UMLAH

230940
TFM:ej
23 May 1952

SUBJECT: Comparative Discharge Measurements

TO: Division Engineer
Upper Mississippi Valley Division
Corps of Engineers, US Army
St. Louis 1, Missouri

1. Reference is made to letter from the Division Engineer, Upper Mississippi Valley Division, UMVOB, dated 30 January 1951, subject, "Mississippi River Flood Discharge Capacity."

2. In accordance with instructions contained in paragraph 2 of above referenced letter, there are forwarded herewith, in a separate report, the conclusions and recommendations of this office, derived from a study of discharge measurements taken by the United States Geological Survey and the Corps of Engineers.

F. B. REESMAN
Colonel, Corps of Engineers
District Engineer

1 Incl
#1--Comparative Discharge
Measurements by USGS and
CofE w/Appendices A, B & C

cc: CH

SUBJECT: Mississippi River Flood Discharge Capacity

UMLGH 1st Ind TFM/ej/jmc

St. Louis Dist, CE, US Army, St. Louis 1, Mo., 27 May 1952

TO: Division Engineer, UMVD, CE, US Army, St. Louis 1, Mo.

A report entitled "Comparative Discharge Measurements, Mississippi River, by U.S.G.S. and Corps of Engineers," is being forwarded this date with letter from this office, UMLGH, subject, "Comparative Discharge Measurements".

F. E. HEBEBRIEU
Colonel, Corps of Engineers
District Engineer

cc: GH

COMPARATIVE DISCHARGE MEASUREMENTS - MISSISSIPPI RIVER BY U.S.G.S. AND CORPS OF ENGINEERS

1. This report contains the results of discharge measurements, taken at various stations on the Mississippi River over a span of 15 years by the United States Geological Survey and the Corps of Engineers (hereinafter referred to as U.S.G.S. and C. of E., respectively), and the recommendations resulting from an analysis thereof.

2. It was believed advisable to try to determine, during the progress of the investigation, the reasons for the variations in discharge results, for the purpose of recommending such changes in methods and equipment that would bring about a greater degree of conformity.

3. There are listed below the main features of the two methods used by the U.S.G.S. and the C. of E.

	U.S.G.S.	C. of E.
(a)	Uses one small Price meter.	Uses two large Price meters.
(b)	Uses torpedo-shaped weights up to 300 lbs.	Uses flatiron-shaped weights up to 150 lbs.
(c)	Counts meter revolutions manually by electrical impulses transmitted to earphones.	Uses Veedol electrical counter connected to each meter.
(d)	Does not standardize length of time of meter spin at each velocity station. Time of spin usually less than 60 seconds.	Time of spin at each station is 300 seconds.
(e)	Measures from fixed structures such as bridges.	Measures from movable structures such as motor boats, launches or barges.
(f)	Velocity stations every 50 feet on discharge range.	Velocity stations every 100 feet on discharge range.
(g)	Takes two velocity observations at 0.2 and 0.8 the depth at each station. Average of two observations assumed to be mean velocity of entire vertical section.	Takes one velocity observation at each station at 0.6 depth. The observation is assumed to be the mean velocity of entire vertical section.
(h)	Relies on heavy torpedo weight on meter cable to obtain soundings.	Uses lead line thrown by leadsman to obtain soundings.

4. The C. of E. also made the following types of observations:

a. One, the "vertical velocity" observation, featured velocity observations at each tenth of the depth at each station. A vertical velocity curve was plotted and the mean velocity obtained by measuring the area under the curve. These data thus obtained, checked the results of previous studies and observations, that a velocity measurement at 0.6 depth closely approximated the mean velocity of the vertical section.

b. Two, the "rod float" observation, featured a velocity observation at each station by recording the elapsed time of travel of the float between two established discharge ranges. The float consisted of a series of connected rods, held vertically in the water by a weight at the bottom. It was assumed that the velocity of the rod would be determined by the varying velocity pressure up and down the length of the rod and would indicate the mean velocity for the entire vertical section. In view of the fact that a number of the earlier discharge measurements were obtained by the "rod float" method, it is believed advisable to establish a relationship between the U.S.G.S. measurements and the "rod float" measurements.

c. Three, the "surface float" measurement and the "submerged float" measurement. These were in the main considered as alternates for the "rod float" measurement, because the "surface" and "submerged" floats were somewhat easier to handle than "rod floats". They are listed in tables 4 and 5, appendix A; however they were not considered in arriving at a conversion factor between C. of E. "rod float" measurements and U.S.G.S. meter measurements, a comparison of which is shown by the curves in appendix C. A relationship between C. of E. "rod float" measurements and U.S.G.S. meter measurements can thus be established through their common relationship to C. of E. meter measurements.

5. An analysis of the results of discharge measurements taken by the two agencies using their respective methods and equipment, as outlined in paragraph 3, shows that the C. of E. discharges exceed the U.S.G.S. discharges by varying percentages up to about 22 percent. Listed in tables 1, 2, 3 and 4, appendix A, are the results of Corps of Engineers discharge measurements since 1933 and their percentages of difference, relative to the U.S.G.S. measurements.

6. Differences in the results of the discharge measurements taken by the two agencies led to a joint stream gaging program which was initiated in 1935, and a number of simultaneous measurements were taken at St. Louis that year. The results of these and subsequent joint measurements and the procedure used are given in appendix B. In 1939, the joint investigation was continued with simultaneous measurements at Alton, Illinois, taken mainly to determine if the lateral motion of the boat from which the C. of E. measurements were obtained had any effect on the meter spin. It was found that lateral motion tends to increase the meter spin over that which would be registered by water velocity alone and, therefore, is one of the causes of the larger C. of E. results.

7. The results of the 1943 flood, measured by the U.S.G.S., led to another series of joint measurements in 1944. Rating curves used in 1943 indicated a discharge of approximately 1,000,000 c.f.s. at the peak stage attained by the flood. However, the peak flow as measured was only 840,000 c.f.s. The 1944 flood attained practically the same stage and peak discharge (844,000 c.f.s.) and afforded an excellent opportunity for further comparison of discharge procedures. The standard U.S.G.S. measurements were obtained from MacArthur Bridge. The C. of E. measurements were obtained from a boat, using U.S.G.S. equipment and methods. Lateral motion was eliminated as much as possible, by anchoring the boat and by rudder action. The results of the simultaneous discharge measurements taken in 1935, 1939, 1944, 1947 and 1948 are given in appendix B.

8. Following are the results, in brief, derived from the study of comparative measurements:

a. The 1935 measurements indicated that C. of E. equipment was to some extent obsolete, and better equipment would have brought about a closer agreement with U.S.G.S.

b. The 1939 measurements at Alton, Illinois, proved that closer agreement could be accomplished if the lateral motion of the boat used in C. of E. measurements could be eliminated.

c. The 1944 measurements at St. Louis, Missouri, verified the above conclusions. In that year, reasonably close agreement was accomplished by standardising equipment and methods to conform to that of the U.S.G.S. and, in addition, by eliminating, as much as possible, the lateral motion of the boat. This simulates to a greater degree the fixed conditions available when measuring from MacArthur Bridge.

9. Before any corrections can be applied to the discharge values now in use by this office, prior to the publication of discharges by the U.S.G.S. (1933), an understanding is necessary of the methods employed by the two offices in arriving at published or report study discharges.

10. The U.S.G.S. basic discharge curve is drawn through the mean of plotted values resulting from discharge measurements usually taken at any one station about once each week. If a subsequent discharge measurement value plots to the left or right of the basic curve, it is considered to be correct and the basic curve, in effect, is treated as though it has shifted through this point. Actually, estimated daily discharges values, for the interim between measurements, are obtained by applying the daily stages to the basic curve and correcting the resulting values of discharge by the percentage difference between the plotted value and the basic curve. It is believed, by the U.S.G.S., that this procedure takes into consideration not only the normal shifts, from basic mean curve, due to rising and falling stages but, in addition, the shifts that are the result of channel cross-sectional area changes caused by scour or fill.

11. Prior to 1928, daily discharges for the years 1844, 1861 to 1927 were obtained by this office frommean rating curves for various periods. (Reference plate 8, Rating Curves, St. Louis, Missouri, of appendix B, Report on Mississippi River and Tributaries between Mouth of Ohio and Illinois Rivers, in accordance with instructions contained in H. Doc. No. 308, 69th Cong., 1st sess., dated 1 August 1935.) Curves were drawn for St. Louis, Mo., for the following periods: 1872-1881; 1896-1915 and 1919-1928, and were constructed by averaging, by foot interval, all discharge measurements, irrespective of method of measurement for the respective period. Daily discharges were then obtained by applying daily gage heights to the mean rating curve drawn through the average rating curve points.

12. From 1928 to 1933, daily discharges were published in "Daily Discharge of Mississippi River and Its Tributaries and Outlets" by Mississippi River Commission, Vicksburg, Mississippi. Daily discharges as published were determined from rating curve, except for those days on which a measurement was obtained, in which cases the actual discharge measurement was used. No shift correction was applied to rating curve discharges. Since October 1933, daily discharges have been published by the U.S.G.S. in their Water Supply Papers.

13. From an analysis of the comparative measurements taken at St. Louis and other stations, it is concluded that, on the average, C. of E. large Price current meter measurements vary from 0 percent at mean stage to slightly more than 10 percent at high stages, when compared to U.S.G.S. meter measurements; and C. of E. "rod float" measurements are slightly larger than U.S.G.S. meter measurements but for all practicable purposes may be considered equal or the same (see St. Louis, Missouri, rating curve appendix C).

14. It can be seen from the discussion in paragraphs 10 - 13, inclusive, that considerable time and money could be expended in deriving C. of E. rating curves for each type of measurement and then applying corrections in order to make them comparable to U.S.G.S. method; also, if the U.S.G.S. shift factor were not taken into consideration and only the straight percentage correction made, the corrected discharge may not be anymore accurate than the original or those now determined. It is believed correct to reduce by 10 percent the yearly peak C. of E. discharge estimates, arrived at by use of the large Price current meter measurements, in order to make them more nearly comparable with results obtained by present U.S.G.S. methods and techniques. In view of the wide dissemination of the discharges in various publications, it is not recommended that the C. of E. measured discharges be revised.

APPENDIX A

Comparison of C. of E. and U.S.G.S

Discharge Measurements

TABLE 1

1933
Cape Girardeau - Thebes

Date	Cape Girardeau gage	Boat range Thebes (1) C. of E. disch. 1,000 c.f.s.	Cape Girardeau bridge (2) U.S.G.S. disch. 1,000 c.f.s.	Method	C. of E. disch. / U.S.G.S. disch. %
31 Mar	20.3	189.0	170.0	(3)	111
13 Apr	27.5	361.0 349.0	355.0	(3)	102 98
20 Apr	27.5	352.0 339.0	351.0	(3)	100 97
27 Apr	22.0	239.0 245.0	234.0	(3)	102 105
18 May	34.3	631.0 612.0	516.0	(3)	122 119
25 May	30.7	448.0	393.0	(3)	115
1 June	32.2	544.0 539.0	445.0	(3)	122 121

(1) Thebes C. of E. range is located about 3/8 mile above Thebes Railroad bridge.
(2) U.S.G.S. range is located at Cape Girardeau Highway bridge.
(3) U.S.G.S. method, 1 meter; C. of E. method, 2 meters.

TABLE 2

1935
Cape Girardeau - Thebes

Date	Cape Girardeau gage	Boat range Cape Girardeau or Thebes C. of E. disch. 1,000 c.f.s.	Cape Girardeau bridge (3) U.S.G.S. disch. 1,000 c.f.s.	Method	C. of E. disch. / U.S.G.S. disch. %
14 Mar	29.0	434.6 (1)	375.0	(4)	116
21 Mar	24.8	277.9 (2)	263.0	(4)	106
28 Mar	22.8	254.1 (2) 248.3 (2)	247.0	(4)	103 101
3 Apr	22.3	250.5 (2)	238.0	(4)	105
9 Apr	22.1	237.1 (2) 235.1 (2)	229.0	(4)	104 103
19 Apr	23.2	261.4 (2) 260.1 (2)	251.0	(4)	104 104
18 May	28.4	346.0 (1)	385.0	(4)	90
22 May	29.1	412.6 (1)	392.0	(4)	105
7 June	34.2	584.3 (2)	574.0	(4)	102
8 June	35.3	600.3 (2)	605.0	(4)	99
10 June	36.3	637.3 (2)	633.0	(4)	101
11 June	36.4	653.6 (2)	604.0	(4)	108
12 June	36.3	636.5 (2)	595.0	(4)	107
14 June	36.0	652.7 (2)	575.0	(4)	114
17 June	34.4	570.8 (2)	524.0	(4)	109
25 June	32.5	556.9 (1)	493.0	(4)	113
1 July	31.1	490.2 (1)	451.0	(4)	109

(1) Cape Girardeau C. of E. range is located at Cape Rock, mile 53.3.
(2) Thebes C. of E. range is located at mile 44.0, 0.3 mile above Thebes Railroad bridge.
(3) U.S.G.S. range is at Cape Girardeau Highway bridge, mile 51.6.
(4) U.S.G.S. method, 1 meter; C. of E. method, 2 meters.

TABLE 3

1938
St. Louis

Date	Stage Market Street gage	U.S.G.S. discharge 1,000 c.f.s.	C. of E. discharge 1,000 c.f.s.	Method	C. of E. disch. / U.S.G.S. disch. %
26 Apr	13.4	188.0	208.5	(1)	111
10 May	16.6	237.0	260.9	(1)	110
6 July	15.4	216.0	234.9	(1)	108
9 Aug	8.4	134.0	138.9	(1)	104
16 Aug	6.9	121.0	130.9	(1)	108
20 Sept	14.4	215.0	227.2	(1)	106
27 Sept	17.8	260.0	279.1	(1)	107
8 Nov	5.8	111.0	109.5	(1)	99
13 Dec	3.0	85.8	85.8	(1)	100

(1) U.S.G.S. method, 1 meter; C. of E. method, 2 meters.

TABLE 4

1939
St. Louis

Date	Stage Market Street gage	U.S.G.S. discharge 1,000 c.f.s.	G. of E. discharge 1,000 c.f.s.	Method	G. of E. disch. / U.S.G.S. disch. %
10 Jan	0.3	68.2	69.5	(1)	102
17 Jan	3.0	88.8	82.6	(1)	93
14 Mar	19.8	306.0	335.6	(1)	110
4 Apr	14.3	210.0	219.7	(1)	105
11 Apr	20.5	311.0	322.3	(1)	104
18 Apr	27.7	466.0	475.6	(1)	102
24 Apr	24.8	363.0	375.4	(1)	103
9 May	14.8	202.0	223.0	(1)	110
23 May	7.2	113.0	118.2	(1)	105
13 June	9.8	148.0	160.7	(1)	109
20 June	12.9	193.0	203.6	(1)	105

(1) U.S.G.S. method, 1 meter; G. of E. method, 2 meters except 18 and 24 April, when G. of E. used 1 meter due to failure of second meter.

APPENDIX B

Simultaneous Discharge Investigations

C
O
P
Y

WAR DEPARTMENT
UNITED STATES ENGINEER OFFICE
Second Field Area
2nd & Arsenal Sts.
St. Louis, Mo.

August 29, 1935

Subject: Experimental Discharge Measurements at St. Louis, Missouri During June and July, 1935.

To: The Area Engineer, Second Field Area, St. Louis, Missouri.

1. During the extreme high water of June and July, 1935, discharge measurements were made on the Mississippi River at St. Louis, Missouri, by the United States Engineer Department in conjunction with the United States Geological Survey. A part of the measurements obtained were standard to the two respective departments, while the remainder were experimental in character.

2. The primary purpose of these measurements was to determine the accuracy of the two most widely used methods of observation, and by experimentation with these two methods, to arrive at a more satisfactory procedure of making observations for stream measurement. A summary of the field work, equipment used, and the methods of observation follows:

(a) The United States Geological Survey, using their standard equipment and method of observation, obtained daily measurements of the stream from a permanent range established on the highway deck of the Municipal Bridge at St. Louis, Missouri.

(b) A party operated by the United States Engineer Department, using their standard equipment and method of observation, obtained daily measurements of the stream from the permanent range establisheded approximately two miles downstream from the Municipal Bridge, at the United States Engineer Depot.

(c) A third range was established at the foot of St. George Street, about equidistant from each of the aforementioned gauging stations. This range was occupied by one party from the United States Geological Survey and one party from the United States Engineer Department. All tests and experimental works connected with the study were conducted jointly by the two parties on this range from a steel barge. The barge was fitted with two "A" frames at the head end, for use of the United States Geological Survey, while at the corner, on the stern of the barge, was another "A" frame, for use of the United States Engineer Department. A pushboat was used to tow the barge on location and an anchor was used to hold it on the range while tests and observations were being conducted.

(d) The equipment of the United States Geological Survey was of a light portable type, designed to offer the least resistance to the current, when submerged. Bullet-shaped meter weights, with a plane surface on the bottom, weighing from fifty to three hundred pounds, were used alternately. Horizontal and vertical fins fastened to the back end of the weights held them parallel to the flow, and in a horizontal plane at all times. The meter staff was made of polished, stainless steel, 1/8" thick and 3/4" wide, and was suspended so as to offer least resistance to the flow. The current meter was of a small design, adapted to the thin staff, yet similar in working parts to the Large Price Meter (now used by the United States Engineer Department). Electric contact points in the meter head were arranged to register either each revolution or each fifth revolution of the meter turbine. The reel used to raise and lower the meter apparatus was also of small design; it was equipped with a counter to register depths, and was easily operated by one man. The cable used on the reel was 1/10", in diameter and had an electric conductor core that served as the primary line of a telephone circuit to the meter. (see Fig. #1)

(e) The party operated by the United States Engineer Department was rigged with the standard equipment, which consisted of three Large Price Current Meters, a 3/4" round brass meter staff, a seventy-five pound meter weight, a length of 3/8" steel supporting cable, and a length of two-circuit electric cable 1/2" in diameter. (See Fig. #2)

(f) The procedure followed by the United States Geological Survey while obtaining observations was noted as follows:- When the barge rested at anchor on the range, the observer obtained a single sounding, with the meter lead (meter attached); the angle of drift of the lead weight was measured with a protractor that was fastened to the "A" frame at the pulley, and a correction for this angle was applied to the observed depth. Velocities were then measured at 8/10 and 2/10, the corrected depth at this location. This procedure was followed on each station as the observations progressed across the range. The notes were computed while the barge was being reset for the next observation.

(g) The procedure followed by the United States Engineer Department was as follows:- Immediately before velocity measurements were started, the cross section was sounded with a M.R.C. Sounding Reel

from aboard the pushboat. Three soundings were obtained at each fifty-foot station on the range — one about twenty-five feet above the range, one on the range, and one about twenty-five feet below the range. The mean of these three soundings was recorded for the depth at that particular station. Upon completion of the soundings, the velocity measurements were then obtained at approximate one hundred-foot intervals across the range.

(h) In the field, the time required to complete a measurement was the only disadvantage noticed in the method employed by the United States Geological Survey. It was readily seen that in order to fully develop the dross-section, twenty-five to thirty stations across the range were required. For each station it was necessary to re-anchor the barge, which operation during the extreme high stages and with the make-shift floating equipment, required about twelve minutes. In addition to this time, there was five minutes time required at anchor, to obtain the sounding and velocities on each station. In the completion of a measurement consisting of some twenty-five or thirty stations, approximately eight or nine hours time was required. If the river stage, during the observation, was changing at a moderate rate, it would then be necessary to apply a correction, for change in stage, to the complete measurement. However, it must be understood that the equipment of the United States Geological Survey was designed to operate from a portable one-man rigging on a bridge deck and not from a barge in the river.

(i) On June 3, 1935, vertical curve observations were made by the United States Engineer Department. During the observations, difficulty was encountered in lowering the meter beyond a depth of twenty-five feet, with only seventy-five pounds of weight attached. More meter weights were attached until a total weight of two hundred pounds was tried. While anchored in forty-six feet of water it was found that in order to rest the meter within one foot of the river bottom, it was necessary to play out fifty-nine feet of the supporting cable. At this depth the angle of drift of the weights and meters was measured at forty degrees. Since the cable described a curve under water instead of a straight line, it was impossible at the time to arrive at a true correctionnto be applied to the line. The objective then was the design of equipment that would reduce the angle of drift of the weights and meters.

In order to accomplish this end, a bullet-shaped meter weight was designed by the Mechanical Design Section at the United States Engineer Depot. In addition, two of the strap-type meter staffs (1/8" x 3/4")

were designed by the undersigned; one to accommodate one meter for vertical observations (See Fig. 3 & 4), and one to accommodate two meters for regular observations (See Fig. 5 & 6). A new steel supporting cable of 5/32" diameter (breaking strain of fourteen hundred pounds), with an electric conductor core was obtained for use with this new equipment. Tests conducted with this new equipment (all of which is now stored at the 2nd Field Area office), gave the desired results. In forty-five feet of water, with the meters resting within two feet of the bottom, the angle of drift was measured at only four degrees. It has been calculated that this new equipment had approximately fifty-two per cent less resisting surface than the old type equipment.

3. In conclusion, suggestions for changes in equipment and procedure of procuring soundings and velocity measurements follow:-

(a) Equipment. A complete change to the newly designed velocity equipment, as shown in Figures 3 to 6 inclusive, in addition to a newly designed barge with power equipment for handling an anchor and "A" frames with small but easily operated reels attached, could be used to a great advantage in making discharge measurements.

(b) Sounding. Take soundings for the cross-section with a M.R.C. sounding reel on a line parallel to the flow, from a point one hundred feet above the range to a point one hundred feet below the range, obtaining about eight or ten soundings while the boat is drifting with the current over this course. Each set of soundings should be taken at intervals of approximately fifty feet across the range in order to get a well developed cross-section. If a study of computations was made it is believed that it would be found that the least sounding obtained by the above method on each station would prove to be the controlling depth when the passage of a volume of water is considered.

(c) Velocity Measurements. When measuring vertical velocities it is suggested that instead of obtaining velocities at regular four-foot intervals on each station, the velocities be obtained at intervals equivalent to each one-tenth the depth at the station when the depth is greater than twenty feet. When the depth is less than twenty feet, obtain velocities at each interval equal to two-tenths

the depth at the station. Bracket, with vertical velocity curves, each five-foot interval of gauge height, and from these vertical velocity curves, compute a depth at which to obtain the mean velocity during the time the stage is between these brackets. This procedure would require a study over a period of several years, yet the result would be beneficial in view of the fact that it would not only make observation and computation of the regular measurement much easier, but would furnish the Department with accurate data. Provided the above suggestions are used, satisfactory and accurate measurements could be obtained by only four men in the field.

Submitted by: Lowell C. Oheim /s/
Lowell C. Oheim
Surveyman

Encl: 6 photographs

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

File Number (District

COMPARISON OF DISCHARGE MEASUREMENTS AT ST. LOUIS, MO. - 1935

DATE 1935	U.S.G.S. DISCH. FROM BRIDGE	%	U.S.G.S. DISCH. FROM BARGE	%	U.S.G.S. DISCH. FROM BARGE	%	U.S.E.D. DISCH. FROM BARGE	%	U.S.E.D. DISCH. FROM LAUNCH	%
June 1									481	
3	495	-0.0							545	+10.1
4	520								563	+8.3
5									628	
6	633								678	+7.1
7	649								711	
8	641								716	+11.7
9	625						670	+7.2		
10	612								648	+5.9
11	607						623	+2.6	636	+4.8
12			513				583		586	
13	546								561	+2.7
14									502	
15							503		526	
17	419		406	-3.1			498	+6.9	470	+12.2
18									433	
20									449	
21			378				412		442	
22	417		394	-5.5			428	+2.6	463	+11.0
24									468	
25	460		432	-6.1			472	+2.6	497	+8.0
26									470	
27									419	
28	369		351	-4.9	*367	-0.5	365	-1.1	397	+7.6
29									424	
July 2	438		416	-5.0	426	-2.7				
3	415		419	+1.0	428	+3.1				
11	318	0.0	318	0.0	336	+5.7				

* MADE WITH U.S.E.D. CURRENT METER

NOTE: DISCHARGES RECORDED IN THOUSANDS OF SECOND FEET

U.S.E.D. DISCHARGES SUBJECT TO REVISION

GH

GU

1 December 1949

Stream Discharge, Mississippi River, Vicinity Alton, Illinois

1. Following is an attempt to reconstruct the comparison of Mississippi River discharge measurements between the U.S.G.S. and U.S.E.D. (2nd Field Area) during the period Sept. thru Dec. 1939.

The undersigned was on assignment to the local U.S.G.S. Water Resource Office, during the period late August thru December 1939, in accordance with agreement between the Dist. and U.S.G.S. on the joint stream gaging program. During the period the U.S.G.S. party (the undersigned a member of the party) was taking weekly observations from the Alton R.R. Bridge or from skiff operating on river-spanning tagline while U.S.E.D. party was taking daily observations from Survey boat hanging on anchor-line. A comparison of early results obtained by the two parties was made by the undersigned and in general the U.S.E.D. discharge appeared excessively high. It was realized that lateral movement of the U.S.E.D. boat might give some additional increase in stream discharge but it did not appear likely that the error could approach figures obtained. The U.S.E.D. party were using "Large Price" meters and the U.S.G.S. were using "Small Price" meters; it was thought some error might be here. In discussion with P.N. Ashlock, Area Engineer, it was agreed that the U.S.E.D. party under R. Vierling would drop down from the usual range in vicinity of mile 201.5 to the U.S.G.S. range at approx. mile 198 for three concurrently run measurements on 20 Oct., 27 Oct. and 3 Nov.

On 20 Oct. the U.S.G.S. party using skiff and tagline and "Small Price" meter and the U.S.E.D. party using Survey boat hanging on anchor line, and, "Large Price" meter and working approx. 100 ft. below the U.S.G.S. tagline made concurrent observations. The U.S.G.S. party took approx. 50% more velocity sections than did the U.S.E.D. party. Approx. difference between results of two measurements was 10½%.

On 27 Oct., at the same locality as 20 Oct., both parties again ran concurrent measurements; the U.S.G.S. procedure was unchanged but on this date the U.S.E.D. party hung on the tagline with bow of the Survey boat; boat was free to swing and with the discharge equipment operating approx. midway of the Survey boat (approx. 15 ft.) some lateral movement during measurement occured. Difference in measurements was reduced to less than 3% by this change in procedure.

On 3 Nov., same place, same procedure except distance between tagline and discharge equipment on the U.S.E.D. Survey boat was reduced by approx. 4 ft. the difference in discharge was further reduced to less than 2½%.

On later dates the U.S.E.D. party returned to its old range with the realization that lateral movement of the boat during periods of observation gave highly inaccurate results. A procedure in which the motorboat was kept in gear at idling speed and the operator attempting to counteract lateral movement of the unit by shifting the rudder was found to be somewhat effective as later results showed.

2. It is to be realized that the results of such a short trial cannot be considered conclusive, however it is thought that the results are indicative of causes of error due to methods used in the determination of stream discharge quantities.

A. E. FEDDER,
Chief, Surveys Branch

1939

Alton

Date	Stage Alton gage	U.S.G.S. discharge 1,000 c.f.s.	C. of E. discharge 1,000 c.f.s.	C. of E. disch. / U.S.G.S. disch. %
22 Sept	-1.9	25.5	28.8	113
3 Oct	-2.3	22.8	26.6	117
13 Oct	-1.3	29.9	33.7	113
20 Oct	-2.1	25.8	28.5	110
27 Oct	-1.3	31.0	31.9	103
3 Nov	-0.6	35.2	36.1	102
14 Nov	-1.2	31.2	33.4	107
21 Nov	-0.9	32.6	35.0	107
28 Nov	-1.9	27.8	27.9	100
5 Dec	-0.6	33.9	34.7	102
13 Dec	-0.4	36.8	37.9	103
22 Dec	-1.1	32.5	34.2	105

1944
St. Louis

Date	Stage	U.S.G.S. discharge 1,000 c.f.s.	C. of E. discharge 1,000 c.f.s.	Method	C. of E. disch. / U.S.G.S. disch. %
13 Apr	28.6	485.8	474.4	M	98
14 Apr	30.3	508.3	530.0	M	104
15 Apr	31.0	526.4	541.3	M	103
16 Apr	31.2	535.9	540.0	M	101
17 Apr	30.9	509.5	521.4	M	102
23 Apr	31.3	524.5	532.5	M	102
25 Apr	34.3	628.9	591.9	M	94
26 Apr	35.5	676.8	649.6	M	96
27 Apr	36.5	734.4	675.0	M	92
28 Apr	37.3	757.8	770.1	M	102
29 Apr	38.2	815.5	801.4	M	98
30 Apr	39.05	829.9	844.4	M	102
1 May	38.8	831.8	828.5	M	99
2 May	38.3	773.4	775.7	M	100
4 May	37.9	742.6	731.9	M	99
5 May	37.0	678.4	680.2	M	100
6 May	35.8	647.7	637.6	M	98

M denotes small Price meter.

1947
St. Louis

Date	Stage	U.S.G.S. discharge 1,000 c.f.s.	C. of E. discharge 1,000 c.f.s.	Method	C. of E. disch. / U.S.G.S. disch. %
8 July	37.2	681.1	709.6	(1) F	104
9 July	36.0	616.0	670.8	(1) F	109
10 July	34.6	585.6	610.3	(1) F	104
11 July	33.1	520.7	560.5	(1) F	108

(1) U.S.G.S. method, 1 meter.
F C. of E. method, denotes surface float, with sub-surface float at 0.6 depth.

1948

St. Louis

Date	Stage	U.S.G.S. discharge 1,000 c.f.s.	C. of E. discharge 1,000 c.f.s.	Method	C. of E. disch. / U.S.G.S. disch. %
23 Mar	30.5	553.6	566.4	(1) SM	102
26 Mar	34.1	626.4	708.5	(1) LM	113
			672.0	RF	107
			663.6	SF	106
27 Mar	34.5	629.5	724.9	(1) LM	115
			709.0	RF	113
			724.7	SF	115
29 Mar	32.6	540.9	620.5	(1) LM	115
			586.8	RF	108
			653.4	SF	121
31 Mar	31.0	520.5	548.6	(1) LM	105
			602.6	RF	116
			606.8	SF	117

(1) U.S.G.S. method, 1 meter.
LM denotes large Price meter, with flatiron weight.
RF denotes rod float 3" diameter.
SF denotes submerged float.
SM denotes use of one small Price meter with "C" type weight.

APPENDIX C

Comparative Rating Curves

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

ELEVATION, FEET - M.S.L. CAPE GIRARDEAU, MO.

GAUGE HEIGHT, FEET

350 348 346 344 342 340 338 336 334 332 330 328 326 324 322 320 318 316 314 312 310

44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6

ONE FOOT FALL CURVE COMPUTED FROM DISCHARGE MEASUREMENTS TAKEN AT CAPE GIRARDEAU BY U.S.G.S.

METERS

METERS

ONE FOOT FALL CURVE COMPUTED FROM DISCHARGE MEASUREMENTS TAKEN AT CAPE GIRARDEAU BY U.S.E.D.

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600

DISCHARGE IN THOUSAND C.F.S.

MISSISSIPPI RIVER

GRAYS POINT, MO. TO CAPE GIRARDEAU, MO.

ONE FOOT FALL CURVES -- 1933 TO 1939

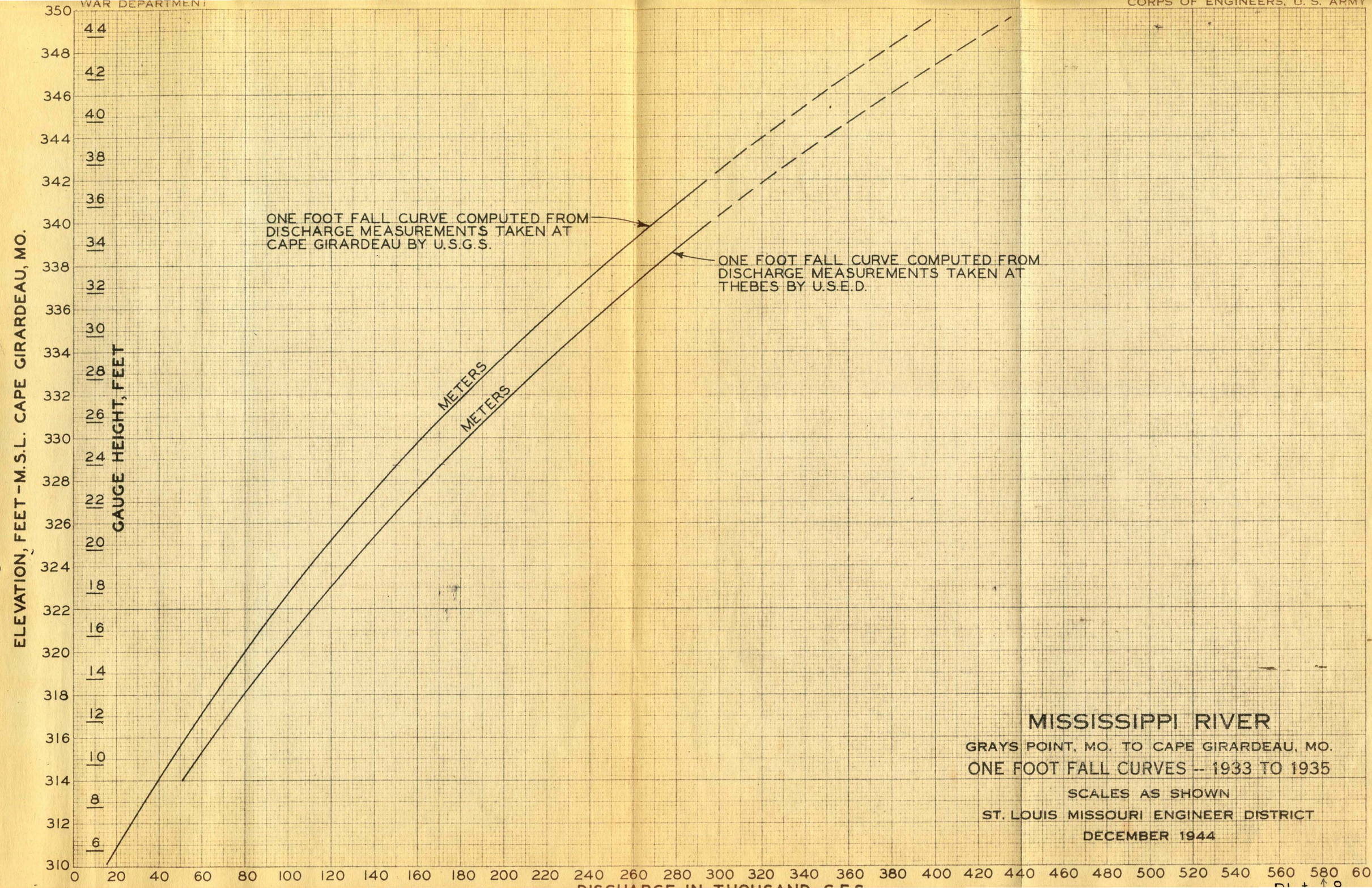
SCALES AS SHOWN

ST. LOUIS MISSOURI ENGINEER DISTRICT

DECEMBER 1944

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



MISSISSIPPI RIVER

GRAYS POINT, MO. TO CAPE GIRARDEAU, MO.

ONE FOOT FALL CURVES -- 1933 TO 1935

SCALES AS SHOWN

ST. LOUIS MISSOURI ENGINEER DISTRICT

DECEMBER 1944

Plate 8

WAR DEPARTMENT

CORPS OF ENGINEERS. U. S. ARMY

ELEVATION, FEET M.S.L. - CHESTER, ILL.

GAUGE HEIGHT. FEET

ROD FLOATS

METERS

DISCHARGE IN THOUSAND C.F.S.

MISSISSIPPI RIVER

CHESTER, ILLINOIS

RATING CURVES -- 1926, 1927 & 1930

SCALES AS SHOWN

ST. LOUIS MISSOURI ENGINEER DISTRICT

DECEMBER 1944

WAR DEPARTMENT

CORPS OF ENGINEERS. U. S. ARMY

THE FREDERICK POST CO.

No. 320-N

CHICAGO

ELEVATION, FEET M.S.L. - CHESTER, ILL.

GAUGE HEIGHT. FEET

380 378 376 374 372 370 368 366 364 362 360 358 356 354 352 350 348 346 344 342 340

38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0

ROD FLOATS

METERS

200 240 280 320 360 400 440 480 520 560 600 640 680 720 760 800 840 880 920 960 1000 1040 1080 1120 1160 1200 1240 1280 1320 1360 1400

MISSISSIPPI RIVER

CHESTER, ILLINOIS

RATING CURVES -- 1926, 1927 & 1930

SCALES AS SHOWN

ST. LOUIS MISSOURI ENGINEER DISTRICT

DECEMBER 1944

WAR DEPARTMENT
CORPS OF ENGINEERS, U. S. ARMY

ELEVATION, FEET M.S.L. – ST. LOUIS, MO.
GAUGE HEIGHT, FEET

METERS
DOUBLE FLOATS

MISSISSIPPI RIVER

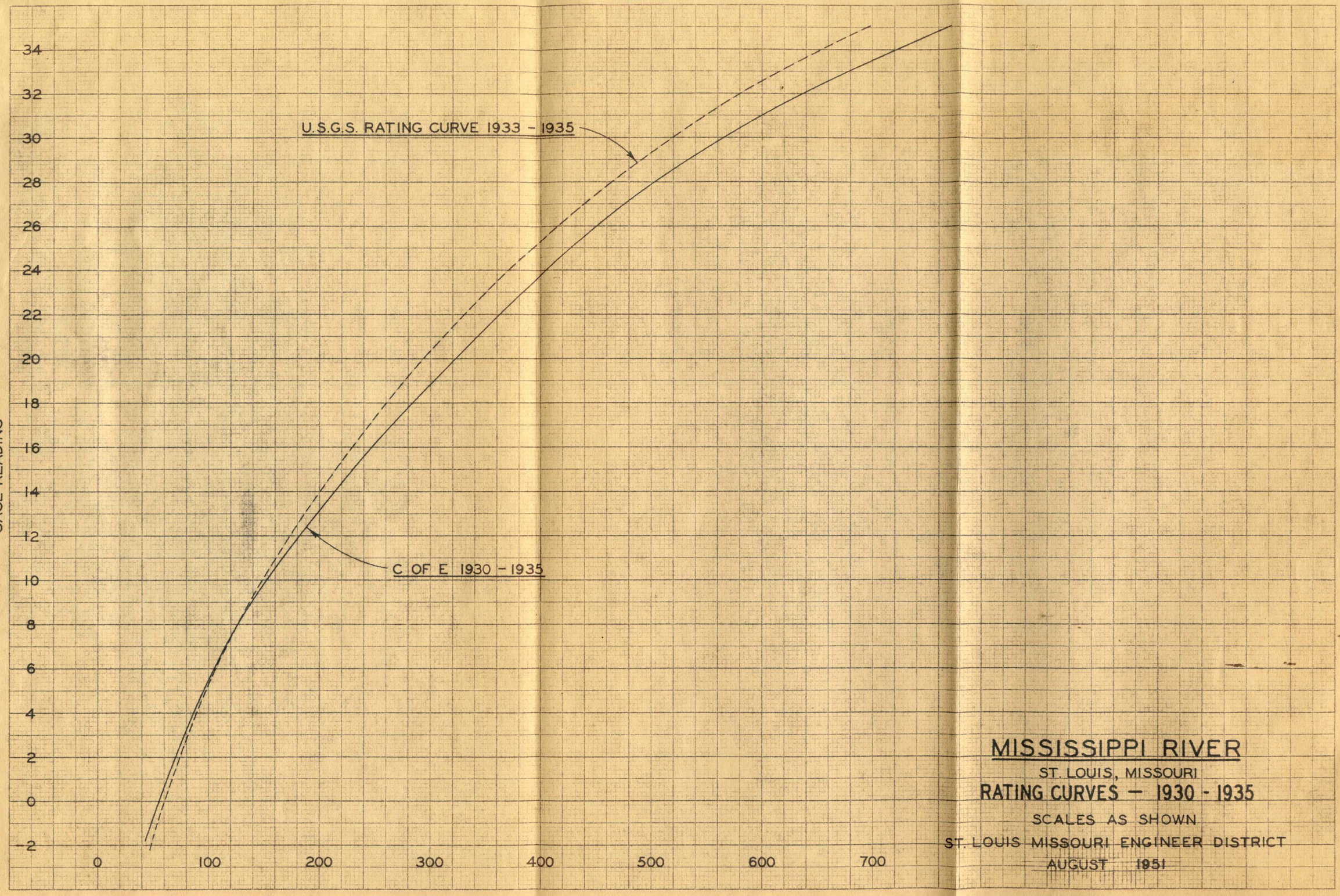
ST. LOUIS, MISSOURI

RATING CURVES -- 1927 TO 1930

SCALES AS SHOWN

ST. LOUIS MISSOURI ENGINEER DISTRICT

DECEMBER 1944



MISSISSIPPI RIVER

ST. LOUIS, MISSOURI

RATING CURVES — 1930 - 1935

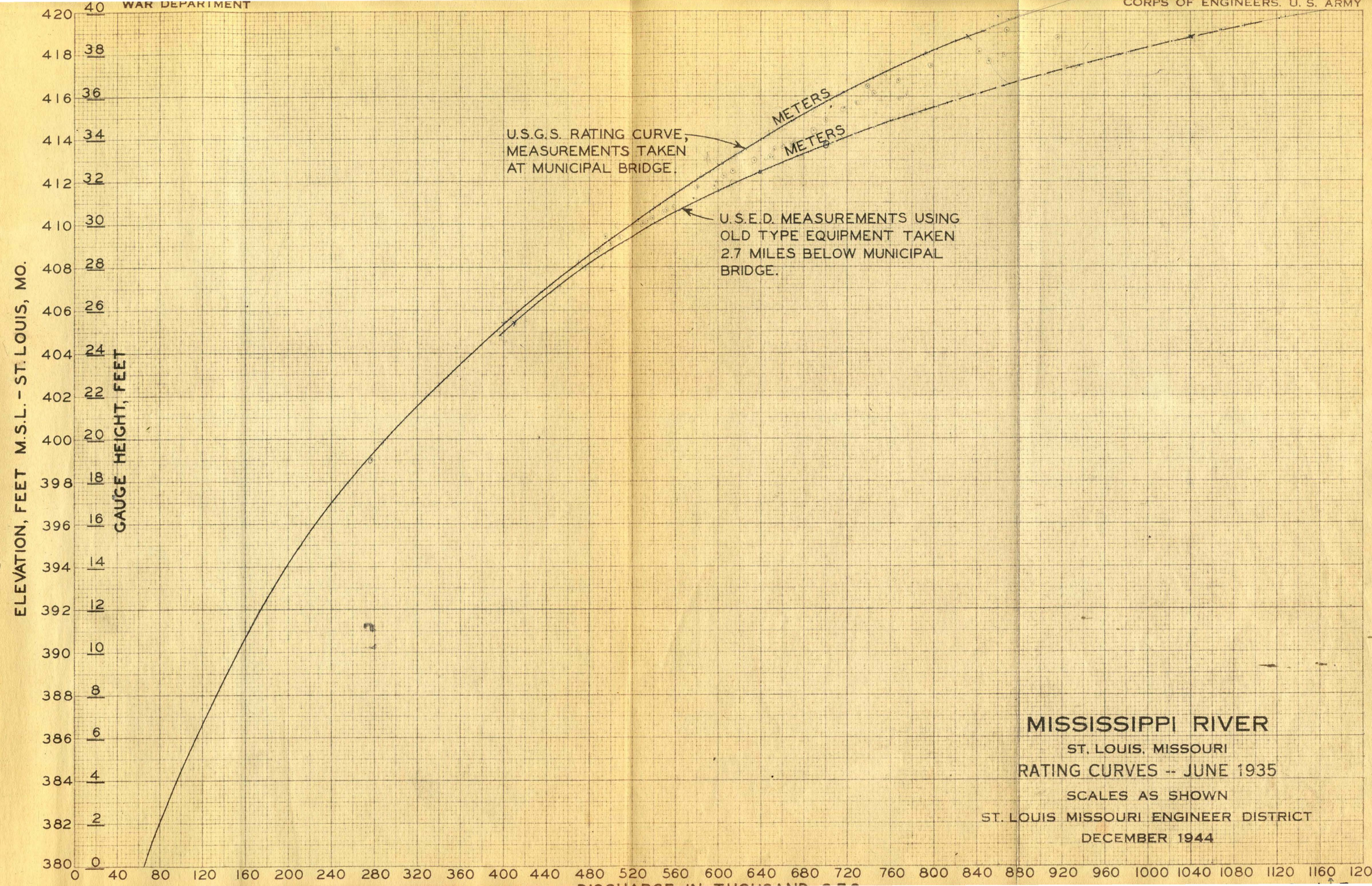
SCALES AS SHOWN

ST. LOUIS MISSOURI ENGINEER DISTRICT

AUGUST 1951

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



MISSISSIPPI RIVER

ST. LOUIS, MISSOURI

RATING CURVES -- JUNE 1935

SCALES AS SHOWN

ST. LOUIS MISSOURI ENGINEER DISTRICT

DECEMBER 1944