DESIGN OF MAJOR DRAINAGE IN THE
MISSISSIPPI DELTA

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GENERAL

The design of major drainage improvements involves a study to resolve three principal factors. First, the design flows, or the amount of water which will be carried within channels without overflow; second, the design flow-line or the elevation at which the design flows will be carried and third, the type and amount of work required to provide channels adequate to carry the design flows without overflow. Most of this discussion will be devoted to design flows since this is the most controversial factor and the one which most influences the frequency and duration of overflow, the benefits to be derived, and the economic justification of the work.

DESCRIPTION OF THE AREA

The Mississippi Delta lies between the Mississippi River levee on the west and the hills on the east, from the Tennessee-Mississippi state line, to the confluence of the Yazoo and Mississippi Rivers at Vicksburg. It is approximately 180 miles long and 40 miles wide with a total area of about 7,000 square miles and is shown on Figure 1. The western portion is drained by Steele Bayou, Deer Creek, and Big Sunflower River and their tributaries and the eastern part by the Coldwater, Tallahatchie and Yazoo Rivers and their tributaries. The alluvial valley land is generally flat with slopes averaging from about 0.3 to 0.9 foot per mile.

Rainfall in the area varies from about 31 to 80 inches per year, with a normal annual rainfall of about 50 inches. Twenty-four-hour rainfalls of from 3.5 to 4.0 inches and 5 day amounts of from 5 to 6 inches, occur about once a year, while storms producing 6 inches of rainfall in 24 hours and 9 inches in 5 days occur about once in 10 years.

MAJOR DRAINAGE PROJECT

In 1947, the Vicksburg District, Corps of Engineers, initiated major drainage work on Steele Bayou and Big Sunflower River and their tributaries in the Mississippi delta and through 1965 a total of about 575 miles of channel work had been completed leaving about 15 miles to be done to complete the first phase of the drainage project. Additional channel improvement on 130 miles, most of which is on Steele Bayou, Main Canal and Black Bayou, have been authorized. Through 1965, about 5 miles on Steele Bayou had been completed. In addition to this, a study is underway at the present time to determine whether additional drainage improvements are needed in the Sunflower River basin.

PEAK FLOWS

The maximum peak flows observed in the Sunflower River basin before improvement under the Mississippi River and Tributaries Project varied from about 10 to 20 cubic feet per second per square mile for areas exceeding 100 square miles. They were low because the flat slopes and low velocities and the effect of the large amount of channel and overbank storage during the larger storms caused low peak flows. After improvement velocities and channel capacities are increased, water surface profiles are lowered, lateral drainage is improved, and storage is materially reduced. These factors increase peak flows considerably with the maximum varying from about 20 to 40 cubic feet per second per square mile. Maximum peak flows observed before and after improvement are shown on Figure 2 in relation to their drainage area. Peak flows observed for the same areas since major drainage improvements have increased from 60 to 100 percent and with further channel improvement they will increase another 20 to 30 percent.

Flow frequencies have been computed for Steele Bayou at Grace and for 9 stations in the Boeuf-Tensas Basin of Arkansas and Louisiana with drainage areas ranging from 40 to 1,200 square miles and with from 6 to 12 years records of observed flows since the original improvement. Rainfall, topography and basin characteristics in the Boeuf-Tensas Basin are comparable to those in the Mississippi Delta and stations in that area were also used in this analysis since most of the stations in the Sunflower Basin have too short a period after improvement to furnish a satisfactory basis for frequency computations. Frequency curves under existing conditions, which include improvements under the original design, were developed for the full year and for the growing season, May through October. These computations show that the original design flows have a frequency of about once a year during a full year and from 3 to 5 years during the period May through October.

Peak flow curves were developed for drainage areas of from 40 to 2,000 square miles which are applicable to the Sunflower River Basin. Figure 3 shows the frequencies plotted in relation to drainage areas and Figure 4 shows the frequencies during the growing season, May through October.

DESIGN FLOWS

The original design under the Mississippi River and Tributaries Project was based on flows obtained from the drainage formula:

$$Q = CA^{5/6}$$

in which Q is the flow in cubic feet per second

C is a coefficient used as 35

A is the drainage area in square miles

This is a modification of Fanning's formula and was developed by drainage engineers of the U. S. Department of Agriculture in 1911-12 for use in the design of drainage canals in the delta lands of southeast Arkansas. With variations in C, it has been successfully used for the design of drainage in delta lands in southeast Arkansas, northeast Louisiana, and northwest Mississippi for over 50 years. Its use by the Vicksburg District is a result of observations, analysis and study of delta streamflow during the last 25 years. Comprehensive studies were made in 1956 and reviewed in 1964. The 1964 study had the advantage of data obtained during the last 6 to 12 years, from 1,200 miles of improved drainage channels.

Drainage is a continuing process and while the design based on a C of 35 provides good agricultural drainage, the design flows occur more frequently now than was the case before hundreds of miles of laterals were constructed and thousands of acres of additional land was placed in cultivation. Under existing conditions, these flows have a frequency of about once a year for the full year, and from 3 to 5 years during the period May through October.

As a result of our 1956 studies reviewed in 1964, the Vicksburg District has adopted a revised drainage formula, $Q = 50A^{5/6} + 400$, for use where this degree of drainage can be economically justified. Channel capacities based on this formula would be increased by from 50 to 100 percent over those from the original design. The new channels would provide for runoffs equivalent to 0.60 inch from a 1,000 mile area and 1.26 inches from a 50 mile area in 24 hours. The duration of floods exceeding bankfull capacity would be decreased about 30 percent which is a most important factor in the drainage of delta lands.

While there are certain inherent weaknesses in using runoff formulas in the design of drainage channels, they are the most practical way to obtain design flows for delta lands. They make the most direct use of observed data, their use is simple, they insure a uniformity of design and the overall results are good. As shown on Figure 2, the revised curve using the formula $Q = 50A^{5/6} + 400$ fits the shape of the maximum peak flows observed in the area. The points are maximum peak flows which are larger than would be used in drainage design. Most of those shown were produced by the 1958 and 1961 floods which have full year frequencies of from 10 to 30 years. Design flows from the revised formula have a frequency of from 1 to 2 years for the full year as shown by the comparison of the runoff curve with curves of 2 and 5-year frequency on Figure 3. They have a frequency of from 5 to 10 years during the growing season, May through October, as shown by the comparison with 5 and 10-year frequency curves on Figure 4.

FLOWLINE ELEVATIONS

Design flowline elevations are set by field investigations. In general, they are elevations where flooding begins. In most alluvial streams they are somewhat below top bank since the land behind the natural top banks is usually lower than that immediately adjacent to the stream. Furthermore, the flowline elevations must be sufficiently low to drain all lands which are to benefit from the drainage improvement.

TYPE AND AMOUNT OF IMPROVEMENT

Combinations of channel clearing and snagging, cleanout or minor excavation, channel enlargement and cutoffs are used to provide sufficient channel capacity to carry the design flows at design elevation. Thus, the determination of type of improvement is made by trial and error based on a series of backwater computations until a reasonable approximation of the design flowline is obtained. Manning's formula:

$$Q = A \frac{1.486}{n} r^{2/3} s^{1/2}$$

where Q is the flow
A is the cross sectional area
n is a coefficient of roughness
r is the hydraulic radius
s is the slope

is used in backwater computations.

"n" values used are:

clearing	.045-050
cleanout	.040
Enlargement	
Bottom width less than 100 feet	.035
Bottom width more than 100 feet	.030

Experience has shown that cutoffs and channel enlargement provide the most lasting improvement. In several instances, streams where most of the work consisted of clearing and snagging have returned to about their unimproved condition in a short time. Care should be used to determine that no damages will occur in reaches where no work is done since an increase in flow from upstream work will increase stages in these reaches.

EFFECTS OF MAJOR DRAINAGE

The best test of any drainage design is the observations and analysis of its effect on stages, flows and duration of overflow. The Vicksburg District makes flow measurements, obtains peak stages and observes the extent and duration of flooding during and after each significant storm in order to be sure that the projects are providing the benefits anticipated and to analyze the results and improve drainage design generally.

Four floods were selected to show the effects of channel improvement work in the Sunflower Basin. Those in November 1957 and April-May 1958, occurred before most of the improvements were made while the April 1964 and February 1966 high waters show conditions with most of the project work completed. These high waters were a result of the rainfall which occurred during the periods of:

November 13-19, 1957
April 25 - May 5, 1958
April 22-28, 1964
February 9-13, 1966

Storm rainfalls at representative stations are shown below:

	Nov.13-19 1957	Apr.25-May 5 1958	Apr.22-28 1964	Feb.9-13 1966
	7 days	11 days	7 days	5 days
Tunica	5.6	7.6	5.7	6.9
Clarksdale	6.9	9.4	7.8	7.9
Cleveland	8.1	15.4	8.0	7.7
Greenville	6.8	14.6	5.2	6.8
Moorhead	5.3	11.9	4.9	6.0
Nitta Yuma	7.4	16.4	6.3	6.4
Average	6.7	12.5	6.3	7.0

The rainfall producing the 1957, 1964, and 1966 high waters compare reasonably well, while the 1958 flood was the result of much larger rainfall with considerably longer duration.

Comparative stage hydrographs for the 1957, 1958, 1964, and 1966 flood at Sunflower and Little Callao on Sunflower River are shown on Figure 5. Hydrographs for 1958, 1964, and 1966 at Doddsville on Quiver River and Leland on Bogue Phalia are shown on Figure 6. The effect of the channel work is readily apparent from these hydrographs. Typical reductions in stage and duration of overflow and increases in discharge are summarized below for Sunflower and Little Callao on Sunflower River.

SUNFLOWER

Peak	1957	1958	1964	1966
Peak stage	120.0	121.3	118.4	117.1
Maximum flow	6,200	9,200	11,700	9,500
Days above floodstage	14	20	2	0

LITTLE CALLAO

Peak	1957	1958	1964	1966
Peak stage	101.4	103.0	100.4	100.6
Maximum flow	17,500	23,000	27,000	21,500
Days above floodstage	14	27	3	5

Stages have been lowered from 1 to 3 feet, discharges increased from 50 to 75 percent. The duration of flooding under unimproved conditions varied from 2 to 4 weeks. Channel improvement works have reduced this to from 0 to 5 days.

Flow measurements are made and stage-discharge relations developed for 10 stations on Sunflower River, 4 on Quiver River, 5 on Bogue Phalia, 4 on Steele Bayou, and 24 on their smaller tributaries. Observations in 1964, 1965, and 1966 show that the improved channels are carrying the flows for which they were designed. Comparative rating curves before and after improvement for Sunflower River at Sunflower and Little Callao, Quiver River at Doddsville, and Bogue Phalia at Leland are shown on Figures 7 and 8, respectively. The large increase in carrying capacities greatly reduces the duration of overflow, thus providing the major benefit from the project.

SOIL CONSERVATION SERVICE PROJECTS

The Sunflower Project contemplated that drainage districts or other interests would improve drainage over the entire area in order to obtain the benefits from the channel improvement on the major outlets. The Soil Conservation Service uses flows from the formula $Q = 40A^{5/6}$, with somewhat lower values of "n" in Manning's formula. Thus, the flows used in the SCS projects are comparable to those used by the Vicksburg District. Of course, as drainage improvements are made on the tributaries, they increase flows on the main stream and decrease the stage reductions over what they were with the area partially developed.

CONCLUSIONS

a. The Big Sunflower Major Drainage Project with design flows based on the formula $Q = 35A^{5/6}$ provides:

(1) Stage lowerings of from 1 to 3 feet.

(2) Channel capacity increases of from 50 to 300 percent.

(3) Reduction in duration of overflow from 2-4 weeks to 0-6 days.

b. Improvement on tributaries.

(1) Original work contemplated drainage improvements throughout the area.

(2) The SCS works are comparable to those of the Vicksburg District.

(3) With full comparable drainage development, the project will provide moderate stage lowerings and large reductions in the duration of overflow.

c. Additional major drainage.

(1) Design flows based on the recommended formula $Q = 50A^{5/6} + 400$ have a full year frequency of from 1 to 2 years and a frequency of from 5 to 10 years during the growing season, May through October. Channels based on this design provide better agricultural drainage.

(2) Drainage is a continually developing process and additional improvement of farm ditches and lateral canals will require additional major drainage in the future.

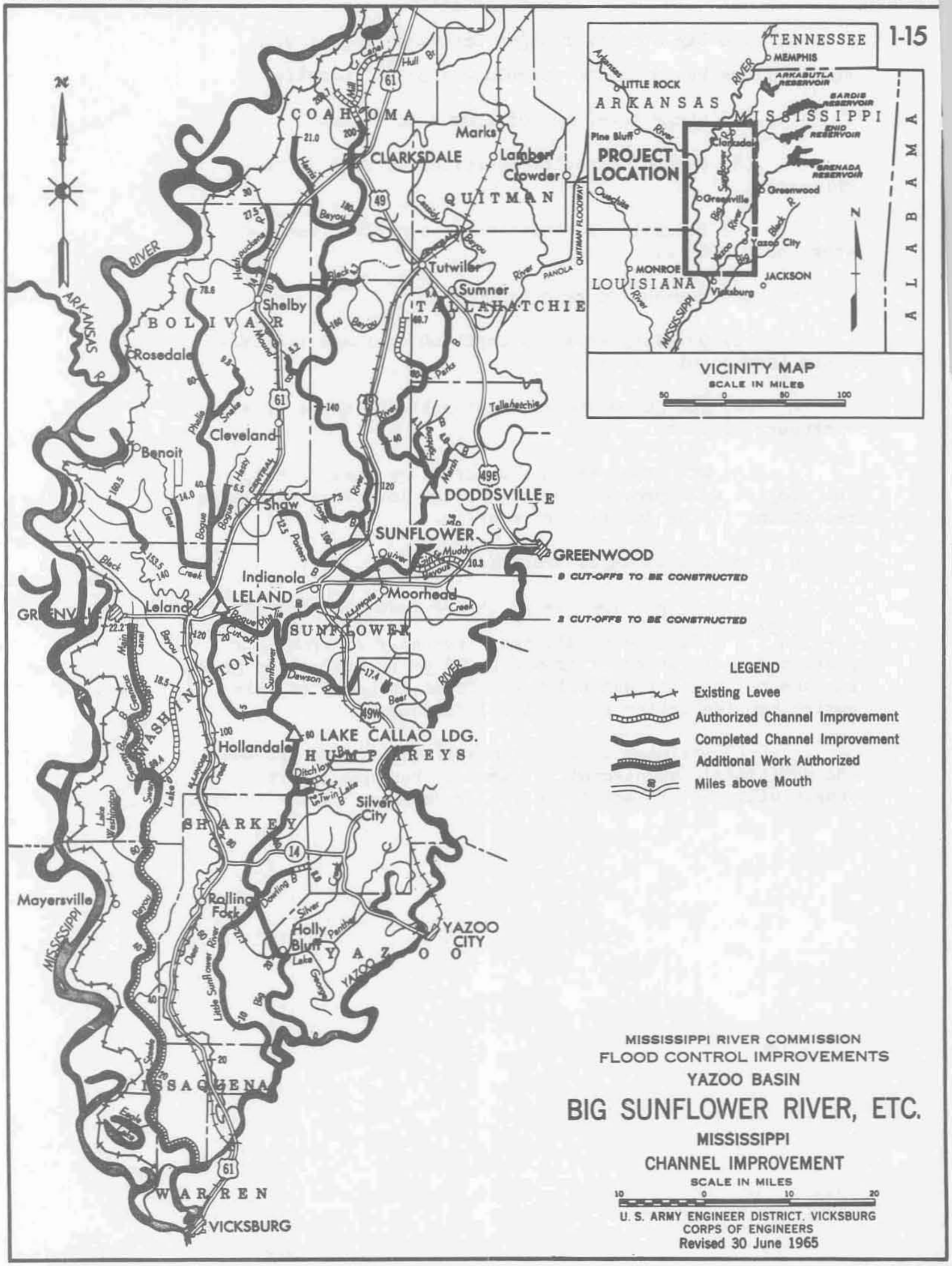
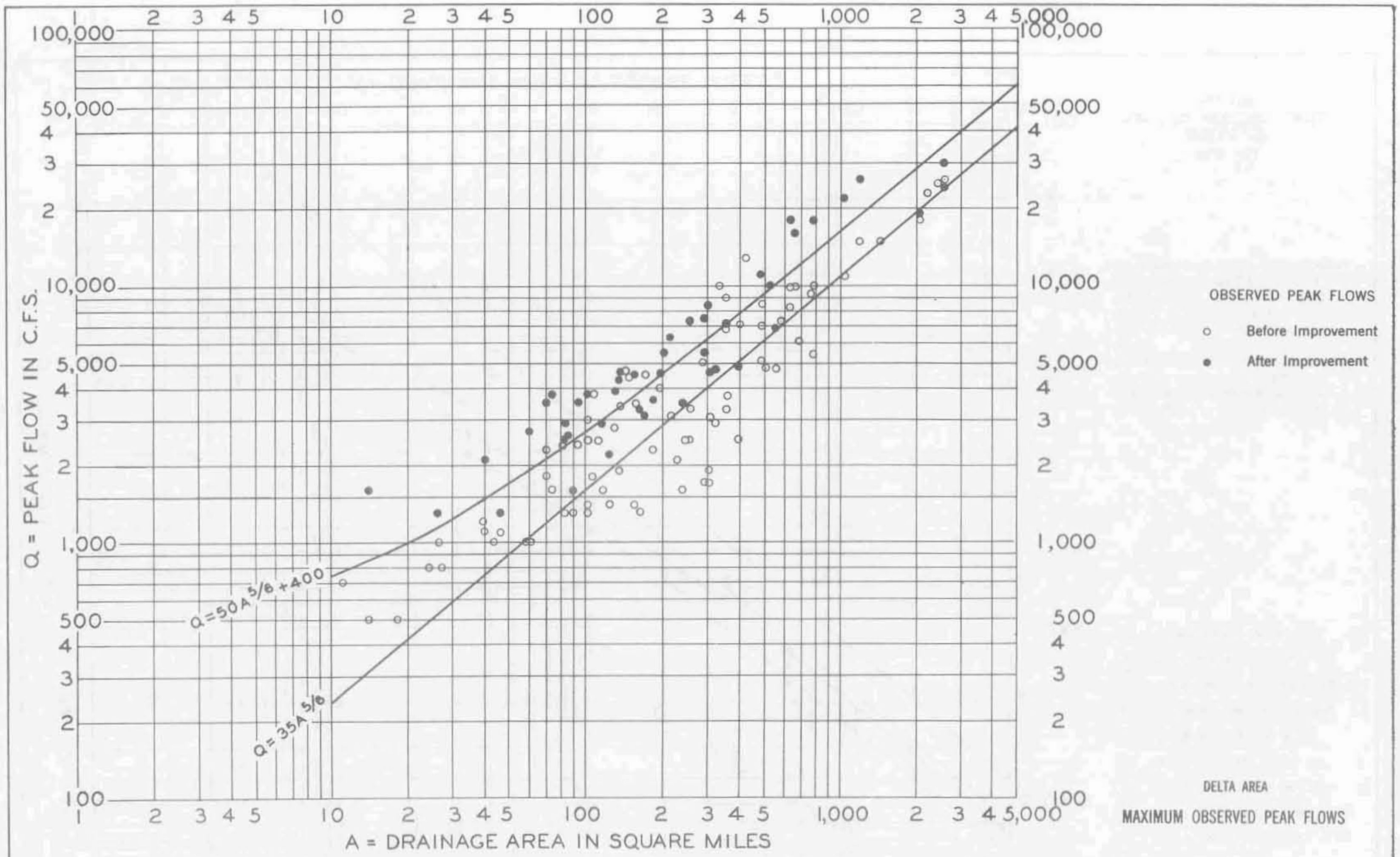

1-15
VICINITY MAP
SCALE IN MILES
PROJECT LOCATION
TENNESSEE
ARKANSAS
MISSISSIPPI
LOUISIANA
ALABAMA
MEMPHIS
LITTLE ROCK
JACKSON
GREENWOOD
9 CUT-OFFS TO BE CONSTRUCTED
2 CUT-OFFS TO BE CONSTRUCTED
LEGEND
Existing Levee
Authorized Channel Improvement
Completed Channel Improvement
Additional Work Authorized
Miles above Mouth
CLARKSDALE
DODDSVILLE
SUNFLOWER
LELAND
LAKE CALLAO LDG.
YAZOO CITY
VICKSBURG
MISSISSIPPI RIVER COMMISSION
FLOOD CONTROL IMPROVEMENTS
YAZOO BASIN
BIG SUNFLOWER RIVER, ETC.
MISSISSIPPI
CHANNEL IMPROVEMENT
SCALE IN MILES
U. S. ARMY ENGINEER DISTRICT, VICKSBURG
CORPS OF ENGINEERS
Revised 30 June 1965

Fig. 1

Fig. 2



DELTA AREA

MAXIMUM OBSERVED PEAK FLOWS

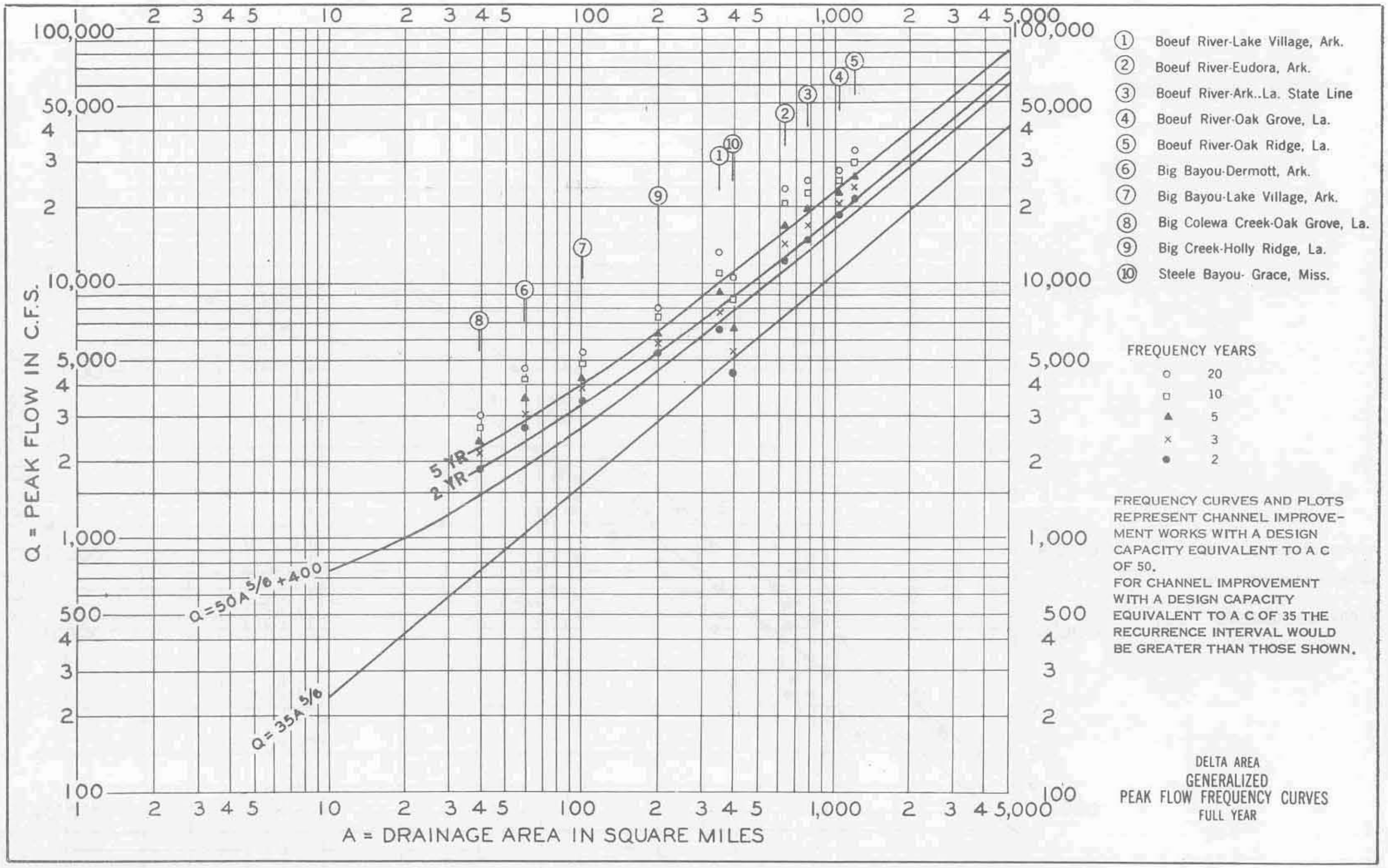
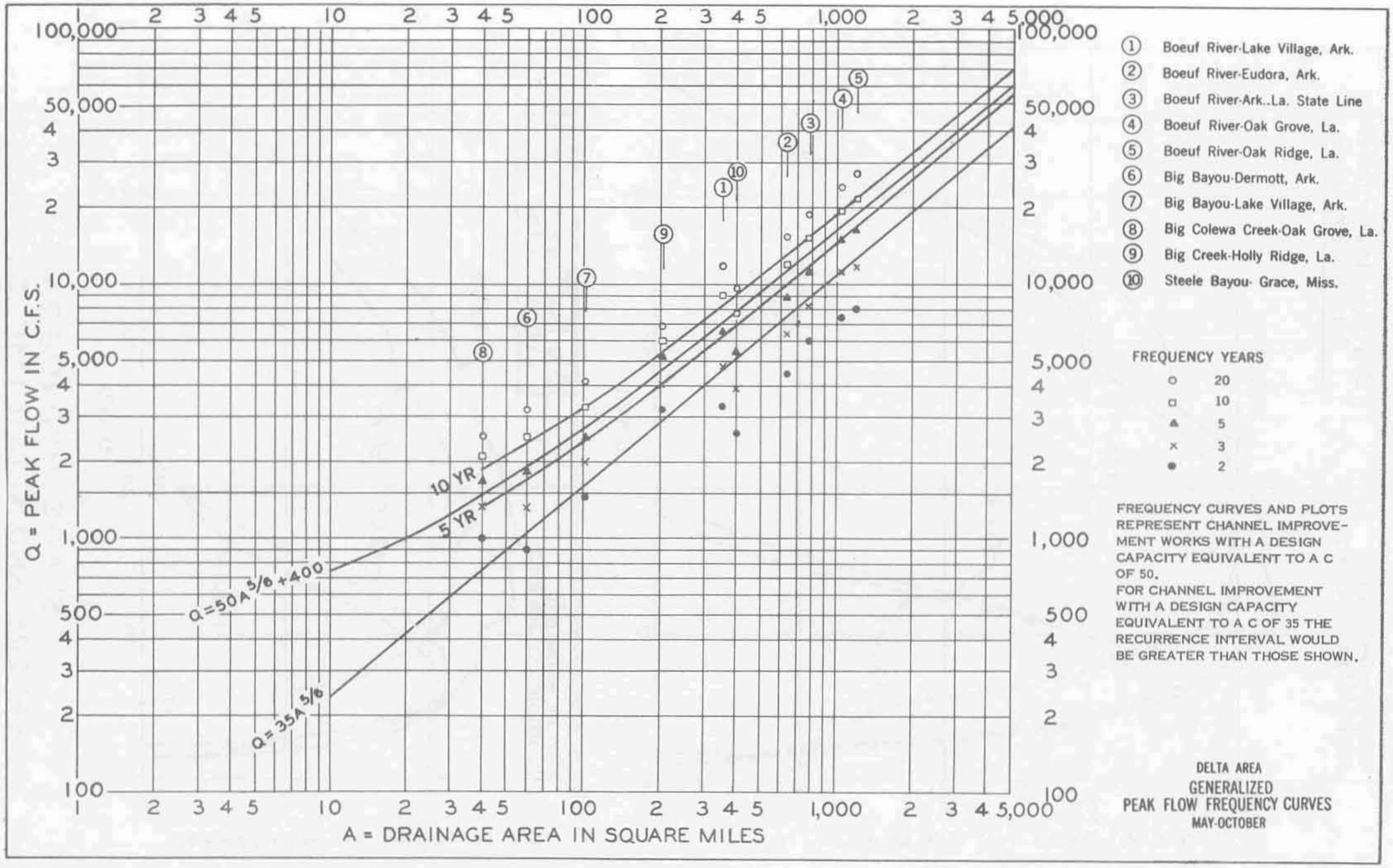
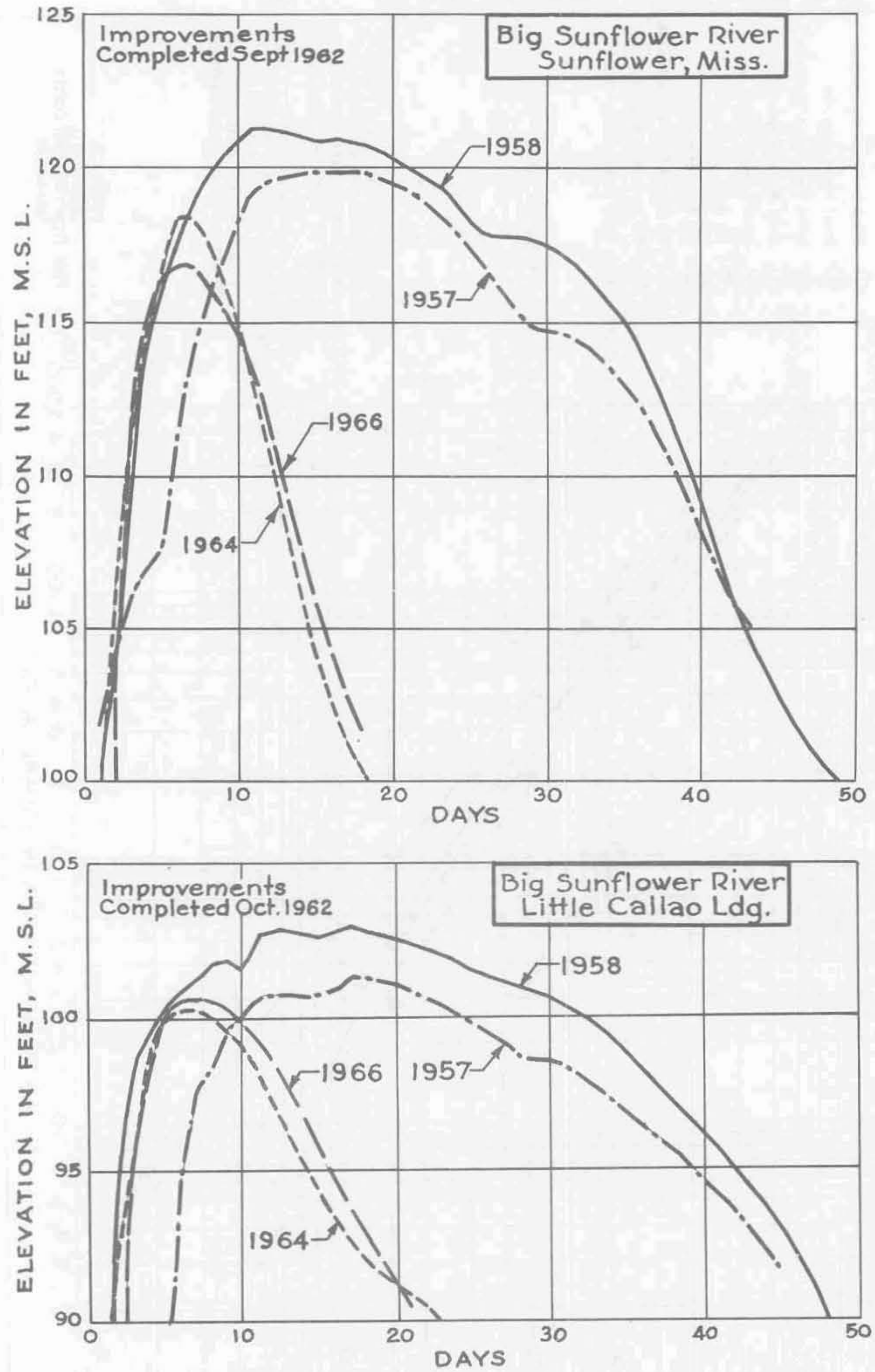

Q = PEAK FLOW IN C.F.S.
A = DRAINAGE AREA IN SQUARE MILES
5 YR
2 YR
Q=50A 5/6 +400
Q=35A 5/6
① Boeuf River-Lake Village, Ark.
② Boeuf River-Eudora, Ark.
③ Boeuf River-Ark.-La. State Line
④ Boeuf River-Oak Grove, La.
⑤ Boeuf River-Oak Ridge, La.
⑥ Big Bayou-Dermott, Ark.
⑦ Big Bayou-Lake Village, Ark.
⑧ Big Colewa Creek-Oak Grove, La.
⑨ Big Creek-Holly Ridge, La.
⑩ Steele Bayou- Grace, Miss.
FREQUENCY YEARS
○ 20
□ 10
▲ 5
× 3
● 2
FREQUENCY CURVES AND PLOTS REPRESENT CHANNEL IMPROVEMENT WORKS WITH A DESIGN CAPACITY EQUIVALENT TO A C OF 50.
FOR CHANNEL IMPROVEMENT WITH A DESIGN CAPACITY EQUIVALENT TO A C OF 35 THE RECURRENCE INTERVAL WOULD BE GREATER THAN THOSE SHOWN.
DELTA AREA
GENERALIZED
PEAK FLOW FREQUENCY CURVES
FULL YEAR

Fig. 3

Fig. 4

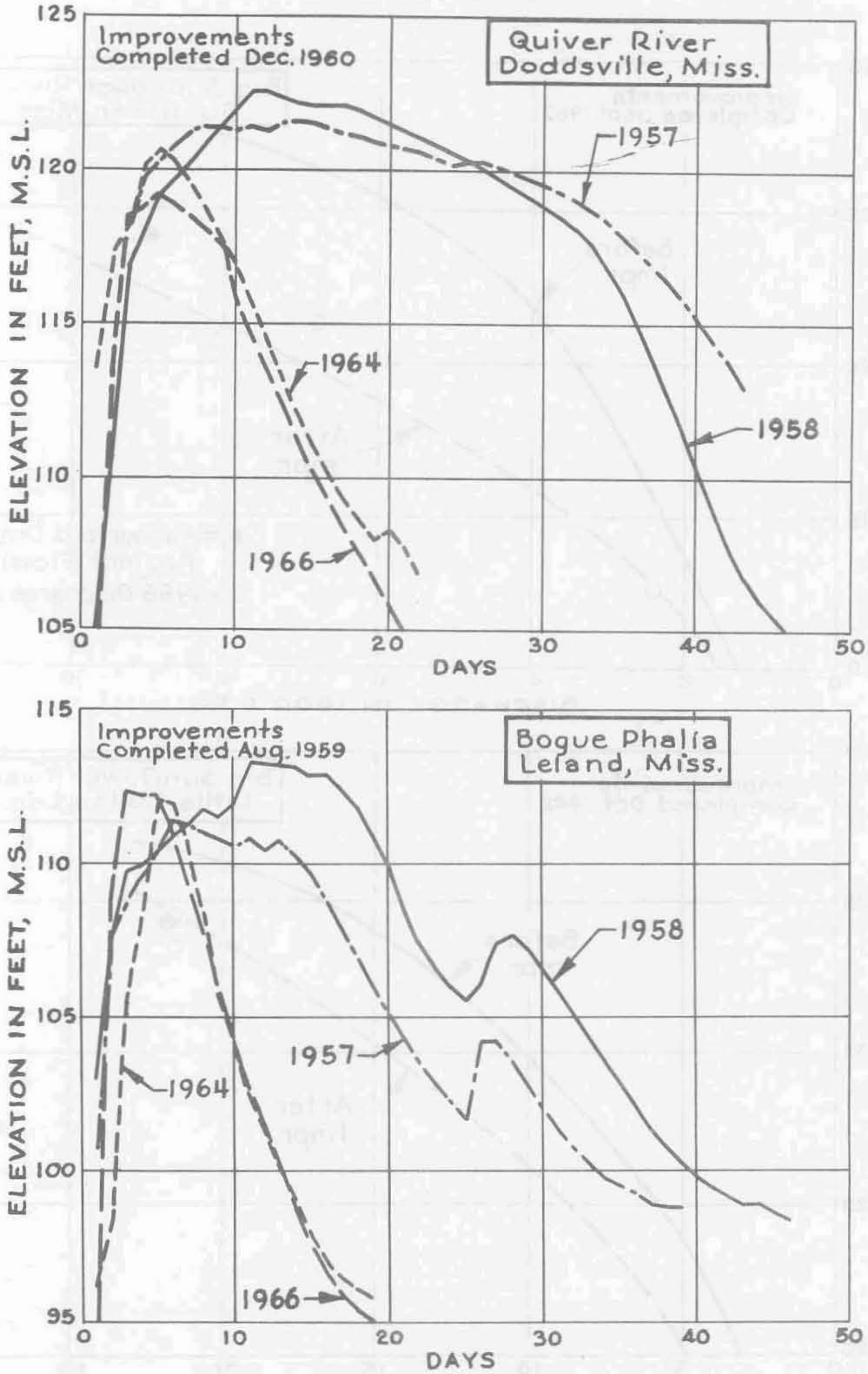


DELTA AREA
GENERALIZED
PEAK FLOW FREQUENCY CURVES
MAY-OCTOBER



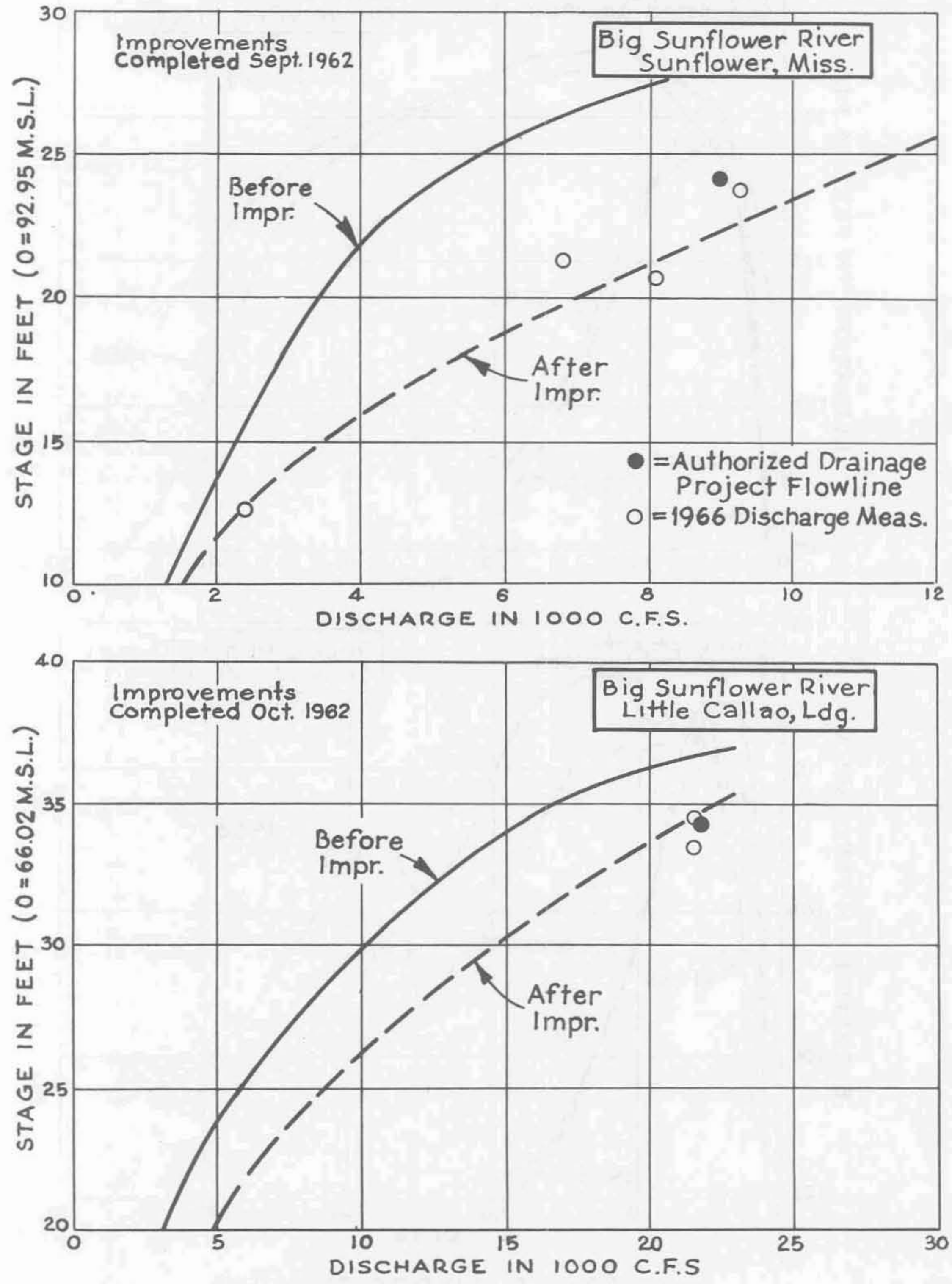
STAGE HYDROGRAPHS
BEFORE AND AFTER IMPROVEMENT

Fig. 5



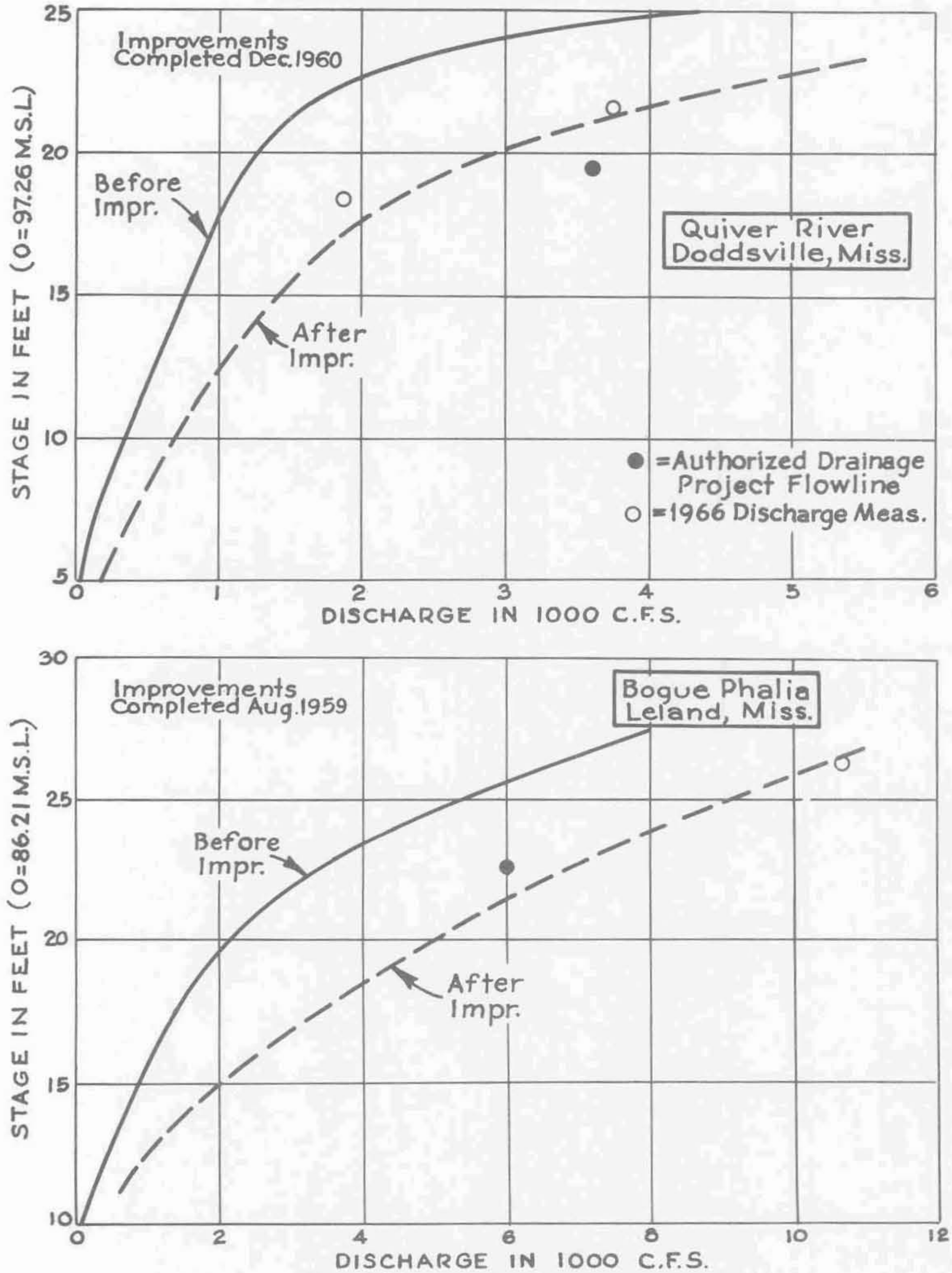
STAGE HYDROGRAPHS
BEFORE AND AFTER IMPROVEMENT

Fig. 6



RATING CURVES
BEFORE AND AFTER IMPROVEMENT

Fig. 7



RATING CURVES
BEFORE AND AFTER IMPROVEMENT

Fig. 8