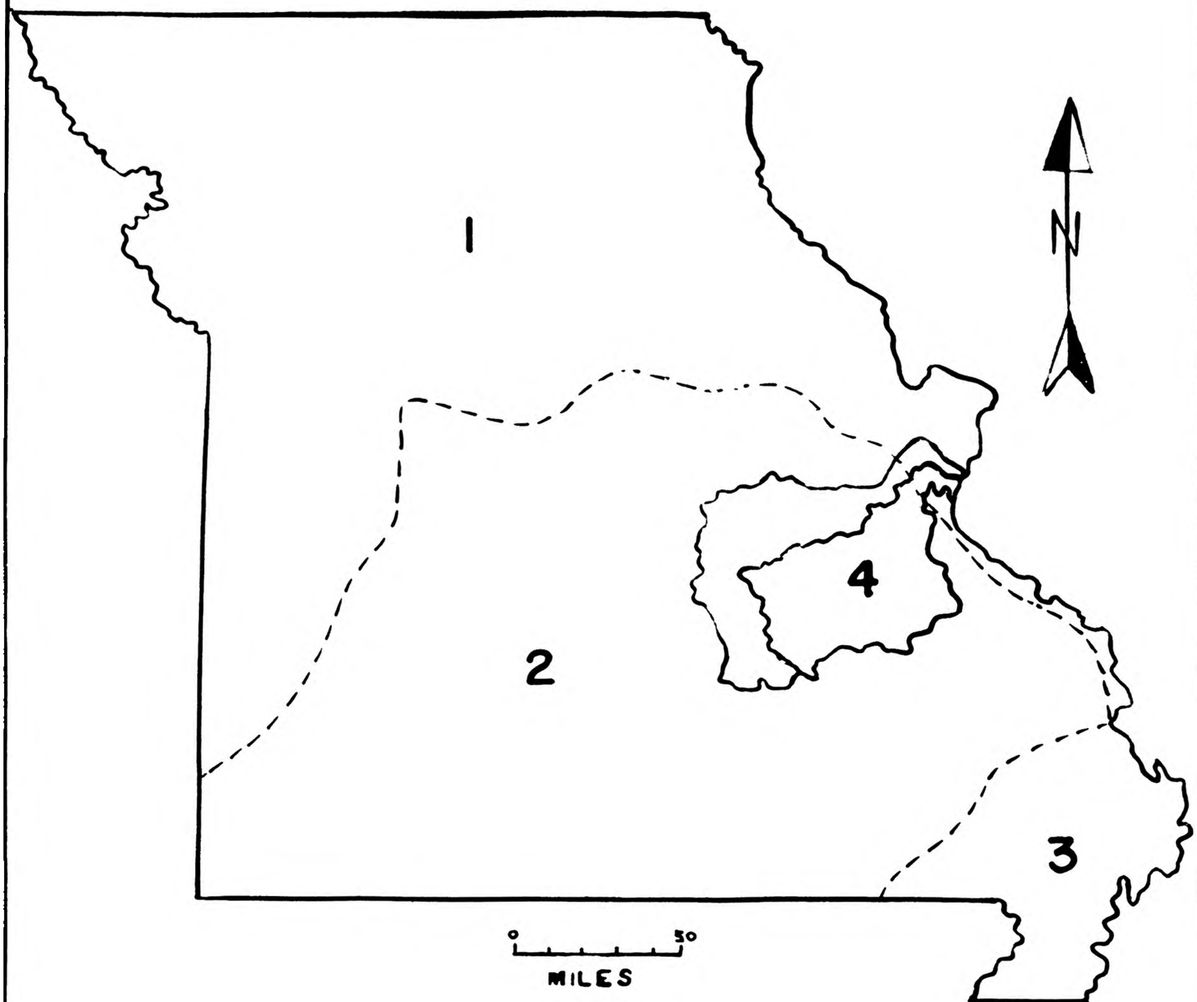
1. 42% of precipitation occurs during the period May - August.

2. Approximately 5% of precipitation falls as snow.

3. Annual run-off is about 25%; run-off plus evapotranspiration is about 30".

4. Average annual temperature is 55 degrees F; average summer temperature is 75 degrees F; average winter temperature is 35 degrees F.

5. Maximum rainfall recorded in 24 hour period is in excess of 10 inches.



1. CENTRAL LOWLAND PROVINCE
2. OZARK PLATEAU PROVINCE
3. COASTAL PLAIN PROVINCE
4. MERAMEC BASIN

RELATION OF MERAMEC BASIN TO MAJOR PHYSIOGRAPHIC DIVISIONS OF MISSOURI

FIGURE 2

series of generally northeast-southwest tending ridges are predominant features in the southern part of the basin.

3. Drainage.

Within the primary basin of the Meramec River, there are two secondary basins of importance -- that of the Bourbeuse River, with an area of 808 square miles, and that of the Big River, with an area of 955 square miles. Average gradients and major tributaries of the Meramec River and other stream data are given in Table 2.

4. Caves.

Solubility of the limestones and dolomites underlying much of the Meramec Basin is responsible for the formation of at least 50 caves known and identified by the Missouri Geological Survey. There are probably at least as many more caves not formally recorded (members of the Missouri Speleological Survey have located 25 caves in the small area of Meramec State Park), plus innumerable smaller solution cavities. Only about one-third of the caves have streams flowing in them; apparently the result of infiltration through small surface sinks and seeps. Caves in reservoir areas are plotted in Figure 3 and are named and classified in Table 3. The areal extent of a typical, although large, cave (Fisher Cave) is shown in Figure 4; Figure 5 is a photograph of solution cavities common in the Eminence formation. Similar or more numerous cavities occur also in the Gasconade formation.

TABLE 2

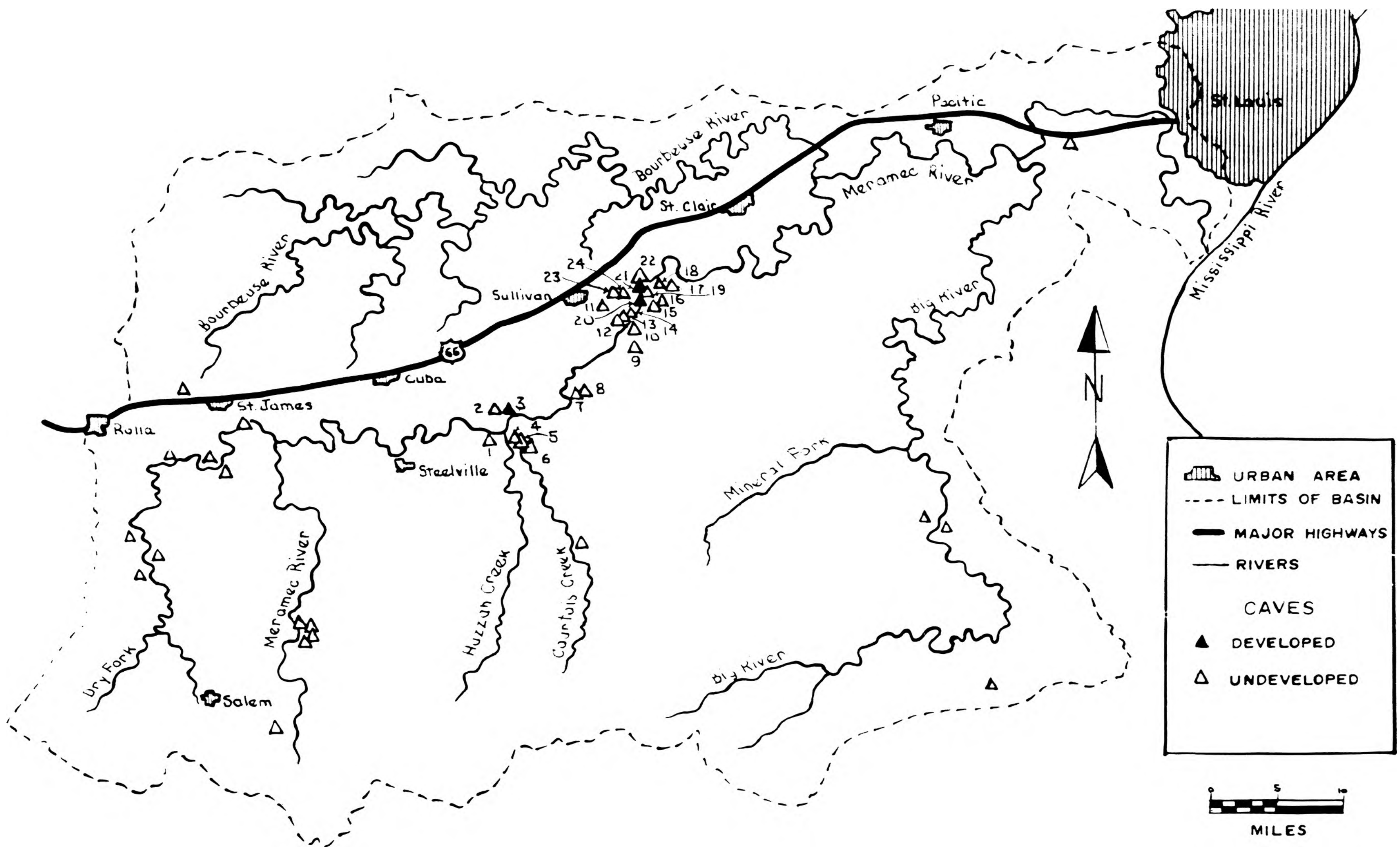
MERAMEC RIVER BASIN

MAXIMUM STREAM DISCHARGE

Record Period 1922-1949

RIVER	STATION LOCATION	AMOUNT (cfs)	DATE	MAXIMUM MONTHLY RUN-OFF INCHES	MAXIMUM MONTHLY RUN-OFF ACRE/FEET
Meramec	Steelville	47,800	26 Jun 35	6.39	266,300
Meramec	Sullivan	77,300	9 Jun 45	6.62	520,200
Meramec	Robertsville	102,000	10 Jun 45	5.89	839,700
Meramec	Eureka	120,000	11 Jun 45	5.89	1,190,000
Tributaries (all stations at intersection of tributary and Meramec)					
Dry Fork		18,800	8 Jun 45		
Huzzah		13,800	8 Jun 45		
Courtois		24,300	8 Jun 45		
Bourbeuse	St. James	4,890	12 Sep 45		
Bourbeuse	NW of Sullivan	33,300	26 Apr 47		
Bourbeuse	Union	28,500	10 Jun 45	6.40	272,700
Big	DeSoto	21,300	15 Feb 49		
Big	Byrnesville	31,700	12 Mar 35	6.23	304,300

Gradients on the Meramec and major tributaries are about 1%.



LOCATION OF CAVES IN MERAMEC BASIN

FIGURE 3

TABLE 3

CAVES NEAR THE MERAMEC STATE PARK RESERVOIR

(After Bretz 1956)

Location on Map	Cave	County	C = Commercial U = Undeveloped
1	Puckett	Crawford	U
2	Cathedral	Crawford	U
3	Onandaga	Crawford	C
4	Bat	Crawford	U
5	Bear	Crawford	U
6	Fault	Crawford	U
7	Unnamed	Crawford	U
8	Unnamed	Crawford	U
9	Hamilton	Washington	U
10	Green's	Washington	U
11	Mud	Franklin	U
12	Mushroom	Franklin	Formerly C
13	Sheep	Franklin	U
14	Unnamed	Franklin	U
15	Walker	Franklin	U

TABLE 3

(Continued)

Location on Map	Cave	County	C = Commercial U = Undeveloped
16	Unnamed	Franklin	U
17	Greene	Franklin	U
18	Eddy	Franklin	U
19	Indian	Franklin	U
20	Fisher	Franklin	C
21	Meramec Caverns	Franklin	C
22	Bat	Franklin	U
23	Unnamed	Franklin	U
24	Bear	Franklin	U

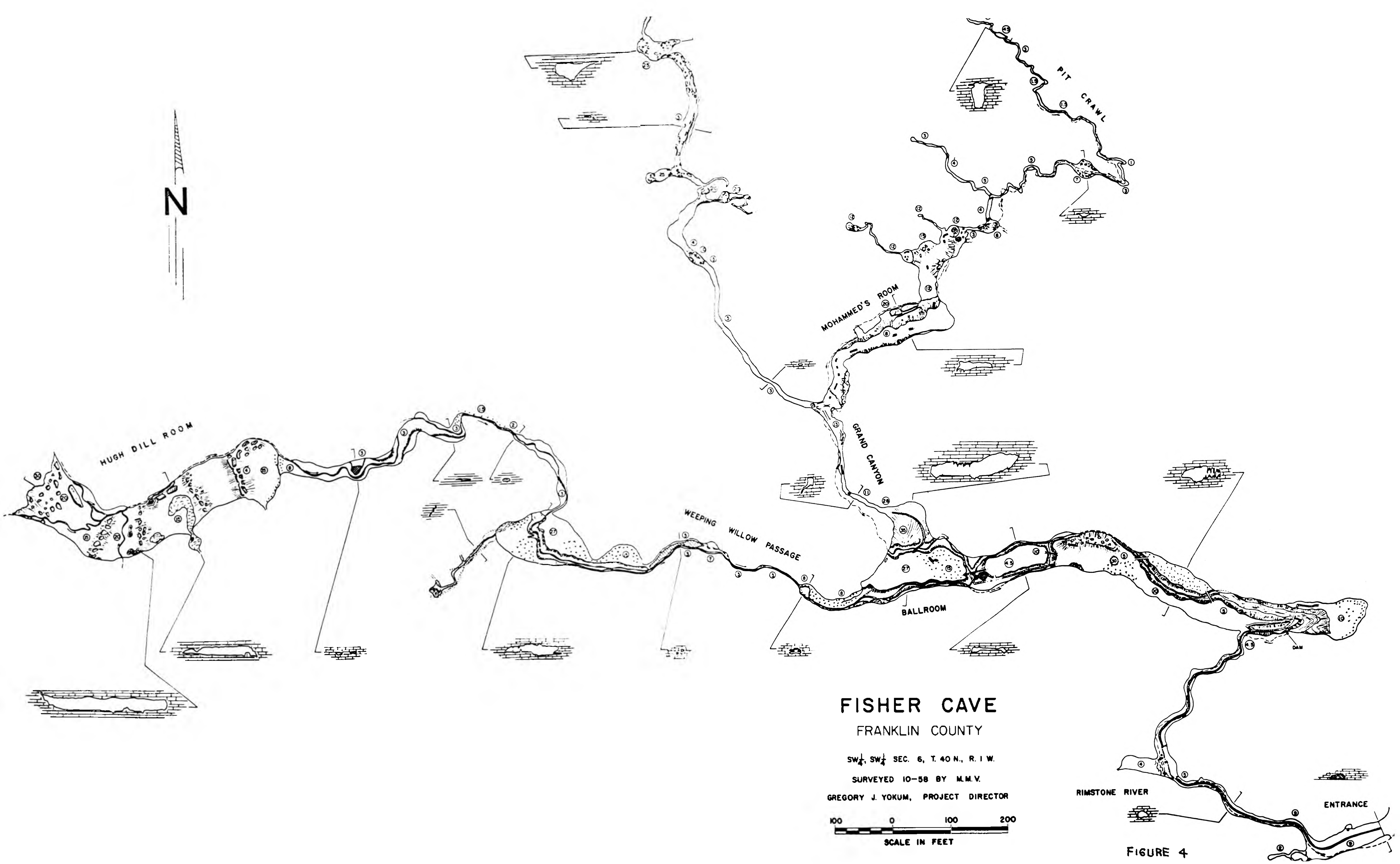

N
HUGH DILL ROOM
WEEPING WILLOW PASSAGE
BALLROOM
GRAND CANYON
MOHAMMED'S ROOM
PIT CRAWL
RIMSTONE RIVER
ENTRANCE
DAM
FISHER CAVE
FRANKLIN COUNTY
SW¼, SW¼ SEC. 6, T. 40 N., R. I W.
SURVEYED 10-58 BY M.M.V.
GREGORY J. YOKUM, PROJECT DIRECTOR
100 0 100 200
SCALE IN FEET

FIGURE 4

SOLUTION CAVITIES IN THE EMINENCE FORMATION,

100 YARDS NORTH OF FISHER CAVE, MERAMEC STATE PARK,

SW QUARTER, SECTION 6, TOWNSHIP 40 NORTH, RANGE 1 WEST

FIGURE 5

C. Geology.

1. Stratigraphy.

Formations located in the thesis area of the Meramec Basin are Pennsylvanian, Ordovician, Cambrian and Precambrian in age and are shown graphically in a standard stratigraphic column, Figure 6.

2. Structure.

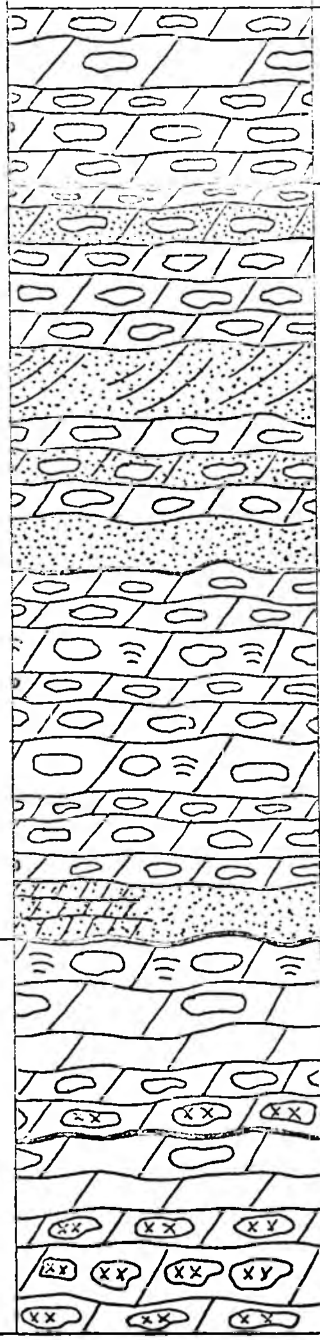
a. Regional Structure. The Meramec Basin lies northwest of the domal structure centered in the St. Francois Mountains. Dips in the basin are generally northeastward, about 10 to 20 feet per mile. Low folds with flank dips of a few degrees occur throughout the Ozark Plateau Province.

b. Local Structure. Flat lying or gently dipping strata characteristic of areas in the vicinity of proposed reservoirs are shown in cross sections, Figures 10, 12 and 14. Wells for which data were available are also indicated by the number of the listing given in the well log tables.

D. Hydrology.

1. Surface water.

Steam flow records are available for the Meramec, Bourbeuse and Big Rivers and for some tributaries of the Meramec River. Discharges are generally greatest during March, April, May and June and relate directly to precipitation. Run-off is about 25% of the average annual precipitation of 41 inches. Run-off plus evapotranspiration is almost 30 inches



		Name	Thickness in Feet	Description
Ordovician System	Canadian Series	Jefferson City Fm.	40-90	Light brown crystalline dolomite
		Roubidoux Fm.	80-150	White to reddish sandstone. Cross-bedded ripple marks.
		Gasconade Fm.	70-250	Light brown-gray crystalline, chert, cryptozoan
		Gunter Mbr.	0-30	Fine quartzose sandstone
Cambrian System	Croixan Series	Eminence Fm.	70-200	Gray-white, massive dolomite. White oolitic chert. Cryptozoan chert.
		Potosi Fm.	30-260	Light gray, massive, crystalline dolomite - quartz druse

LEGEND

Dolomite w/chert; Dol.: cavities w/quartz druse; Sandstone; Cryptozoanes; Sandy Dolomite; Dolomite; Cross-Bedded Sandstone

GENERALIZED STRATIGRAPHIC COLUMN
RESERVOIR AREAS

FIGURE 6

annually. Table 2 shows maximum discharge for selected streams in the Meramec Basin.

2. Flood Data.

Flood damage is not a critical problem in the Meramec Basin at present. Three major floods have occurred in the recent past; in August 1915, April 1927 and June 1945. Three types of floods cause damage in the basin; floodwaters from the Mississippi River back up in the Lower Meramec (this last occurred in 1961), tributary streams flood as the result of local high intensity storms, and the main streams of the Meramec, Big and Bourbeuse Rivers flood when widespread, heavy precipitation occurs over the drainage area. Estimates on average annual flood damage in the basin range from $500,000 to $1,000,000. The relationship between rainfall and maximum discharges for selected floods is shown in Tables 1 and 2. A 5 year and a 50 year design flood were computed for the Meramec River and are shown in Table 4 and Figure 7. Computations followed a method developed by Tate Dalrymple and M. A. Benson and outlined in USGS Circular 370. Other methods have been developed and used by other federal agencies, notably the Departments of Commerce and Agriculture.

3. Ground Water.

Ground water occurs throughout the Meramec Basin, both in the alluvium of valley floors and in the consolidated sedimentary rocks of several formations; the Roubidoux, Gasconade, Eminence and Potosi formations. Most wells range from 4 to 8 inches in diameter, from less than 100 to more than 1200 feet deep and yield from 10 to 500 gpm.

TABLE 4

FLOOD DATA INFORMATION

Site: Meramec Park Reservoir. River: Meramec. Station: Sullivan

Drainage Area: 1,475 square miles

Mean Annual Flood (cfs): 24,000

Flood Frequency Ratio to Mean Annual Flood:

5 years ... 1.5 50 years ... 2.9 100 years ... 3.4

Design Flood: 5 year: 36,000 cfs 50 year: 69,600 cfs

100 year: 81,600 cfs

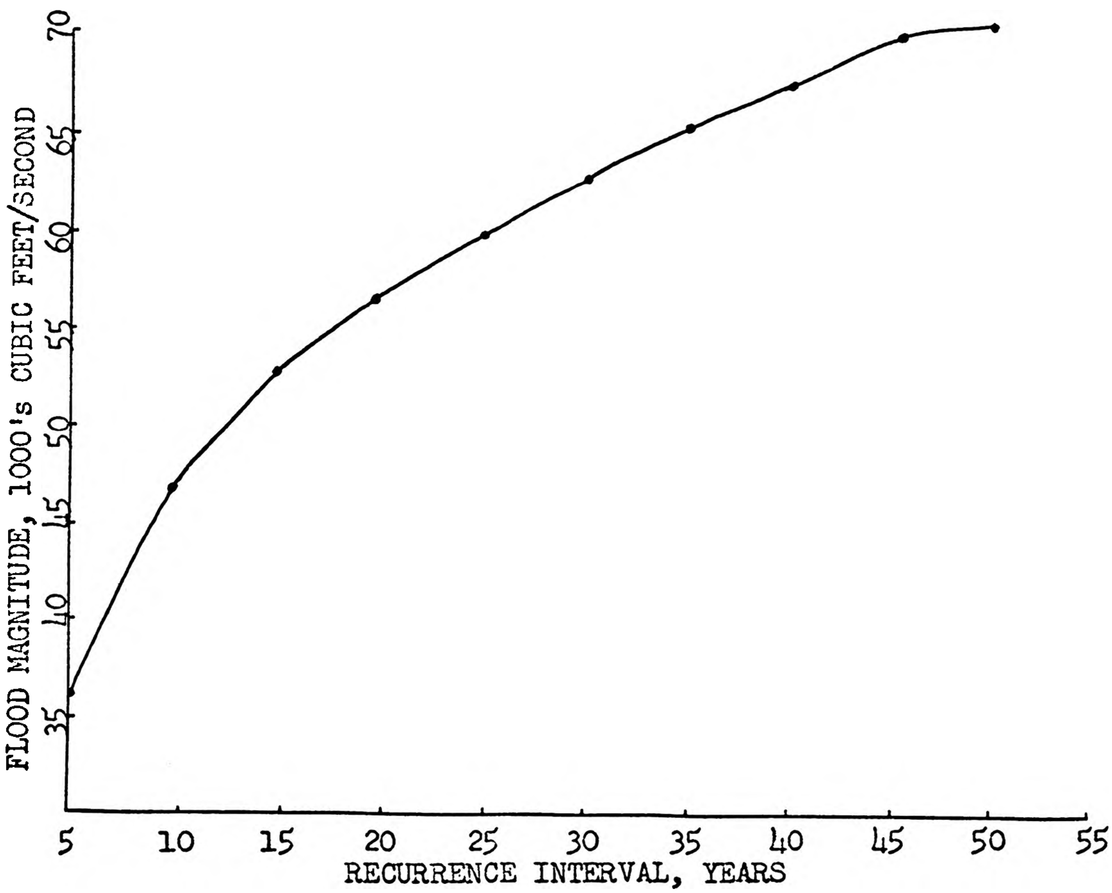
Design Criteria: "Contain flood of 7 to 11.5 inches of run-off, plus joint-use pool of about half this amount,"

Maximum Recorded Discharge: 77,300 cfs or 153,054 Acre/feet/day

Maximum Recorded Monthly Run-off: 6.62 inches; 520,200 acre/feet

Corps of Engineers Reservoir Design:

Normal Storage	418,440 acre/feet
Flood Storage	581,560 acre/feet
Total Storage	1,000,000 acre/feet

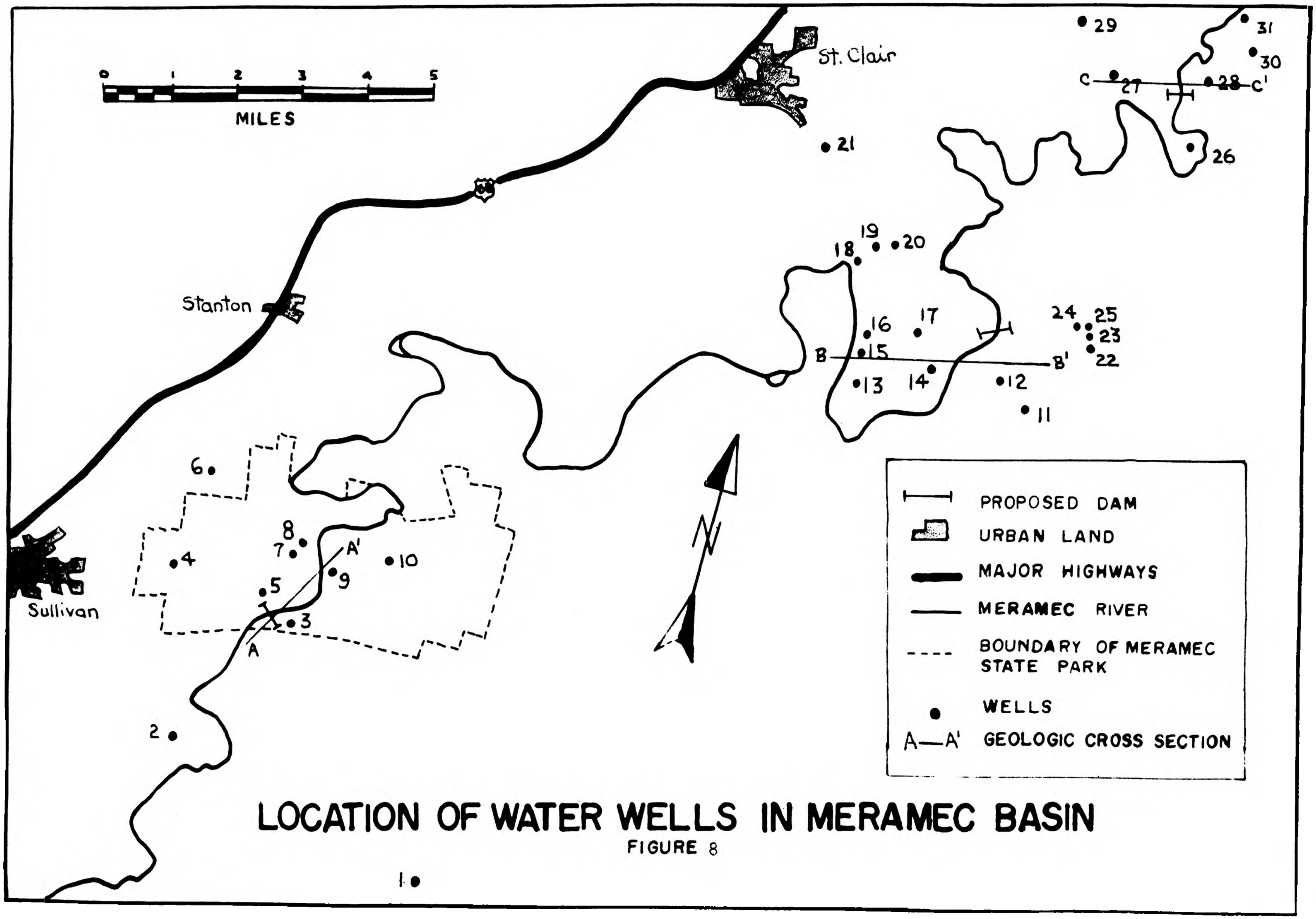


FLOOD FREQUENCY CURVE

MERAMEC STATE PARK RESERVOIR

(USGS CIRCULAR 370)

FIGURE 7



LOCATION OF WATER WELLS IN MERAMEC BASIN

FIGURE 8

Specific capacity varies from about .05 to 2.5 units. Water quality is satisfactory for most uses, except in the northeast part of the basin where excessively mineralized ground water occurs. Data for selected wells near reservoir locations in the basin are given in Tables 6, 7 and 8; location of these wells is shown in Figure 8.

4. Springs.

The Missouri Geological Survey has located at least 31 springs in the Meramec Basin; all but three of these springs have mean annual flows of less than 10 cfs. Springs occur most frequently in areas containing solution channels, caves and sinks -- characteristic karst topography. "Dry valleys," whose sand and gravel beds act as drains to underground channels, are common. Normal flows of most springs are constant, although quantity of flow is directly related to precipitation; most springs increase in flow and become turbid within a few hours after heavy local rains. Table 5 lists data for springs in the Meramec Basin; Figure 9 shows locations of these springs.

TABLE 5

LARGE SPRINGS IN THE MERAMEC BASIN

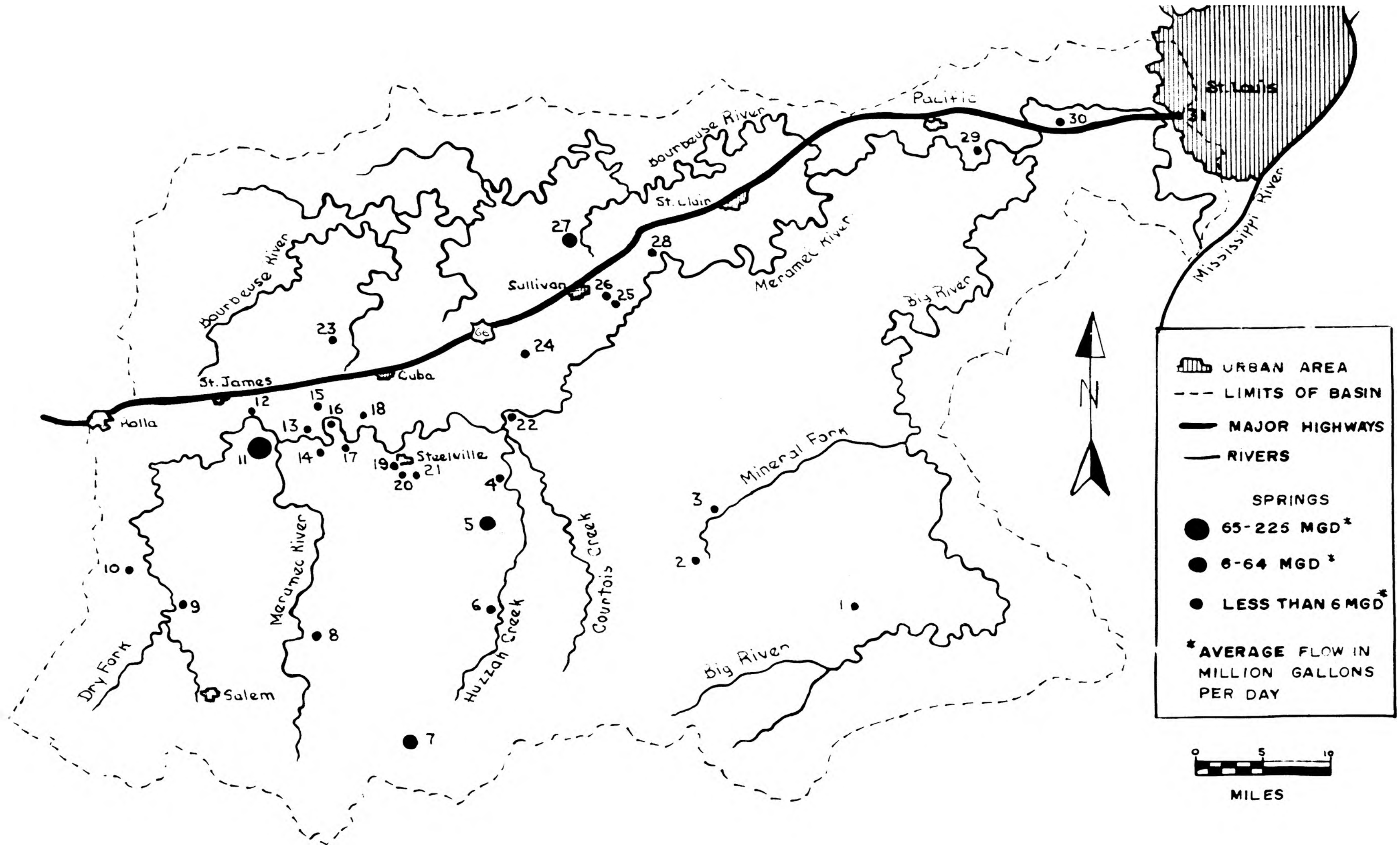
(After Beckman and Hinchey, 1944)

LOCATION ON MAP	SPRING	COUNTY	FLOW (100,000 GAL) PER DAY
1	Hopenwell	Washington	13.1
2	Racing	Washington	15.1
3	Cold	Washington	4.5
4	James	Crawford	14.3
5	Westover	Crawford	40.7
6	Woodlock	Crawford	13.0
7	Howes Mill	Dent	45.9
8	Mint	Dent	3.9
9	Brown	Dent	.9
10	Lake	Dent	.14
11	Meramec	Phelps	362.0
12	Brook	Phelps	4.0
13	Richart	Crawford	8.1
14	Beaver	Crawford	1.2
15	Elm*	Crawford	4.8 - .15
16	Roaring	Crawford	26.5
17	Indian	Crawford	1.5
18	McIntosh	Crawford	6.1

Table 5
(Continued)

LOCATION ON MAP	SPRING	COUNTY	FLOW (100,000 GAL) PER DAY
19	Steelville	Crawford	9.7
20	Collins	Crawford	10.3
21	Evans	Crawford	2.6
22	Onondaga	Crawford	7.7
23	McDade	Crawford	5.2
24	Blue	Crawford	31.7
25	Falling	Franklin	.5
26	Elm	Franklin	8.0
27	Kratz	Franklin	43.9
28	Roaring	Franklin	6.5
29	Rock	St. Louis	.6
30	Blue Brass	St. Louis	.6
31	Rott Road	St. Louis	.15

*Ebb and Flow Spring



LOCATION OF SPRINGS IN MERAMEC BASIN

FIGURE 9

V. EVALUATION OF RESERVOIR SITES

A. Meramec State Park.

A site in Meramec State Park was chosen by the Corps of Engineers in 1948, and more recently by the Meramec Basin Corporation as a "key" reservoir in any basin development plan. The relationship of the reservoir to areal geology is shown in Plates Ia and Ib; maximum and normal pool levels are indicated on Plate Ia. Specific data for the Corps of Engineers and Meramec Basin Corporations reservoirs and dams are listed in Table 9. A cross section along the axis of the reservoir is shown in Figure 10; logs for wells in the area are listed in Table 6.

The topography and geologic structure of this area appear suitable for reservoir construction. The level floor of the alluvial valley is from 500 to 1000 feet wide, depth of alluvium is about 20 feet. The distance between ridge lines is from 3000 to 6000 feet. The vertical distance from normal river level to the tops of the bordering hills is about 250 feet. Surface features indicate the probability of satisfactory geologic structure and the local structure is relatively simple. Surface and underlying beds are approximately horizontal, dipping gently toward the northeast about 20 feet per mile. There are no recognized faults in the vicinity and only minor localized folding. Nearly vertical, north-south trending, joints are common in the area. There may be a connection between the joint orientation and the elongated north-south doming in Precambrian basement rock shown on the map of magnetic anomalies for the state of Missouri.

Only two stratigraphic units, the Gasconade and Eminence formations, outcrop in this area and underlie the proposed reservoir. The unconformable stratigraphic contact between the Eminence and Gasconade formations occurs in this area between 670 and 620 feet elevation. The Gunter member of the Gasconade formation has been identified at several points in the area; elsewhere, the Eminence-Gasconade contact has been approximately located by variations in the chert of both formations. Although the Gunter member is described as an aquifer, its thickness in this area is not great enough to cause special problems. The Meramec River, in this area, has eroded several vertical bluffs, exposing the Gasconade formation.

A most striking feature in the area is the large number of caves, springs and solution cavities developed in both formations. An example of the size and configuration of cavities in the Eminence formation is shown in Figure 5. The center line trace of Fisher Cave, a representative (although larger than average) cave of this area is shown on Plate Ib. At normal pool level, some caves upstream from the dam will be inundated. There appears to be no likelihood of underground steam piracy at Fisher Cave (Woodward 1961).

At maximum and normal pool levels, the Eminence formation and the lower part of the Gasconade formation will be submerged. Leakage into both the Gasconade and Eminence formations appears to be a definite problem. The regional dip, to the northeast toward the dam, will result in a greater hydraulic head on any given stratum and may accentuate the leakage. Because both formations will be hydraulically connected to the reservoir, a rise in the ground water table may be expected. For example, from the area around well number 4 (see Figure 8 and Table 6), the average slope of the ground water table toward the Meramec River is 64 feet per mile. With an increased height of water of 92 feet at the dam (normal pool level) and a corresponding increase in head, the estimated rise in the ground water table at well number 4 is 36 feet. In the area around well number 1 (see Figure 8 and Table 6), the estimated rise in the water table is 23 feet. At this location, the average slope of the ground water table toward the Meramec River is about 50 feet per mile. The maximum change of head between natural and post-construction conditions should occur with a steepening of the water table around the ends of the dam; the estimated rise of the water table at wells 3 and 5 may exceed 200 feet. This increased elevation of the water table near the dam and the resultant steepening of the ground water gradient will increase the lateral flow of water through the aquifers, perhaps enlarge joints and cavities, flush clay seams and generally increase the leakage problem. Estimations in rise of the ground water table represent the best judgment of the writer from the limited data available.

Permeabilities and transmissibilities of the Gasconade and Eminence formations should be determined, although the large number of solution cavities in both formations would introduce many variables into any standard determination. Because the total depth of water at the dam at normal pool level is to be more than 100 feet, hydrostatic pressure may force new channels in cavities that are presently

MERAMEC PARK RESERVOIR

GEOLOGIC MAP

AND

RESERVOIR OVERLAY

LEGEND

MAP

Qal - Alluvium

Og - Gasconade formation

Ꞓe - Eminence formation

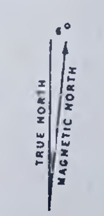
xxxx Caves, center line

OVERLAY

Normal Pool Boundary

Flood Control Pool Boundary

Proposed Dam



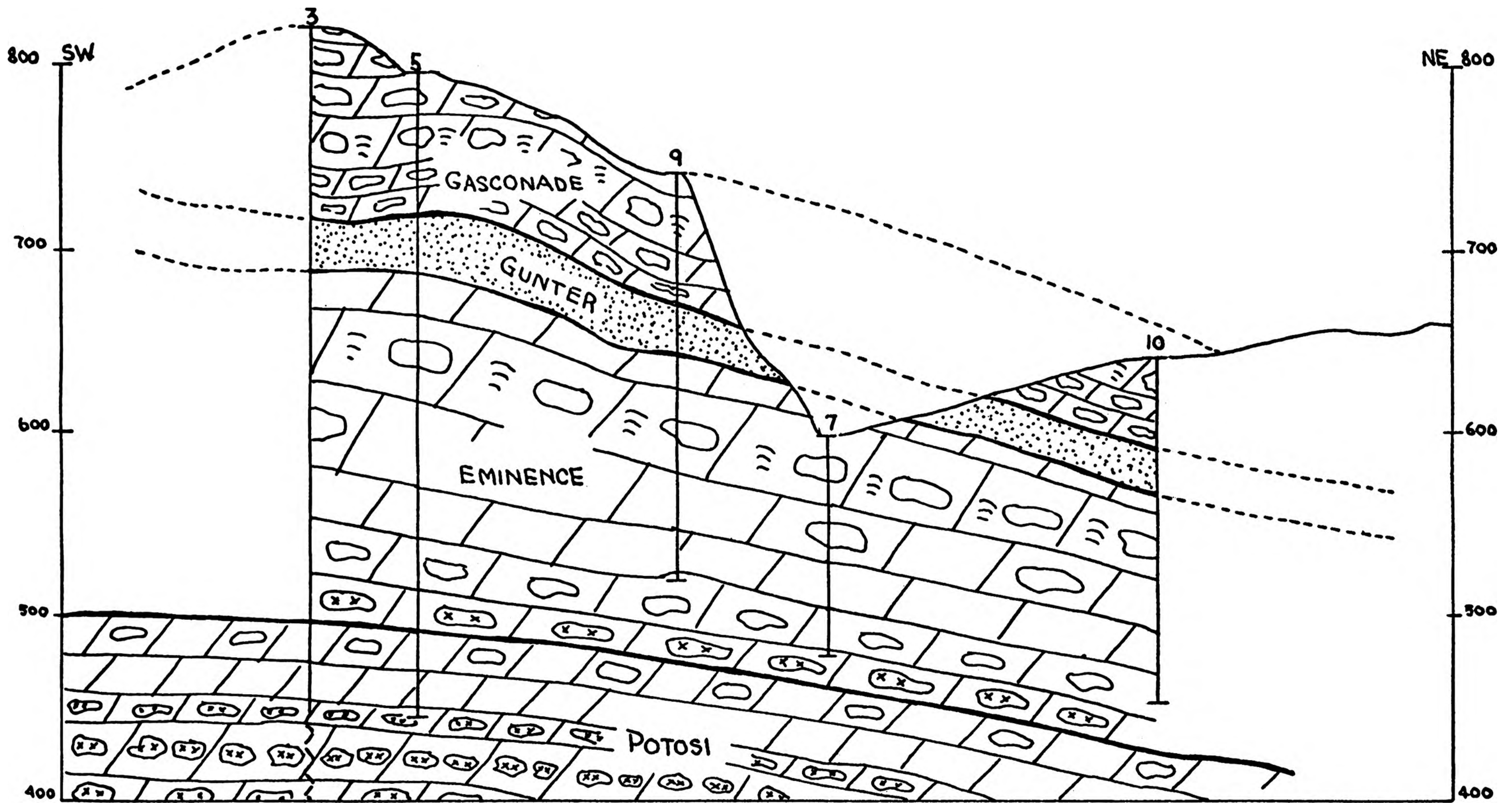
Scale $\frac{1}{24000}$

1 ½ 0 1 Mile

5000 4000 3000 2000 1000 0 5000 Feet

Contour interval 20 feet

Datum is mean sea level



CROSS SECTION A-A'
HORIZONTAL SCALE 1:24,000
VERTICAL SCALE 1" = 100'
FIGURE 10

<u>TABLE 6</u>

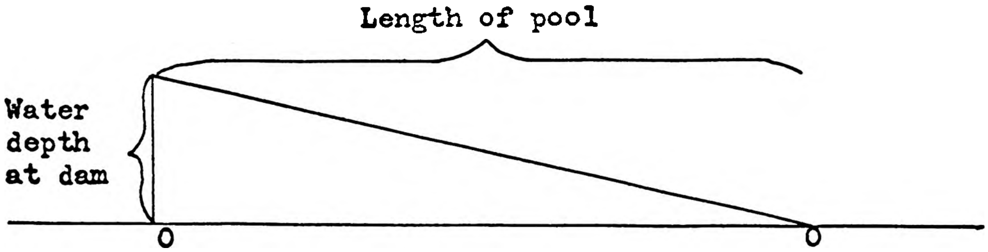
WELL LOGS - MERAMEC STATE PARK RESERVOIR

Map No.	MGS No.	Location	Elev. (ft)	Total Depth (ft)	S.W.L. (Depth ft)	Formations Penetrated	Prod. (gpm)
1	15872	T40N R1W Sec. 28, SE SW	879	245	140	0-80 ft. N.S. 80-245 ft. Eminence	7
2	8510	T40N R2W Sec. 24, SW SW	620	200	40	0-125 ft. Eminence 125-200 ft. Potosi	20
3	2900	T40N R1W Sec. 18, NW NW	817	605	230	0-38 ft. N.S. 38-105 ft. Van Buren 105-140 ft. Gunter 140-340 ft. Eminence 340-605 ft. Potosi	25
4	2477	T40N R2W Sec. 11, SW NW	750	175	60	0-175 ft. Eminence	Unk.
5	2747	T40N R2W Sec. 12, SW NE	790	383	200	0-5 ft. N.S. 5-75 ft. Van Buren 75-110 ft. Gunter 110-315 ft. Eminence 315-350 ft. Potosi	12
6	2089	T40N R2W Sec. 2, NE NW	778	209	Unk	0-8 ft. N.S. 8-140 ft. Gasconade 140-209 ft. Eminence	Unk.
7	2464	T40N R1W Sec. 6, SW SW	595	120	16-20	0-120 ft. Eminence	Unk.

TABLE 6

(Continued)

Map No.	MGS No.	Location	Elev. (ft)	Total Depth (ft)	S.W.L. (Depth ft)	Formations Penetrated	Prod. (gpm)
8	2463	T40N R1W Sec. 6, SW SW	595	126	16-20	0-126 ft. Eminence	Unk.
9	5043	T40N R1W Sec. 7, NE NW	737	220	Unk.	0-25 ft. N.S. 25-70 ft. Van Buren 70-100 ft. Gunter 100-220 ft. Eminence	Unk.
10	3754	T40N R1W Sec. 5, SE SW	635	185	18	0-5 ft. N.S. 5-50 ft. Van Buren 50-70 ft. Gunter 70-185 ft. Eminence	Unk



Head Change Along Stream Due To Impoundment

Assumptions

1. Stream hydraulically connected with aquifer.
2. Change in stream stage upstream from dam due to impoundment is nearly linear with distance from the damsite.
3. Upstream from upper extreme of pool and downstream from dam, change in surface-water stage due to impoundment is negligible.
4. Distribution of head change in aquifer caused by change in stream stage can be determined.

Data

1. Average water depth at dam = 101 feet.
2. Length of pool = 27 miles.
3. Width of pool 5000 feet upstream from dam = 3000 feet.

Using data listed and Reed and Bedinger's head-change distribution table, head change in aquifer is 32 feet.

ESTIMATING EFFECTS OF STREAM IMPOUNDMENT ON GROUND-WATER LEVELS

MERAMEC STATE PARK RESERVOIR

(after Reed and Bedinger, 1962)

FIGURE 11

blocked with clay or silt. The location of the proposed pumped storage reservoir, with a head of more than 240 feet above the Meramec River level, should require critical examination of the site selected, because several small, only vaguely located, caves are reported in the area. The pressure gradient of that reservoir could cause leakage through the underlying formations.

Assuming that leakage will be anticipated, major caves and sinks located and treated, and the dam properly founded and keyed to the abutments, the construction of a reservoir at this location appears hydrogeologically feasible.

B. Virginia Mines.

Both the Corps of Engineers and the Meramec Basin Corporation have selected a location for a smaller reservoir southeast of St. Clair, as shown in Plate IIa. Well logs for the area are listed in Table 7, data for the two reservoirs (the sites for the dams are not the same) are listed in Table 9 and a cross section along the axis of the Corps of Engineers dam is shown in Figure 12.

In this area, the valley is from 1200 to 2000 feet wide; the difference in elevation from the river level to the tops of the bluffs is about 200 feet. These bluffs are in the Gasconade formation. The overlying Roubidoux formation outcrops on the upper valley walls and caps the hilltops. Although the contact between the Gasconade and the Roubidoux formations is normally covered by residium, the contact is occasionally marked by a growth of pine, rooted in the sandy Roubidoux; this, however, has not been found to be a definite criteria.

Burke (1951) has described the geology of the area surrounding the proposed reservoir sites. He mentions the generally horizontal beds as having a gentle northeastward dip of about 2 degrees, and further describes a low doubly plunging anticlinal fold, trending southeast-northwest, with dips of about 2 degrees on the southwest flank and 0.5 to 1.5 degrees on the northeast flank, located in sections 17 and 20, Township 41 North, Range 1 East. Burke offers no explanation for the less-than-regional dip on the northeast flank of this fold. Other features described by Burke include the local joint pattern, with major sets that bear N65W to N70W and N15E to N15W. Perhaps the most important structural feature listed by Burke is the Virginia Mines Fault, which has a strike of N36E and a vertical displacement of about 100 feet. According to Burke, the northeast extension of this fault passes through the Corps of Engineers dam site.

An area in Section 10, T41N, R1E (see Plate IIb) appears to present a specific problem. Unless the area immediately adjacent to the northeast abutment of the Corps of Engineers dam is extensively grouted, leakage around the dam into an adjacent small tributary valley will take place. Another problem area that should be carefully studied before reservoir construction is undertaken is in the center of Section 18, T41N, R1E (see Plates IIa and IIb). At maximum (Corps of Engineers) pool level, the water will be within 10 feet of the low point in the ridge. If the road along the ridge in that area is to be utilized (it was being improved in April 1963), revetments or levees may be required to prevent wave erosion. Figure 13 shows the Roubidoux formation near this location.

A notable feature in this area and one that would be a cause of reservoir leakage are the 25 to 30 abandoned, partially filled mine shafts and dozens of test pits. Many of the shafts were reported to be from less than 100 to more than 300 feet deep. Almost all the shafts are partially filled or blocked by debris or caving of the shaft itself. Although mining for barite and galena was carried on in the area, on a small scale, as recently as World War II, the majority of the shafts and test pits are only poorly recorded. At normal pool level, many of the old diggings would probably be inundated.

The Gasconade formation in this area has the characteristic amount of solution cavities and sinks and will be hydraulically connected to the reservoir. Leakage through local joint patterns and down dip in the Gasconade formation may also be a problem. Well logs and Corps of Engineers test borings show many weathered or fractured zones in the Gasconade formation.

The major problem in the Virginia Mines reservoir area is the possibility of leakage into the old mine shafts, tunnels and test pits. If these openings, which, historically, had inflows sufficient to require constant pumping, are now acting as ground water conduits, reservoir construction, which would raise the water table, may result in blocking and ponding of subsurface drainage. Ground water thus ponded may rise with the reservoir level and result in poorer quality of water in some wells in the area through flushing action in the old

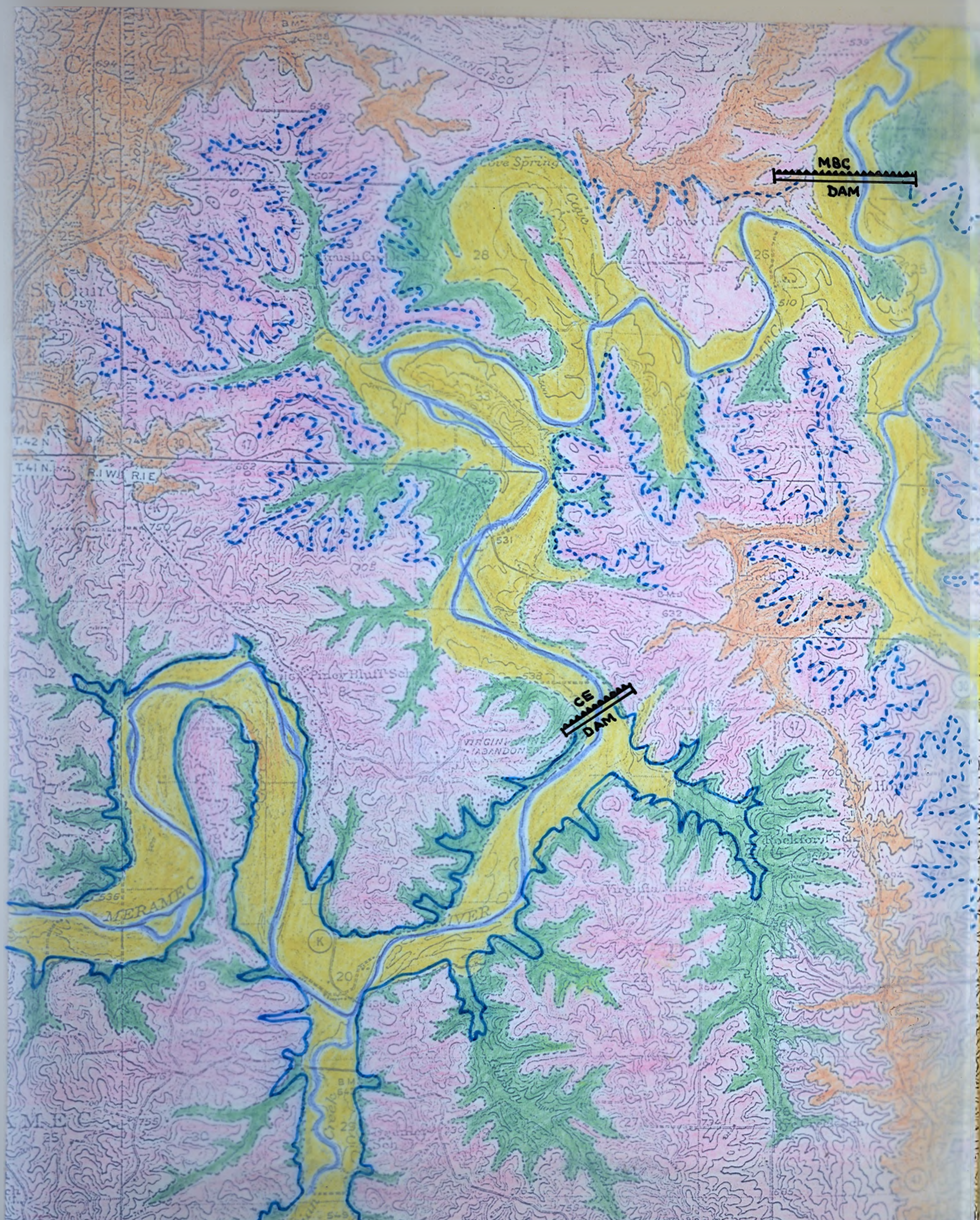


PLATE IIa PLATE IIb

VIRGINIA MINES RESERVOIR

ST. CLAIR RESERVOIR

GEOLOGIC MAP AND RESERVOIR OVERLAY

LEGEND

MAP

Qal - Alluvium

Ojc - Jefferson City formation

Or - Roubidoux formation

Og - Gasconade formation

OVERLAY

Normal Pool Boundary

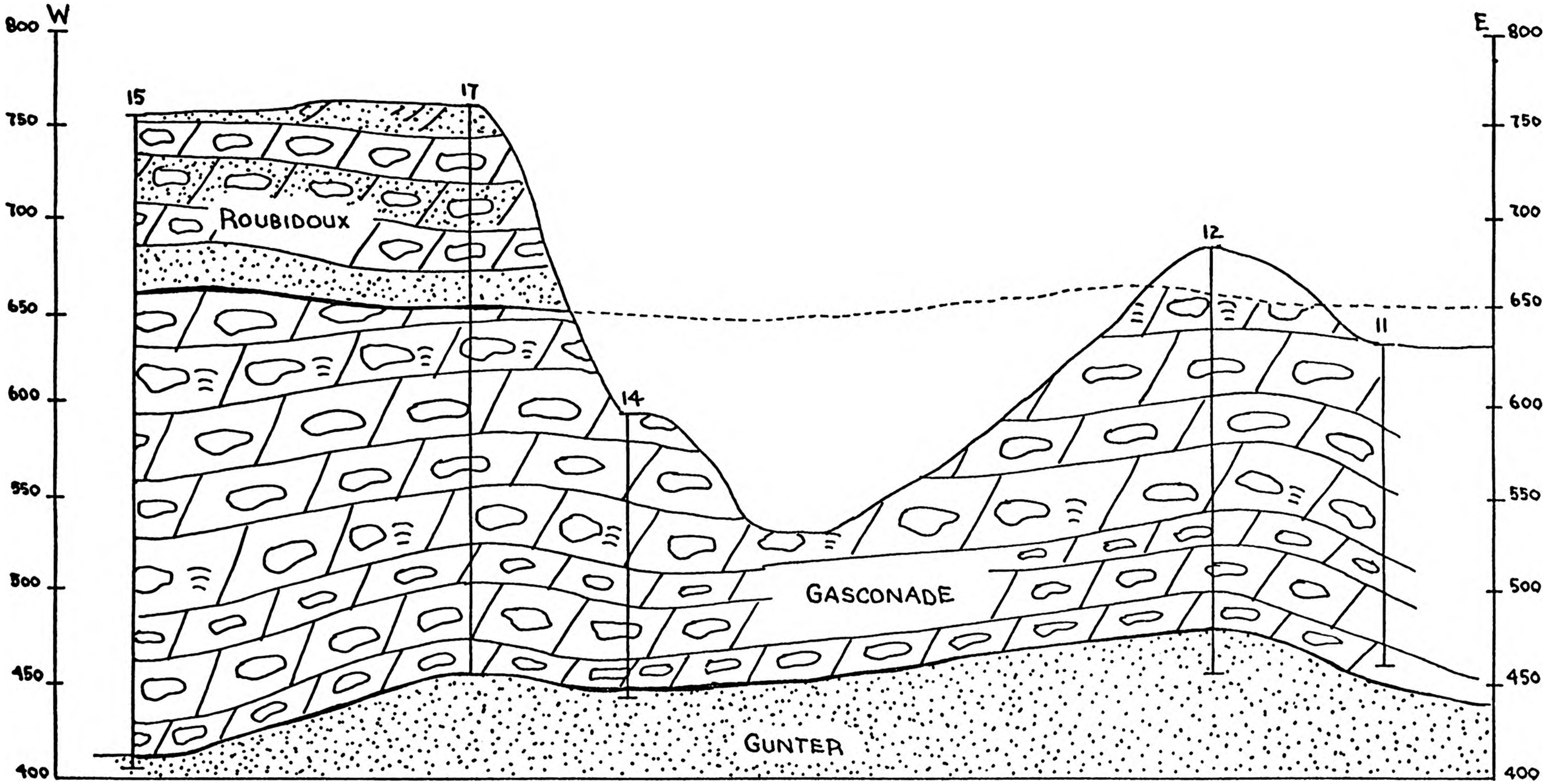
Flood Control Pool Boundary

Proposed Dam

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1947

SCALE 1:62500

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL



CROSS SECTION B-B'
HORIZONTAL SCALE 1:24,000
VERTICAL SCALE 1" = 100'
FIGURE 12

TABLE 7

WELL LOGS - VIRGINIA MINES RESERVOIR

Map No.	MGS No.	Location	Elev. (ft)	Total Depth (ft)	S.W.L. (Depth ft)	Formations Penetrated	Prod. (gpm)
11	13091	T41N R1E Sec. 15, SW NE	636	175	Unk.	0-40 ft. N.S. 40-50 ft. U. Gasconade 50-175 ft. L. Gasconade	13 @ 175 ft.
12	15613	T41N R1E Sec. 15, NE SW	687	235	115-125	0-25 ft. N.S. 25-205 ft. Van Buren L. Gasconade 205-235 ft. Gunter	6 @ 175 ft. 10 @ 235 ft.
13	12832	T41N R1E Sec. 17, SW NE	691	260	125	0-60 ft. N.S. 60-85 ft. Roubidoux 85-115 ft. U. Gasconade 115-260 ft. L. Gasconade	6 @ 200 ft. 10 @ 250 ft.
14	12825	T41N R1E Sec. 16, NW SE	597	150	52	0-30 ft. N.S. 30-145 ft. Van Buren - L. Gasconade 145-150 ft. Gunter	25 @ 100 ft.
15	16158	T41N R1E Sec. 17, NW NE	755	350	225	0-65 ft. N.S. 65-95 ft. Roubidoux 95-125 ft. U. Gasconade 125-345 ft. Van Buren - L. Gasconade 345-350 ft. Gunter	7

TABLE 7

(Continued)

Map No.	MGS No.	Location	Elev. (ft)	Total Depth (ft)	S.W.L. (Depth ft)	Formations Penetrated	Prod. (gpm)
20	14141	T41N R1E Sec. 8, NE NE	560	100	13	0-30 ft. N.S. 30-100 ft. L. Gasconade	12-13 @ 100 ft. 8 @ 40 ft.
21	13250	T42N R1E Sec. 31, SW SW	742	255	125	0-110 ft. N.S. 110-140 ft. Roubidoux 140-180 ft. U. Gasconade 180-225 ft. L. Gasconade	20
22	12830	T41N R1E Sec. 11, NW NE	734	195	131	0-15 ft. N.S. 15-90 ft. Jefferson City 90-195 ft. Roubidoux	4 @ 160 ft. 15 @ 195 ft.
23	17621	T41N R1E Sec. 11, NW NE	731	210	115	0-30 ft. N.S. 30-50 ft. Jefferson City 50-190 ft. Roubidoux 190-215 ft. U. Gasconade	7 @ 210 ft. 5 @ 180 ft.
24	13352	T41N R1E Sec. 11, NW NE	728	215	155	0-40 ft. N.S. 40-50 ft. Jefferson City 50-190 ft. Roubidoux 190-215 ft. U. Gasconade	5

TABLE 7

(Continued)

Map No.	MGS No.	Location	Elev. (ft)	Total Depth (ft)	S.W.L. (Depth ft)	Formations Penetrated	Prod. (gpm)
16	16939	T41N R1E Sec. 17, NW NE	723	370	175	0-30 ft. N.S. 30-80 ft. Roubidoux 80-115 ft. U. Gasconade - Van Buren 115-275 ft. L. Gasconade 275-290 ft. Gunter	12
17	13573	T41N R1E Sec. 16, NW NW	760	300	Unk.	0-65 ft. N.S. 65-105 ft. Roubidoux 105-125 ft. U. Gasconade 125-300 ft. Van Buren - L. Gasconade	7 @
18	14266	T41N R1E Sec. 8, NW NW	698	255	138	0-40 ft. N.S. 40-100 ft. Roubidoux 100-130 ft. U. Gasconade 130-255 ft. Van Buren L. Gasconade	15 @ 255 ft. 14 @ 200 ft. 10 @ 175 ft.
19	14260	T41N R1E Sec. 8, NE NW	568	100	10½	0-30 ft. N.S. 30-90 ft. Gunter - Van Buren L. Gasconade 90-100 ft. Eminence	10 @ 100 ft. 8 @ 40 ft.

<u>TABLE 7</u>

(Continued)

Map No.	MGS No.	Location	Elev. (ft)	Total Depth (ft)	S.W.L. (Depth ft)	Formations Penetrated	Prod. (gpm)
25	12829	T41N R1E Sec. 11, NW NE	716	295	135	0-30 ft. N.S. 30-40 ft. Jefferson City 40-160 ft. Roubidoux 160-210 ft. U. Gasconade 210-295 ft. L. Gasconade	9 @ 200 ft. 11 @ 295 ft.

OUTCROP OF THE ROUBIDOUX FORMATION

IN ROAD CUT IN SW QUARTER, SECTION 7,

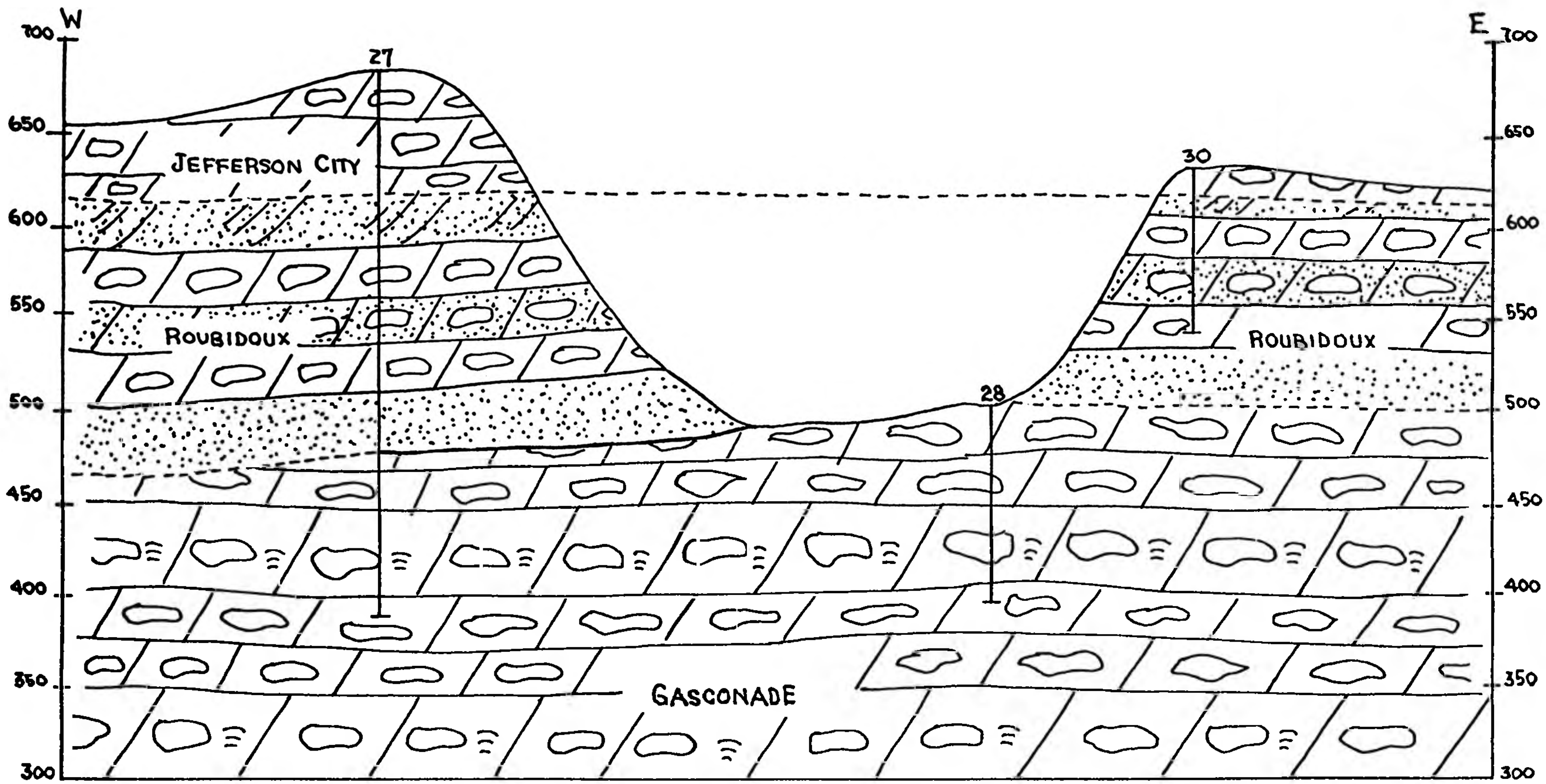
TOWNSHIP 41 NORTH, RANGE 1 EAST

FIGURE 13

mine workings. The Meramec Basin Corporation has proposed a reservoir at this site with maximum and normal pool levels higher than those of the Corps of Engineers reservoir; problem areas would be increased accordingly. Reservoir construction is hydrogeologically feasible in this area if old mine workings and major cavities in the Gasconade formation are located and sealed.

C. St. Clair

The Meramec Basin Corporation has selected the site shown in Plate IIa as the location for a large reservoir. This reservoir would be the second largest proposed by the Corporation. Table 8 lists well logs for the area, data for this reservoir are listed in Table 9 and a cross section is shown in Figure 14. Although the valley of the Meramec is wider here (widths average 3000 feet), the area is geologically a continuation of the Virginia Mines area four miles to the south. The bluffs along the river are not as high (averaging about 100 feet) and the slopes are more gentle. In addition to the formations present in the Virginia Mines area, the Jefferson City formation occurs, capping the hilltops. This formation, plus the Roubidoux and Gasconade formations, will be wetted by both maximum and normal pool levels. The Jefferson City formation is less massive than the Gasconade and has generally fewer solution cavities, perhaps the result of a larger number of bedding planes. The Roubidoux formation in this area is locally very sandy, vuggy and conglomeratic (Sections 26 and 36, T42N, R1E, for example) and, in such areas, may create leakage problems. Leakage through the sinks and solution cavities of the Gasconade formation may be expected as at the Virginia Mines reservoir.



CROSS SECTION C-C'
HORIZONTAL SCALE 1:24,000
VERTICAL SCALE 1" = 100'
FIGURE 14

TABLE 8

WELL LOGS - ST. CLAIR RESERVOIR

Map No.	MGS No.	Location	Elev. (ft)	Total Depth (ft)	S.W.L. (Depth ft)	Formations Penetrated	Prod. (gpm)
26	13088	T42N R1E Sec. 25, NW SE	517	100	Unk.	0-40 ft. N.S. 40-100 ft. L. Gasconade	12 @ 60 ft.
27	16243	T42N R1E Sec. 23, SW NW	684	290	Unk.	0-20 ft. N.S. 20-65 ft. Jefferson City 65-200 ft. Roubidoux 200-240 ft. U. Gasconade 240-290 ft. L. Gasconade	15 @ 250 ft.
28	17768	T42N R1E Sec. 24, SW NE	503	102	30	0-25 ft. N.S. 20-25 ft. U. Gasconade 25-102 ft. L. Gasconade	30
29	15662	T42N R1E Sec. 15, SE SW	638	245	165	0-60 ft. Jefferson City 60-210 ft. Roubidoux 210-240 ft. U. Gasconade 240-245 ft. L. Gasconade	16.6
30	6628	T42N R1E Sec. 24, NE NE	636	81	45	0-15 ft. N.S. 15-81 ft. Roubidoux	20
31	15209	T42N R1E Sec. 13, SE SE	573	159	90	0-15 ft. N.S. 15-50 ft. Jefferson City 50-159 ft. Roubidoux	30 @ 116 ft.

TABLE 9

RESERVOIR DATA SHEET

MERAMEC RIVER

Reservoir	Top of Dam Elevation	Flood Control Pool Elevation	Normal Pool Elevation	Flood Control Pool Storage	Normal Pool Storage	Total Storage
Meramec (CE)	736	701	667	581,560 af	418,400 af	1,000,000 af
Meramec (MBC)	710	690	660	450,000 af	17 sq mi	30 sq mi
Virginia Mines (CE)	610	577	556	139,730 af	110,270 af	250,000 af
Virginia Mines (MBC)	650	620	590	400,000 af	15 sq mi	28 sq mi
St. Clair	650	620	590	850,000 af	33 sq mi	57 sq mi

NOTES

1. All elevations above mean sea level.
2. CE = Corps of Engineers dam; MBC = Meramec Basin Corporation dam.
3. af = acre/feet

A specific area of interest is near Cove Spring, in Section 21, T42N, R1E. It would be appropriate to install a stream gage or a ground water observation well in this area in order to detect leakage through the divide, which is honeycombed with sinks. For example, a rise in the level of the small stream to the north of the divide would indicate leakage through the divide. Such leakage would, in turn, require specific action to prevent damage to the Frisco Railroad mainline located at the foot of the valley.

Relocation of a major state highway (Missouri Highway 30) in Section 4, T41N, R1E, would also be required if this reservoir were to be constructed. Both Meramec Caverns and Fisher Cave are below normal pool level for this reservoir. Although it appears hydrogeologically feasible to construct a reservoir at this site, the size of the impoundment would affect ground water levels in hydraulically connected aquifers over a large area.

D. Rolla

An additional reservoir on the Dry Fork near Rolla was investigated. Corps of Engineers test borings studied by the writer indicated a high degree of fracturing and permeability in the formations in the reservoir area. A major factor considered in the investigation of the Rolla reservoir was that the aptly named Dry Fork, the stream which would be impounded, is typical of streams in karst-type regions. Surface run-off, which normally would be expected to fill the channel of Dry Fork, apparently seeps through the bed of the Fork and into a series of underground channels. Missouri Geological Survey well logs studied indicated an appreciable rise in the ground water table between Dry Fork and Meramec Springs, downstream from the dam site. It would appear that the entire Dry Fork-Meramec Springs area may be an integrated subsurface drainage system, with discharge occurring at Meramec Springs. Treatment of the proposed reservoir area to retard leakage would probably have an adverse effect on the flow of the spring, which is a major tourist attraction in the area. Because of the probability of rapid depletion of impounded water through subsurface passageways towards Meramec Springs and the cost of remedial measures which would have to be undertaken (including the probable expense of litigation from property owners whose water supplies might be adversely affected by construction of a reservoir designed to minimize subsurface drainage), the Corps of Engineers eliminated the site from consideration. No further study was made of the Rolla reservoir by the author.

VI. SUMMARY AND CONCLUSIONS

A general description of the area of the Meramec Basin is presented in this report, with emphasis on those karst features that have special bearing on the effects of reservoir construction on ground water.

A flood frequency curve for a reservoir site has been calculated, for various recurrence intervals, according to procedure outlined in United States Geological Survey Circular 370. This was done to arrive at an independent confirmation of available reservoir design data.

Hydrogeologic maps for three reservoir areas were constructed, based on the writer's field observations and well logs studies, Corps of Engineers reservoir design information and areal mapping by Piskin and Burke.

Occurrence of ground water in the thesis areas has been evaluated through the study of previous work, well logs and test borings. Ground water occurs in several major aquifers throughout the area, at depths ranging from shallow wells in valley alluvium to more than 1000 feet. Production rates range from less than 10 to more than 500 gallons per minute - enough for small cities and industries. Water quality is adequate for normal domestic and industrial use. The number of caves and springs in the area indicates the solubility of underlying formations and the probability of increased solution activity resulting from a general rise in the water table.

As a result of the study of previous work in the subject, it appears that only specific, limited studies have been made of the effects of reservoirs on adjacent water tables. Therefore, the writer did not feel justified in making general comparisons between the Meramec Basin area and other, similar areas. Specific examples of structure and lithology in karst areas which appeared to affect reservoir-ground water conditions were studied. When compared with similar conditions in the Meramec Basin, these examples were indicative of the types of problems to be expected if reservoirs are constructed in the area studied.

Construction of reservoirs in areas investigated by the writer appears feasible, although leakage, with an accompanying rise in the ground water table of adjacent areas, is to be expected. This rise in the water table may further be expected to steepen ground water gradients near dams and decrease gradients around the periphery of the reservoir. Additionally, this rise in the water table may raise the static water level in wells; perhaps increase the flow of some streams near reservoirs as a result of leakage. Areas hydraulically connected to reservoirs may become more permeable through enlargement of joints and solution cavities or the flushing of clays and silts. In some areas, this flushing action may affect water quality at some wells by moving more heavily sedimented water through aquifers that are tapped by these wells. Generally, water quality should not be affected by construction of impoundments on the clear, upstream reaches of the Meramec River in the areas studied; concentration of objectionable minerals or industrial wastes is not presently a problem.

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V I T A

John H. Anderson was born on 16 August 1925 at Mt. Holly, New Jersey. He attended public schools there and graduated from Mt. Holly High School in 1943. From October 1943 to April 1946, he served in the U. S. Army in Europe and the Philippines. After attending Rutgers University for one year, he enrolled in the University of Arkansas, from which he received the degree of Bachelor of Science (Geology) in June 1950. Graduate study in Geology at the University of Arkansas was terminated by entry on active duty as a Second Lieutenant, Infantry, U. S. Army, in June 1951. He was married to the former Mary Louise Gillam in October 1953. A transfer to the Corps of Engineers and service in France and Korea in a variety of topographic and intelligence assignments eventually led, in October 1960, to his present assignment as Assistant Professor of Military Science at Missouri School of Mines and Metallurgy. He enrolled for graduate study in January 1961 as a candidate for the degree of Master of Science in Geology. Captain Anderson was integrated into the Regular Army in October 1962.