Report
October 1929 Flood

Contents:
File Name: 88_192910_Report_1
Note:

GIVES HISTORY OF RECENT FRESHETS

Says Railfall Reports in Watershed Enabled River Forecasts

SAVANNAH REACHED PEAK

Valuable Information Gained in Recent Flood by Weather Man

By E. D. Emigh
Assistant Meteorologist, Augusta.

That the Savannah is one of the most remarkable of flood streams was most impressively demonstrated by the record breaking stages of September 27th and October 2nd, 1929.

Picture a deluge of rain averaging 8.84 inches in approximately thirty-four hours over a watershed embracing 7,294 square miles of rugged topography of clay hills varying in elevation from 200 feet at the eastern edge of the Piedmont Plateau, at Augusta, to 1,000 feet on the western edge.

Rushing through fields, roads and bottoms in streams where none had been before, converting creeks into turbulent rivers, swelling with unbelievable rapidity the main tributaries, and on into the Savannah poured the violent flood waters. Rocky River, Little River and Stevens Creek, on the Carolina side, and Broad River and Little River, on the Georgia side, contributed vigorously to the result, while lesser quotas swept down from the Seneca and Tugaloo which converge to form the Savannah. At Augusta, on the evening of September 25th, the Savannah River flowed placidly at the 10 foot stage, with a discharge of approximately 10,000 cubic feet per second. In twenty-four hours there was an increase in stage to 33.1 feet and a discharge of 100,000 cubic feet per second. At the end of forty-eight hours the river was carrying thirty-seven times as much water as at the outset and was discharging 370,000 cubic feet of water per second at the crest stage of 46.3 feet.

It will be seen in Table 1, in which stations are named in the order of their distance from Augusta, that excessive rainfall was general over the watershed on September 26th and 27th but the heaviest downpours occurred in the middle and lower portions. On this account the highest stages recorded in the Broad River at Carlton, Ga., and the Savannah River at Calhoun Falls, S. C., 19.2 feet and 8.7 feet, respectively, were lower than during the flood of August, 1928, when the river at Augusta reached a stage of only 40.4 feet. Double Branches, Ga., the station closest to Augusta, at the confluence of the Georgia Little River with the Savannah, reported the greatest amount of rain, 14.51 inches, with Washington, Ga., a close second, 14.49 inches. The least amount, 5.03 inches, was reported from Toccoa, Ga., the most remote reporting station.

At 9 A. M. of September 26 a preliminary forecast for a stage of 36 feet in the Savannah river at Augusta was issued, but at 11 A. M., special reports having been received from several rainfall stations, a revised estimate was disseminated, predicting a stage of 39 feet in the forenoon of the 27th. At 3:30 P. M. reports from all stations showed continued heavy rains which averaged 5.30 inches in less than 24 hours and a prediction for a stage of 41 feet on the 27th was issued. This forecast was considered to

be of great importance, since the highest stage in the history of the river was indicated, and was given careful dissemination to all railroads and other industries. On receipt of the 8 A. M. reports of the 27th it became evident that a major flood of unprecedented volume was in prospect, in which the discharge would exceed that of 307,000 second feet in August, 1908. Torrential rains had fallen during the night and the figures showed an average of 8.84 inches in about 34 hours, 4.43 of which had fallen up to 8 A. M. of the 26th, and 4.41 from 8 A. M. of the 26th to 8 A. M. of the 27th, much of it during the night of the 26th-27th. At 9 A. M. the final forecast for a stage between 46 and 47 feet was issued.

TABLE 1.

	Sept. 26th			Sept. 27th	
	8 A.M.	3 P.M.	8 A.M.	8 A.M.	Total about 34 Hr.
Augusta, Ga.	.90	01	.91	6.88	7.78
Double Branches, Ga.	8.26	.10	8.36	6.22	14.51
Edgefield, S. C.	4.76	.07	4.83	3.08	7.84
Warrenton, Ga.	2.96	2.00	4.96	6.20	9.16
Greenwood, S. C.	5.59	2.00	7.59	4.22	9.83
Washington, Ga.	5.61	1.51	7.12	8.90	14.49
Calhoun Falls, S. C.	3.62	2.60	6.22	5.86	9.48
Carlton, Ga.	5.07	.40	5.47	2.60	7.67
Gillsville, Ga.	5.30	.05	5.35	.65	5.95
Anderson, S. C.	2.68	.55	3.24	2.82	.50
Toccoa, Ga.	3.95	.31	4.26	1.08	5.03
Averages	4.43	.87	5.30	4.41	8.84

Predicted stage, 39 feet, 41 feet, 46 feet-47 feet.
Initial stage, 8 P. M., September 24, 10 feet.
Average upper shed first day, 4.12; 1-3 equals 1.37.
Calculation on 8 A. M., 27th, 4.41 plus 1.37, equals 5.79 rainfalls, argument on estimated stage 8 A. M., 39 feet (explained).
Highest stage reached, 46.3 feet, 8 P. M., September 27.

Although the greatest quantity of water in the history of the river was expected and considerable nervousness was inevitable, most Augustans had faith in the levee to restrain the flood and protect the city. This confidence was justified, for the main portion of the levee proved adequate both in capacity and stability to withstand the test. About three miles below the city, however, a breach occurred. Fortunately the break did not attain great width until after the river had fallen considerably from the crest stage, while the situation was somewhat relieved by the city engineers, who opened the outlet gates at the mouth of Butler's Creek, and by two breaches in the levee near the Butlers Creek gates. Backwater, however, overflowed much farm land and flowed into the lower sections of the city to a depth of two to four feet. Since the houses in the area affected were built well above the ground in prelevee days no great harm was done. Ample warning of the approach of the backwater had been given by the city engineers and dis-

seminated by them, the newspapers and the Weather Bureau office.

THE SECOND FLOOD

On the morning of October 1st, Thomasville, Ga., was at the center of an energetic storm, with barometric pressure of 29.12 inches. This disturbance had advanced from the West Indies through the Gulf of Mexico west of Florida. Though it had lost much of the characteristic violence of the hurricane, it was still possessed of considerable energy, which, fortunately, it demonstrated only in torrential downpours of rain unattended by destructive winds, in its advance through Georgia and the Carolinas to Richmond, Va., where it was centered at 8 A. M. October 2nd. The deluge in the Savannah River watershed gave an average of 7.84 inches in about 30 hours, which caused steady rapid rise in the river from a stage of 21 feet at 8 P. M. of September 30th to a crest of 45.1 feet at midnight, October 2nd.

During the storm of September 26th and 27th only one special rain fall report was received from all stations, though a number of extra reports came in, but on October 1st reports were sent from all stations at noon, 2 P. M., and 4 P. M., and from most stations at 6 P. M., 8 P. M., and 10 P. M. In this connection, a fact worthy of special note, since it contributed in a most essential way to the accuracy and reliability of the service rendered by the Weather Bureau office, was that perfect telegraphic communication was maintained through both torrential storms. The only interruption to communication was on the private telephone line between Double Branches, Ga., and Lincolnton, Ga., and the faithfulness of Mr. J. M. Price and members of his family in carrying messages through the downpour over almost impassable roads ten miles to Lincolnton to get to a telephone merits special mention in this report.

For the fact that telegraph offices were kept open into the night grateful acknowledgement is made for the cooperation of Mr. B. E. Lester and Secretary L. S. Moody of the Augusta Chamber of Commerce who brought about the arrangement, and to the superintendent and operators of the Western Union Telegraph Company.

The distribution of rainfall over the watershed was more regular than on September 26-27, but it was somewhat heavier in the middle and lower sections than at more distant points. Augusta, Double Branches, Warrenton and Washington received 9.00 inches or more of rain in about thirty hours. Toccoa with 4.30 inches, was again credited with the least amount.

Predictions were issued at 9 A. M. for a 35 foot stage, 1 P. M. for a 41 foot stage, 4 P. M. for a 44 foot stage, and 7 P. M. for a stage of 46 to 47 feet.

TABLE 2. October 1st

	8 A. M.	8 A. M. Noon	8 A. M. 4 P. M.	8 A. M. 6 P. M.	Total 30 Hrs.
Augusta, Ga.	2.06	1.03	3.49	6.37	.983
Double Branches, Ga. ...	4.49	1.05	....	....	9.00
Edgefield, S. C.	3.02	.52	2.19	4.19	8.26
Warrenton, Ga.	.70	.80	4.60	5.80	9.02
Greenwood, S. C.	3.42	1.01	2.56	3.25	7.12
Washington, Ga.	2.74	1.40	3.50	5.60	9.68
Calhoun Falls, S. C. ...	2.70	1.20	2.30	4.00	8.30
Carlton, Ga.	2.90	1.26	2.92	3.45	8.15
Gillesville, Ga.	2.05	.53	1.07	3.31	6.75
Anderson, S. C.	1.75	....	2.16	....	5.85
Toccoa, Ga.	2.00	.95	1.77	2.10	4.30
Averages	2.44	.95	2.36	4.33	7.84

Predicted stage, 35 feet, 41 feet, 44 feet, 46 feet-47 feet.
Rainfall 8 A. M. plus noon equals 3.39; 8 A. M. plus 4 P. M. equals 4.80.
Highest stage reached, 45.1, midnight, October 2.

From the experience gained in these two floods of major ma[gnitude] the writer has formulated the opinion that the capacity of the S[avannah] River at Augusta, Ga., to discharge water was closely approaches [in] instances, and that circumstances under which a stage of 47 feet [was] exceeded with obstructions as they were September 25th, or 46 fee[t] obstructions cleared away as during the rise of October 1st and 2[nd] almost inconceivable. Had the experience of September 26th been [had] the forecaster would very likely have made a prediction on Octob[er 1st] for a stage of 48 feet or more. Although 6.77 inches of rain had [fallen] over the shed up to 6 P. M. of October 1st, the forecase issued, [for a] stage of 46 to 47 feet, was based on only 5.75 inches. Though the [rainfall] for the watershed subsequently swelled to 7.84 inches in about 30 h[ours] the estimate proved to be adequate. Had allowance been made for the fact that the Hamburg Road had washed out during the first flood which was hardly safe in the circumstances, the prediction would have been for a stage of 45.46 feet.

Although the crest stage reached was 45.1 feet, as against 46.3 feet on September 27th, discharge measurements at Stevens Creek power dam disclosed the fact that the discharge in the October flood was 382,000 cubic feet per second, as against 370,000 in the September flood. The fact that the river carried more water at a lower stage was due to the removal by the first flood of the Hamburg Road embankment and in some degree to the clearing away of other obstructions further down stream in the same manner, particularly the Charleston and Western Carolina bridge approach.

AUGUSTA MEETS AND CONQUERS GRAVE DANGER

Upon completion of the forecast for a stage of 46 to 47 feet, the official in charge immediately communicated with the Augusta Chronicle and requested that an extra edition of that paper be issued at the earliest possible moment to warn the people in the low lying residence and business sections of the grave danger which existed. The paper appeared promptly on the streets and exodus to the hill section, which had already begun, was greatly accelerated.

The next step was a visit to the City Hall to apprise the Mayor and Levee Commission of the gravity of the situation. It was found that considerable preliminary work pointing to the organization of working forces had already been done and the extreme imminence of danger of the levee breaking should the volume of water come up to expectations galvanized the officials into immediate and effective action. Fire Department cars and trucks, police cars and motorcycles, and ambulances, with horns blowing and sirens screaming, aroused all residents and urged that they move to high ground. The tourist hotels, which at this season are closed, were thrown open for accommodation of the refugees and ample accommodations were afforded to all, in these hotels and the private homes of friends.

Throughout the day the weather bureau office had been in touch with Mr. Ralph S. Howard, U. S. Engineer, who was familiar with the weakness which had developed in that portion of the levee extending from Eighth Street upstream past the cottom mills, a distance of about a mile. Softened by the previous heavy rains and flood waters, the levee, which had been treated with considerable indifference so far as proper care was concerned, had developed several dangerous slides. With rain falling and the river rapidly rising the situation looked hopeless, but under the capable leadership of Engineer Howard, who with the consent of his superior officer, was placed in charge of the repair work, and of Mr. T. S. Gray, Chairman of the Levee Commission, order sprang from chaos and the apparently impossible was accomplished. Citizens volunteered to work as laborers beside negroes, who volunteered or were conscripted. The American Legion was particularly helpful in directing organizing acticities and the experience and work en masse of several large contracting firms brought about systematic work. Thousands of bags were miraculously at hand and railroad freight cars and numerous trucks hauled immense quantities of sand to the critical points. Mr. Elroy G. Smith, a local engineer, capably assisted Mr. Howard in inspection and organization work.

In six short hours, from 2 A. M. to 8 A. M. of October 2 the most dangerous places were brought into condition to withstand the flood. Thenceforth hundreds of citizens and alert engineers patrolling the entire levee from its highest point above the city to the break opened during the first flood several miles below, quickly detected any weaknesses that developed. Hundreds of workmen were at hand, with abundant materials, to conquer every threat.

BACKWATER IN OCTOBER FLOOD

Backwater from the break in the levee covered an extensive area of

farm lands, the city cemeteries, white and colored, May Park, and about 40 city blocks in the low-lying southeastern portion of Augusta, extending to Union Station and the Federal Building. The depth of the water was two feet greater than in September. On the lower farmlands it was over 15 feet deep and at lowest points in the city 8 to 10 feet deep. Aside from filling cellars of business houses and churches and creating a situation that called for a sanitary cleanup, the damage in the city was not great. On the farms there was total loss of crops, including stacked hay and stored hay and other property, while considerable numbers of cattle, mules and hogs were drowned and houses, barns, cabins and farm equipment were carried off, destroyed, or seriously damaged. Advance warnings prevented loss of human life, but the deluge of rain and resulting flooded condition of land and roads prevented the saving of property.

RIVER PREDICTIONS FOR THE LOWER SAVANNAH

It is gratifying to be able to state that it was possible during the crisis resulting from the immense accumulation of flood waters in the swamp and delta lands in the coastal plain area below Augusta, to make accurate predictions of the stages to be expected at the Seaboard Air Line bridge and Atlantic Coast Line bridges, particularly the S. A. L. bridge at Clyo. From the information thus made available the railroads were enabled to make all possible preparations, the state highway district engineers to take protective measurements along the Coastal Highway, and Maj. D. L. Weart, United States army engineer at Savannah, to direct precautionary measures in Savannah and elsewhere in the lower reaches of the river.

Data From Which Predictions Were Made Are Given Below

	Augusta	Martins		Hudson's Ferry		Clyo	
March ..	38.8'	5.9'				20.0'	
Sept. ..	46.3'	10.2'	plus 4.3' 3 days	8.0'	5 days	23.0'	plus 3.0' 5 days
Oct. ..	45.1'	12.3'	plus 6.4' 2 days	9.9'	4 days	25.4'	plus 5.4' 4 days

With difference between March and September at Martins 4.3 feet and difference between March and October 6.4 feet, and difference between March and September at Clyo 2.9 feet, it was possible in the October problem to make a simple computation, whereas the September estimate was roughly based on gage relations and assumed flatening out of water.

October: Let X equal expected rise Clyo; (given above date)
Then: 4.3' : 3.0' : 6.4' : X
and X equals 4.5', giving estimated stage Clyo 24.5'.
Sept. 30: Forecast Clyo, 23.0', Oct. 2-3 crest, 23.0'; 3rd 8 A. M.
Oct. 5 : Forecast Clyo, 24.5', Oct. 7 crest, 25.4'; 6th 8 A. M.

The river gage at Martins was installed by the South Carolina State Highway Commission during the March freshet and readings are being furnished by him on request. The gages at Clyo and at Hudson's Ferry, 17 miles above Clyo, were installed by the Seaboard Air Line railway, for temporary use, but it is understood permanent gages are to be established by the U. S. engineers, on the same datum. Little difficulty will be experienced, therefore, in making future flood predictions.

So closely did the second flood crowd upon the first that at Clyo the river, after remaining stationary for only a brief period, began its second rise. In this connection the accompanying diagram, furnished by Mr. W. D. Faucette, Chief Engineer of the Seaboard Air Line Railroad, is of interest, showing as it does the advance of the flood through the swamp country.

STORM AND FLOOD LOSSES

Railways, highways and bridges suffered so severly that no traffic moved into or out of Augusta for several days after the second flood, which completed the devastation efficiently begun by the first storm, from which only partial recovery had been possible. Conditions were considerably aggravated in many places on both sides of the Savannah River, by the breaking of the dams of practically all of the numerous fishing and bathing ponds, and of eight of the power dams in the Horse Creek Valley, in South Carolina. Fortunately the absence of heavy winds prevented the complete destruction of corn, cotton and other standing crops outside of the actual flood areas, but over hundreds of square miles of inundated area, the losses to agriculture were complete, including in many cases harvested crops, equipment and buildings. Difficulty was experienced in protecting the Coastal Highway in South Carolina, 25 miles from the normal channel of the Savannah River, while the lower Ogeechee River overflowed the same highway, in Georgia, for a distance of three miles. The loss of livestock over these flooded areas was undoubtedly very great, since the swampy nature of the country and its inaccessibility under storm conditions prevented precautionary measures.

The industrial concerns along the river opposite Augusta experienced heavy losses, the brick yards being deeply submerged and frame buildings of all sizes being wrecked and carried away. Many of the houses in Hamburg, also opposite Augusta, were carried away and the negro occupants rendered homeless for the time being.

Replacement of damaged parts of the Sand Bar Ferry highway bridge below Augusta will cost $150,000, while two spans of the City Bridge, at Fifth Street, were swept away and the Southern Railway bridge lost two massive steel spans. At the Thirteenth Street Bridge only the approach on the Carolina side was damaged and the bridge was put back into use promptly.

Losses in Augusta were due to storm damage and the effect of the backwater. Many streets in the Hill section were badly torn up, while breaks of considerable length occurred in the banks of the City Power canal.

Total damage in the city and to city property was probably about $275,000. County roads and bridges, including Sand Bar Ferry, suffered to the extent of $500,000, while the loss to the agricultural interests in this, Richmond, County has been placed at $175,000. Total damage in North Augusta and Hamburg is estimated at $200,000, while elsewhere in Aiken County storm and flood damage to public and private interests must have amounted to at least $400,000. In Columbia County, Georgia, above Augusta, agriculture suffered a loss exceeding $200,00 and roads and bridges were undoubtedly damaged in like extent. Losses in Georgia and South Carolina in counties contiguous to the Savannah River must have aggregated in the neighborhood of $5,000,000 to public, corporation and private property. This may be reasonably considered a low estimate.

Timely warnings enabled the City of Augusta to save its levee and thereby protect lives and property of unknown numbers and value. At the time the warnings were issued danger was real and imminent.

Although steps taken to prevent storm damage were on the spur of the moment, information furnished the highway departments of the two states and railroad and other officials regarding the distribution and amount of rainfall greatly assisted in the making of plans for the protection of bridges and other property from flood waters in smaller stream resulting in the saving of much property that would otherwise have been lost. Railroads were enabled to remove freight cars and other property and to ballast bridges and take other protective and precautionary measures. The Augusta office of the Weather Bureau was in constant touch with district highway engineers in both states, with the United States Engineers' office in Savannah and its representative in Augusta, and with the chief engineers of all railroads, as well as with local interests both public and private.

In the coastal plain area the saving of many lives undoubtedly resulted from the wide dissemination of warnings, but unfortunately from the swampy nature of the country, the protection and saving of private property was possible only to a limited extent.

Little more than a guess can be made as to the saving of prop as a result of flood warnings, though it may be roughly estimated about $1,000,000.

I hereby certify that this is a true and correct copy of t article that appeared in the Augusta Chronicle under the date tober 27, 1929.

H. J. Blackmon,
Locating Engineer,
S. C. State Highway De

Levee Commission Report
October 1929 Flood

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THE CITY COUNCIL
OF
AUGUSTA, GEORGIA
LEVEE COMMISSION

May 24rth, 1930.

MAY 27 1930

South Carolina State Highway Dept.,
Columbia, S. C.

Gentlemen:-

We have taken the privilege of instructing the Morgan Engineering Company of Memphis, Tenn, to send you a full copy of a survey made by them covering the flood situation at Augusta, and making suggestions for protection for the future.

We request that you examine this report closely, especially in reference to the height of bridges and approaches, and see if these suggestions in the survey will conflict in any way with your plans in connection with the bridges and approaches at Sand Bar Ferry, Fifth Street and Thirteenth Street.

We are now attempting to reach a decision fixing the height and width of the levee, and are anxious that the plans we decide upon will conform to the height of the bridges, and approaches, as these two propositions are so interlocked and affect each other to that extent that there must be no difference between our plans.

We will be glad to have any suggestions that you wish to make along these lines.

Yours very truly,

T. S. Gray

Chairman.

TSG:M

#571 Aiken

S.R. 2020/5

NOTICE OF PUBLIC HEARING

The War Department, having under consideration the application of

SOUTH CAROLINA STATE HIGHWAY DEPARTMENT,

for approval of plans for the reconstruction of the James U. Jackson Memorial Bridge (13th St. Bridge-North Augusta Bridge) across Savannah River, Georgia, at North Augusta, S. C., a public hearing will be held by the undersigned at Augusta, Ga., in the City Council Chamber of the City Hall, at 10:00 A.M., June 27, 1930.

Plans submitted by the applicant for the reconstruction of the James U. Jackson Memorial Bridge ("13th St. Bridge", "North Augusta Bridge"), include the north approach only and, beginning at the north pier of the present steel structure will consist of 3 concrete pier spans of 50 feet each, 150 feet, with a vertical clearance above the ground line of from 17 to 28 feet, and 38 pile trestle bents of 30 feet each, 1140 feet, with a general vertical clearance of about 24 feet between the ground line and the steel superstructure. The existing earth fill approach and approach spans immediately adjacent to the bridge will be removed, also a portion of the existing earth fill at the north end of the proposed trestle, to a point within 450 feet of the Georgia and Florida Railway underpass.

The plans may be seen at Room 207, Post Office Building, Savannah, Ga., or at the hearing.

All interested persons are invited to be present or to be represented at the above time and place; particularly navigation interests, land owners and the officials of any city, town, county, or local association, whose interests may be affected by the construction of the proposed bridge. They will be given an opportunity to express their views upon the suitability of the location and the adequacy of the plans in reference to navigation and flood control, and to suggest changes considered desirable in the interests of navigation and flood control.

Oral statements will be heard, but for accuracy of record, all important facts and arguments should be submitted in writing, as the records of the hearing will be forwarded for consideration by the War Department. Written statements may be handed in to the undersigned at the hearing or mailed to him beforehand.

D. L. Weart
Major, Corps of Engineers
District Engineer

JUN 21 1930

U. S. Engineer Office,
Post Office Building,
Savannah, Georgia,
June 20, 1930.

THE CITY COUNCIL
OF
AUGUSTA, GEORGIA
LEVEE COMMISSION

June 19th, 1930.

Mr. J. W. Barnwell,
Chairman, State Highway Commission,
Columbia, S. C.

Dear Mr. Barnwell:-

Major Weart has under consideration some changes suggested for the approach to the Fifth Street Bridge, these suggestions coming from the Levee Commission of Augusta to co-ordinate with their plans.

Major Weart also wants a public hearing on the method of handling the Thirteenth Street Bridge approach. He advises that he is going to call for a conference some day next week. He will communicate with you direct, naming the date of meeting.

We trust you will find it convenient to be present.

Yours very truly,

T. S. Gray

Chairman.

TSG:c

Zero of Augusta City Datum equals
(102.957) -102.6' M.S.L.
or 106.1' Pulaski

Port Augusta City St

13th St - elev. lowest member bridge - Augusta City Datum 52.5 = 155.1 M.S.L.

High level approach
clear openings 40 feet
Lowest member at or above elevation 155.1 MSL
Total area of clear opening in approach to be 27 000 sq. ft below elevation 154.6 MSL

150 / 20 / 3000

5th St - Elev. lowest member 152.6 MSL
High level approach
clear openings of spans 40 feet
Lowest member at or above 152.6 MSL

Total area of clear opening in approach 27,800 sq. feet below elevation of 152.1 MSL

Mr Barnwell 28 May

MORGAN ENGINEERING COMPANY

620-634 GOODWYN INSTITUTE BUILDING

MEMPHIS

THE MORGAN ENGINEERING COMPANIES

MEMPHIS, TENN.
DAYTON, OHIO
DALLAS, TEXAS

May 26, 1930.

South Carolina State Highway Dept.,
Columbia, S. C.

Gentlemen:-

As requested by the Levee Commission of Augusta, Ga., we are sending you, under separate cover, a copy of our report to them.

Yours very truly,

MORGAN ENGINEERING COMPANY,

By L. L. Hidinger

L. L. Hidinger.

LLH/k.

SOUTH CAROLINA
STATE HIGHWAY DEPARTMENT
OFFICE OF DIVISION ENGINEER
SOUTHEASTERN DIVISION
ORANGEBURG, S. C.

FORM 141

16 March 1929

Att. Brunswell

Savannah River

From: Southeastern Division Engineer.

To: State Highway Engineer.

For your information, I have listed below the actual elevations taken on Project 286 on 12 March, 1929. The Savannah River crested on the night of March 12 and the elevation of the top of the water near the east end of the bridge nearest Hardeeville was 8.65.

Sta.	Elevation water north side of Route #17		Elevation center-line Pavement	Elevation water south side of Route #17.	
	(1)	Diff (1+2)	(2)	(3)	Diff (1+3)
1190	8.69	1.36	10.05	7.40	1.29
1200	8.71	1.37	10.08	7.38	1.33
1210	8.71	1.05	9.76	9.41	.9
1220	8.54	1.33	9.87	7.55	.99
1230	8.53	1.26	9.79	7.51	1.02
1240	8.36	2.12	10.48	7.60	.76
1250	8.55	1.22	9.77	7.53	1.02
1260	8.59	1.09	9.68	7.57	1.02
1270	8.34	1.29	9.63	7.43	.91
1280	8.30	1.23	9.53	7.45	.85
1290	8.44	1.17	9.61	7.39	1.05
1300	8.43	1.75	10.18	Island	
1310	8.26	1.36	9.62	7.11	1.15
1320	8.17	.93	9.10	7.17	1.00
1330	7.90	1.42	9.32	7.34	.56

L. W. Pollard.

Levee Commission Report
October 1929 Flood

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File 522

Aiken Co

REPORT

TO

LEVEE COMMISSION

AUGUSTA, GA.

- - -

MORGAN ENGINEERING COMPANY

MAY 1930

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MORGAN ENGINEERING COMPANY
622-631 GOODWYN INSTITUTE BLDG.
MEMPHIS

THE MORGAN ENGINEERING COMPANIES
MEMPHIS, TENN.
DAYTON, OHIO
DALLAS, TEXAS

May 15, 1930

Levee Commission,
City of Augusta,
Augusta, Georgia.

Gentlemen:

We have completed our study of floods in the Savannah River and this is a report of our findings. This Report deals only with the flood problem as it affects the City of Augusta. However, in order to do so effectively, it has been necessary, among other things, for us to (a) Study past floods of the Savannah River in connection with the rainfall producing them; (b) Compile and analyze heavy rain storms in the southeastern states to ascertain whether heavier storms have occurred nearby; (c) Determine the discharge of the flood of 1929; (d) Make a prediction of the magnitude of the largest flood that may reasonably be expected at Augusta; (e) Decide upon a flow line for such flood as the city should be protected against.

This Report does not attempt to outline a plan for the protection of the City of Augusta against floods. Plans therefor can not be designed nor even undertaken until complete surveys have been made.

CONCLUSIONS

For your convenience, we are setting out, at this time, the conclusions we have reached.

1 - That it is reasonable to expect a flood discharge in the Savannah River at Augusta of 600,000 cubic feet per second and that the flood protection works for the City of Augusta should be designed to protect against a flood of that magnitude.

2 - That the 13th Street Bridge be raised so that the clearance of the lower chord will be not lower than elevation 55.5 Augusta City Datum and that a low level approach be left on the South Carolina side with a clear opening of 22,000 square feet below Elevation 55.5, or, if a high level approach be built, that the spans be not less than 40 feet in length, with a clearance elevation of 55.5.

3 - That the Southern Railway bridge be raised so that the clearance of the lower chord will be not lower than elevation 53.0, Augusta City datum and that the approach on the South Carolina side have a clear opening of 40,000 square feet below Elevation 53.0, in which the spans are not less than 40 feet in length and with a clearance elevation of 53.0.

4 - That the 5th Street Bridge be raised so that the clearance of the lower chord will be not lower than Elevation 52.5, Augusta City datum, and that the approach

on the South Carolina side have a clear opening of 30,000 square feet below Elevation 52.5, in which the spans are not less than 40 feet in length and have a clearance elevation of 52.5.

5 - That the river spans of the Sand Bar Ferry Bridge may remain at the present elevation but that the approach on the Georgia side have a clear opening of not less than 70,000 square feet below Elevation 42.5, in which the spans are not less than 40 feet in length and have a clearance elevation of 42.0, or that it be constructed in accordance with a joint design of the Carolina State Highway Department and the State Highway Board of Georgia, under date of January 16, 1930, as revised February 1, 1930.

6 - That the C. & W. C. Railroad Bridge be raised so that the clearance of the lower chord be not lower than Elevation 41.5, Augusta City Datum, and that the railroad embankment on the Georgia side be removed to a point 750 feet from the levee. The part from which the embankment is removed, as well as all existing trestle, is to be replaced by spans not less than 40 feet in length, with a clearance elevation of 41.5.

7 - That the flow line of a flood discharging 600,000 cubic feet per second, with the bridges adjusted as hereinabove specified, will reach the line shown on the profile, Exhibit No. 5.

8 - That should the C. & W. C. Railroad Bridge

remain in its present condition and the Sand Bar Ferry Bridge be reconstructed in accordance with the joint agreement between the South Carolina State Highway Department and the State Highway Board of Georgia, as of January 16, 1930, revised February 1, 1930, and also the 5th Street Bridge, be reconstructed in accordance with plans of the State Highway Board of Georgia under date of February 7, 1930, the flow line will be raised at the C. & W. C. Railroad Bridge approximately five-tenths of a foot and remain about that much above the 600,000 cubic feet per second flow line shown on the profile on upstream.

8 - That if it is economically feasible, the levee should be reconstructed to an elevation three feet above the flow line for the 600,000 cubic feet per second flood. No effort has been made to design the cross section nor ascertain the location, nor estimate the cost for the reconstruction of the levee, because of insufficient data. Such matters can not be given mature consideration until the preparation of the official plan is undertaken, which, in turn, must follow detailed surveys.

SAVANNAH RIVER DRAINAGE BASIN

The drainage basin of the Savannah River lies in North Carolina, South Carolina, and Georgia. The upper end of the basin lies along the crest of the Blue Ridge Range of mountains in Jackson and Transylvania Counties, North Carolina. The main axis runs from north-

west to southeast and terminates at the Atlantic Ocean, a few miles below Savannah, Georgia. The basin is about 260 miles long, 90 miles in maximum width, and contains about 11,000 square miles. The upper 7300 square miles lie in the mountains or the foothills thereof, and the remainder in the coastal plain. The elevation of the head waters is between 4,000 and 5,000 feet above sea level and the fall of the valley is very rapid until the Piedmont Plateau is reached, after which the fall decreases but still is sufficient to cause high velocities in the river. The river is properly classified as a mountainous stream above Augusta, with rapid fall and rocky bed. Below Augusta it should be classified as an alluvial stream with a crooked channel winding about through a gently sloping flood plain.

Various names are given to the streams at the upper end of the watershed and the river is not designated as the "Savannah" until, at the junction of the Tugaloo and the Seneca Rivers, between Anderson County, South Carolina, and Hart County, Georgia. The more important branches below this point are Broad and Little Rivers from the Georgia side, and Little River and Stevens Creek from the South Carolina side.

SAVANNAH RIVER FLOODS

Flood records have been kept for many years at Augusta and a list thereof has been compiled by the U. S. Engineer Corps office at Savannah, and is accepted by us as the best available data for all floods prior to 1929.

Table No. 1

Augusta, Georgia
Flood Heights and Discharges in Savannah River
(Compiled by Savannah Office, U. S. Engineer Corps)

Date	Gage Heights	Discharge in c. f. s
1796	40	360,000
1840	37.8	270,000
1852	37.4	255,000
1865	36.9	240,000
1877	29.8	106,000
1879	30.1	110,000
1881	30.5	113,000
1881	32.1	133,000
1883	29.9	107,000
1886	29.7	105,000
1886	32.1	133,000
1886	32.4	138,000
1887	34.6	176,000
1887	34.3	170,000
1887	32.6	140,000
1888	38.7	300,000
1889	32.9	146,000
1891	35.5	200,000
1892	32.8	144,000
1895	30.2	111,000
1895	30.1	110,000
1896	30.2	110,000
1897	28.5	95,000
1898	28.4	94,000
1899	31.0	120,000
1900	32.31	135,000
1901	30.9	118,000
1902	33.8	160,000
1903	33.0	146,000
1904	24.5	65,000
1905	27.6	87,000
1906	29.3	102,000
1907	28.3	93,000

Date	Gage Heights	Discharge in c.f.s.
1908	38.8	300,000
1909	28.3	92,000
1911	31.4	124,000
1912	36.1	190,000
1913	34.8	168,000
1915	28.8	98,000
1916	30.3	112,000
1917	28.9	99,000
1918	34.9	170,000
1919	34.5	164,000
1920	31.3	123,000
1921	34.4	163,000
1922	31.8	128,000
1927	36.5	151,000
1928	40.4	226,000
1929-March	38.8	193,000
1929-September	46.3	370,000* 343,000 } U.S.G.
1929-October	45.1	383,000+ 350,000 }

* Our computation for this flood is 350,000.
\+ Our computation for this flood is 360,000.

THE FLOOD PROBLEM AT AUGUSTA

The business section of the City of Augusta, as well as part of the residential district, lies in the flood plain of the Savannah River at the head of the alluvial section thereof. Prior to the construction of the present levee, the city was overflowed at frequent intervals. The most destructive flood, although perhaps not the largest, occurred in 1908. The reason this flood was more destructive than any other was because the city was much larger than when former large floods occurred and the property values and population greater.

In 1912 plans were made for the construction of the present levee and during the following few years, the levee and appurtenant structures were

constructed. The flood studies made at the time these plans were prepared contemplated that the maximum flood that would occur would be approximately 400,000 cubic feet per second and the levee was planned to protect against a flood of that size. The location of the levee is shown on the map, Exhibit No. 1. This levee was considered to be adequate to protect the city until the floods of September and October, 1929, at which time the levee broke in two places below the city and it is reported was artificially breached at another place to let the water out of the lower end of the leveed area. Also, several slides occurred along the river side of the upper end of the levee in front of the city.

The crest of the first flood of 1929 passed Augusta September 27, and the second October 2nd. Between these crests the river had fallen to 24.0 feet on the Augusta City gage. The first flood reached a stage of 46.3 feet on the gage, with a discharge of 350,000 cubic feet per second. The second flood reached a stage of 45.1 feet on the gage, with a discharge of 360,000 cubic feet per second. It will be noted that the second flood, with a larger discharge, did not reach as high a stage as the first one. This is due to the fact that a number of obstructions in the valley had been swept out so that the greater discharge was carried at a lower level.

The floods of 1929 are the largest that have been recorded with any reasonable accuracy. The

a slightly smaller discharge at Augusta than the October storm, had a considerably larger rainfall. The maximum report for any one station on the watershed above Augusta during the September storm, was 14.49 inches also at Washington, Ga. This storm also is recorded as a two day storm.

Of the 211 storms studied, 27 had a rainfall greater than 14 inches in three days at any one station and 15 of them had a rainfall greater than 14 inches in two days at any one station. The center of the September storm was located below Augusta, and that of the October storm was located to the northeast. The maximum rainfall during the September storm was recorded at Brooklet, Ga. and amounted to 16.81 inches for two days. The maximum rainfall during the October storm was recorded at Saluda, S. C. and amounted to 10.51 inches for two days. It is thus seen that there are many storms larger than those which occurred over the Savannah River drainage area above Augusta during the two storms of 1929. As a matter of fact these two identical storms were much larger at some distance from that part of the Savannah River drainage area under consideration than they were over it.

Out of the 211 storms studied, we have selected nine for special examination, including the two that occurred over the Savannah River watershed in 1929. While they are smaller than the other seven, they have been selected for the purpose of comparison. If any one of these seven storms had

occurred over the watershed of the Savannah River above Augusta, they would have produced a much greater run-off than that which occurred following either the September or October storms of 1929. The location of the nine storms is shown on the map, Exhibit No. 2.

In order to assist in the study of these nine rain storms, we have prepared charts thereof and have drawn lines of equal rainfall (known as isohyetal lines) with a rainfall interval of two inches. On these charts we have superimposed the area of the watershed of the Savannah River above Augusta and have computed the average rainfall over an area of this size. These charts are included with this report as Exhibit Nos. 3 and 4.

In the following Table No. 2 is shown the nine storms referred to with the rainfall listed for the first two days and also for the first three days of each storm. The total rainfall for the storms of September and October 1929 is shown even though the heaviest part of these storms was not over the watershed of the Savannah River above Augusta. In the same table, the rainfall for the September and October storms, that actually did occur on the watershed of the Savannah River above Augusta, is given.

Table No. 2

List of Seven Maximum Storms in the Southeastern United States

Year	Month	Days	State	Peak Sta.	Average 2 Day Rain-Fall On Area of 7300 Sq.Mi.	Average 3 Day Rain-Fall On Area of 7300 Sq.Mi.
1899	June) July)	27 1	Texas	Turnersville	12.0	16.6
1915	Aug.	17-20	Texas	Rockland	11.5	17.3
1916	July	6-10	Ga.	Blakeley	10.9	12.8
1916	July	14-16	N.C.	Altapass	11.8	12.0
1921	Sept.	8-10	Texas	Taylor	12.0	12.9
1924	Oct.	18-20	Fla.	Jupiter	11.4	13.9
1929	March	13-15	Ga.	Elba	14.1	16.7
				Maximum Augusta Storms		
1929	Sept.	25-27	Ga.	Brooklet	10.6	10.8
1929	Sept.) Oct.)	30 1-2				
				Actual Average Over Watershed Above Augusta		
1929	Sept.	25-27	Ga.	Brooklet	7.8	8.7
* 1929	Sept.) Oct.)	30 1-2	S.C.	Saluda	6.7	6.8

* This storm produced run-off of 360,00 second feet, which is maximum of record at Augusta.

RAINFALL THAT MAY BE EXPECTED IN THE FUTURE

From the rainfall study outlined above, it is evident that much larger storms than those of 1929 may be expected over the Savannah River watershed in the future. Just how large a storm may some time occur is difficult to foretell. However, there are some deductions that can be made with a high degree of probability. For instance, the three largest storms in Table No. 2, which were 16 inches or over, fell near the coast and it seems logical to assume that storms of this intensity will not reach as far inland as the Savannah River watershed above Augusta. However, there are several storms with a rainfall of 12 inches or more in three days that fell as far or farther inland than Augusta and it may reasonably be expected that storms of that magnitude will some time occur over the Savannah River watershed above Augusta. In our opinion, protection should be provided against such storms.

RAINFALL CAUSING FLOODS OF 1929

Two heavy rain storms occurred on the Savannah River watershed in the Fall of 1929. (See Exhibit No. 4, Figures 1 and 2). The first occurred on September 26 and 27 and covered a period of about 34 hours. The following table (No. 3) gives a list of rainfall stations and the amount of rain that fell at each, prepared by Mr. E. D. Emigh, Weather Forecaster at Augusta.

Table No. 3

Rainfall - Storm September 26 - 27, 1929

	Total about 34 hours
Augusta, Ga.	7.78
Double Branches, Ga.	14.51
Edgefield, South Carolina	7.84
Warrenton, Ga.	9.16
Greenwood, S. C.	9.83
Washington, Ga.	14.49
Calhoun Falls, S. C.	9.48
Carlton, Ga.	7.67
Gillsville, Ga.	5.95
Anderson, S. C.	5.50
Toccoa, Ga.	5.03
Average	8.84

The second storm occurred on October 1 and 2 and covered a period of approximately 30 hours.

The following Table No. 4 is taken from a statement compiled by Mr. Emigh.

Table No. 4

Rainfall - Storm October 1 - 2, 1929

Augusta, Ga.	9.98
Double Branches, Ga.	9.40
Edgefield, S. C.	8.26
Warrenton, Ga.	6.75
Greenwood, S. C.	9.02
Washington, Ga.	9.68
Calhoun Falls, S. C.	8.30
Carlton, Ga.	7.12
Gillsville, Ga.	8.15
Anderson, S. C.	5.83
Toccoa, Ga.	4.38
Average	7.84

These are the two largest storms that have occurred over the Savannah River Drainage Basin since U. S. Weather Bureau records have been kept. The discharge of

the river was somewhat larger from the second storm than from the first, although the rainfall was lighter. This is accounted for by the fact that the second storm followed the first so closely that the ground was still saturated, and the river valley still partly covered with water from the first flood.

RUN-OFF FROM 1929 STORMS

The discharge of the floods of 1929, together with the flow lines thereof, provide the best data on which to predicate the flow line of floods of greater magnitude. The flow lines were obtained by field surveys soon after the floods. The best method of ascertaining the discharge of these floods is to calculate the quantity of water passing the Stevens Creek power dam. This dam is located on the Savannah River about seven miles above Augusta. It is a concrete structure with a spillway 2008 feet long. On one-half of the spillway temporary flashboards have been installed that float out at high stages. On the other half of the spillway, collapsible flashboards have been installed that assume a horizontal position at high stages but that cause a disturbance in the flow of water so that it is somewhat difficult to calculate the discharge over this section of the spillway.

Taking into account the conditions that exist, our calculations indicate that the discharge for the September flood was 350,000 cubic feet per second and for the October flood 360,000 cubic feet per second. These

discharges include the flow of water through the turbines and sluiceways. These discharges are less than have been estimated by several engineers but conform closely with those obtained by Mr. J. E. Parker of the Southeastern Engineering Company, Engineers for the Stevens Creek Power Dam and who undoubtedly have the best information obtainable.

COMPARISON OF RAINFALL AND RUN-OFF

The storm of September 25 to 27, with a rainfall of 7.8 inches in two days and 8.7inches in three days over the Savannah River watershed above Augusta, which crested at Augusta September 27, produced a run-off of 350,000 cubic feet per second. The storm of September and October, 1929, with a rainfall of 6.7 inches in two days and 6.8 inches in three days over the Savannah River watershed above Augusta and which crested at Augusta October 2, produced a run-off of 360,000 cubic feet per second.

It has been shown hereinbefore that storms producing a rainfall of 11½ to 13 inches may reasonably be expected over this watershed; in other words, that a rainfall approximately 60 percent in excess of that occurring in the storms of 1929 may be expected. Should the run-off be increased in the same proportion, such storms would produce a flood of approximately 600,000 cubic feet per second.

COMPARISON WITH OBSERVED RUN-OFF ON OTHER RIVERS

For many years engineers have measured the run-off from rivers with watersheds of varying size, and a compilation of the data secured has been made from time to time. From such compilations we have selected records of high run-off from watersheds comparable with that of the Savannah River above Augusta, which are given below in Table No. 5.

Table No. 5

Maximum Flood Discharges in the United States

Name of River	Date	Drainage Area Square Mile	Discharge In Second Feet Per Square Mile
Savannah, Ga.	Oct. 1929	7,300	49.5
Savannah, Ga.	1884	7,300	41
Little River, Texas.	Sept.1921	7,010	92.3
Miami, Ohio	Mar. 1913	2,450	100
American, Calif.	Jan. 1862	1,900	99.5
Canadian, N.M.	Oct. 1909	1,480	105
Changres, Panama		1,320	93.9
Yuba, Calif.	Jan. 1909	1,200	92.5
Scioto, Ohio	Mar. 1913	1,500	92.

From this table it can be seen that the higher rates of run-off are usually from drainage areas smaller than that of the Savannah River above Augusta. However, there is one record on the Little River in Texas of approximately the same drainage area, where a measured

run-off of 92.3 cubic feet per second per square mile was observed. This same rate of run-off on the area above Augusta would have produced a flood of 675,000 cubic feet per second. The area of the Little River watershed in Texas is only slightly nearer to the coast than the Augusta watershed. A similar rate of run-off at Augusta would seem to be well within the range of possibility.

Many hundreds of these run-off records have been platted on logarithmic paper and curves have been drawn, based on Meyer's formula for maximum floods, which take into consideration the size of the watershed and the expected frequency of flood discharge. This graph was published in the Transactions of the American Society of Civil Engineers, 1926, Page 1003. On this graph the 1929 flood at Augusta falls on a line passing through approximately 20 other records, showing that storms of this intensity are not at all infrequent.

The curve for the maximum observed flood indicates a run-off of 120 cubic feet per second per square mile, or 880,000 cubic feet per second for a drainage area the same size as the drainage area of the Savannah River above Augusta. This would obviously be a very rare flood and only two or three floods that have ever been observed fall on this line. Somewhere half way between the maximum ever observed and floods that occur fairly frequently would seem to be the

logical flood to anticipate. This would point to a discharge of approximately 600,000 second feet.

COMPARISON WITH OTHER FLOOD CONTROL DESIGN

In providing flood protection for various projects and also in providing spillway capacity for large dams, engineers have made intensive studies of probable flood run-off. The design selected is frequently expressed in terms of percent greater than the maximum known flood. A compilation of such designs are listed in Table No. 6.

Table No. 6

Run-off Provided in Dams and Flood Protection Projects in the United States

Project	Drainage Area	Maximum Known Run-off in Feet Per Square Mile	Run-off Designed for Second Feet Per Square Mile	Percent In excess of Maximum Flood
Pittsburgh	18,600	23	34	45
Miami	2,450	100	140	40
Trinity	6,000	42	83	100
Scioto	1,500	92	132	45
Pueblo	1,740	61	100	65
Stevens Dam	7,300	41	62	50

It can be seen that of the designs listed above, the lowest factor of safety is 40 per cent and the highest is 100 per cent. The Engineer's judgment in each case has been tempered by his opinion as to whether the

maximum known flood was a reasonably large flood or not. For instance, in the Miami Conservancy District, it was the Engineer's opinion that the maximum known flood was extremely high whereas, on the Trinity River, it was known from rainfall records that the maximum known flood was well below what might reasonably be expected. It appears that the flood of 1929 at Augusta was a fairly large flood and that a factor of safety of about 65 per cent constitutes a reasonable safeguard. A flood 65 per cent in excess of 1929 flood would produce a run-off of about 600,000 second feet.

SELECTED FLOOD

The three methods of analysis outlined above, namely, that of the expected rainfall, that of comparing with known run-offs and that of comparing with the design of other projects, all appear to point to very nearly the same conclusion; that is, that a flood of 600,000 cubic feet per second may reasonably be expected. We conclude, therefore, that any plan for protection at Augusta should be designed for a flood of 600,000 cubic feet per second.

METHODS OF FLOOD PROTECTION

An investigation of methods of flood protection for Augusta has been made and the conclusion reached that protection by means of a levee is the only practicable method. Any analysis of this matter should

properly come in the Report made at the time the official plan is prepared.

DETERMINATION OF FLOOD FLOW LINES

Having ascertained the flood discharge that may be expected at Augusta, it becomes necessary to determine the height at which this flood of 600,000 cubic feet per second would flow through the River and its Flood plain past Augusta.

In order to make this determination, it was necessary to have certain data with regard to the cross-section of the channel and floodway, the conditions at the five bridges and the heights reached by the 1929 flood. These data had all been assembled by the U. S. Engineer Corps Office at Savannah and were turned over to us for use in making this report. We have accepted them as correct, with the exception of a few minor changes which we have made in the flood profile of the 1929 flood, which were considered desirable in order to reconcile this profile with information obtained by Mr. Wise, Engineer of Augusta. The City Engineer had readings of the flood heights taken during the actual flood, whereas the Government Engineers made their profile from high water marks obtained some time later. On that account, some slight adjustment was made.

Inasmuch as the high water marks from the

first flood were higher than those of the second flood and would therefore be more distinct and accurate and also because the marks obtained by the City Engineer's staff were for the first flood, and these data are considered to be more dependable and have been used.

Using a discharge of 350,000 cubic feet per second, as determined for the first flood and the high water profile of that flood, we have computed the co-efficient of friction for short reaches of the channel and floodway by the use of Kutter's formula. These co-efficients, which are the value of "n" in Kutter's formula, proved to be about .040 for the channel and .080 to .090 for the floodway. As these co-efficients are in reasonable conformity with general experience for the proper co-efficients to use for this type of channel and floodway, they have been used as a basis for computing the flow line for larger floods.

Using these co-efficients, a flow line has been computed for a flood of 600,000 cubic feet per second, giving consideration to the conditions prevailing at each of the five bridges. After a detailed study had been made, it was decided that certain changes should be required at all of the bridges and that should these requirements be complied with, that the flow line for a 600,000 cubic feet per second flood would conform to the line for such a flood, shown on the profile, Exhibit No. 5.

ADJUSTMENT OF BRIDGES

There are five bridges across the Savannah River and floodway between the upper and lower end of the Augusta levee. Some adjustment is necessary at all of these bridges, if interference with large flood flows is to be kept at a minimum. It is inevitable that some interference will occur even if the bridges are raised and the approaches properly reconstructed.

In order that there may be as little interference as possible, the following adjustments should be made:

1 - The 13th Street Bridge should be raised so that the clearance of the lower chord will not be lower than elevation 55.5 Augusta City datum and a low level approach left on the South Carolina side with a clear opening of 22,000 square feet below Elevation 55.5, or, if a high level approach be built, the spans should be not less than 40 feet in length, with a clearance elevation of 55.5.

2 - The Southern Railway bridge should be raised so that the clearance of the lower chord will be not lower than elevation 53.0, Augusta City datum and the approach on the South Carolina side should have a clear opening of 40,000 square feet below Elevation 53.0, in which the spans are not less than 40 feet in length with a clearance elevation of 53.0.

3 - The Fifth Street bridge should be raised so that the clearance of the lower chord will be not lower

than Elevation 52.5, Augusta City datum, and the approach on the South Carolina side should have a clear opening of 30,000 square feet below Elevation 52.5, in which the spans are not less than 40 feet in length and have a clearance elevation of 52.5.

4 - The river spans of the Sand Bar Ferry Bridge may remain at the present elevation but the approach on the Georgia side should have a clear opening of not less than 70,000 square feet below Elevation 42.5, in which the spans are not less than 40 feet in length and have a clearance elevation of 42.5, or be constructed in accordance with a joint design of the Carolina State Highway Department and the State Highway Board of Georgia, under date of January 16, 1930, as revised February 1, 1930.

5 - The C. & W. C. Railroad bridge should be raised so that the clearance of the lower chord will be not lower than Elevation 41.5, Augusta City datum. Also all of the railroad embankment on the Georgia side, except 750 feet adjacent to the levee, should be removed, and the space now occupied thereby, together with all existing trestle, should be replaced with spans not less than 40 feet in length and with a clearance elevation of 41.5.

The following Table No. 7, gives pertinent data in connection with the bridges in condensed form.

to Engineers to know that this rating curve is a straight line when platted on logarithmic paper.

LEVEE HEIGHTS

No attempt has been made in this Report to fix definitely the height to which the levee should be built. That is an economic consideration which depends largely on costs that can be determined only after a complete survey has been made. If economically possible, the levee should be built to a height three feet or more above the flow line that is given for a flood of 600,000 cubic feet per second.

ACKNOWLEDGMENTS

It is desired to acknowledge the hearty co-operation of the following organizations and individuals:

Major D. L. Weart and his staff in the Savannah Office of the U. S. Engineer Corp, in furnishing data collected in connection with a survey of the Savannah River.

Mr. J. E. Parker, of the Southeastern Engineering Company, for data concerning discharge and conditions at the Stevens Creek dam, current meter measurements and other data.

Mr. E. D. Emigh for rainfall records, method of predicting floods and other data.

Mr. W. H. Wise, City Engineer of Augusta, for profile of the levee, high water marks of the 1929 flood, and other data.

EXHIBITS

All of the exhibits referred to in this Report, together with a title sheet thereof are appended hereto.

If there is any part of this Report that is not clear to you, we will be glad to answer any questions that may occur to any of the members of your Commission.

Respectfully submitted,

MORGAN ENGINEERING COMPANY,
By L. L. Hidinger.
L. L. Hidinger.

LLH/k.

LIST OF EXHIBITS

1- Sketch Map of the Augusta Levee and adjacent territory.

2 - Location Map of Maximum Storms.

3 - Charts of seven maximum storms in Southeastern United States (Figures 1 to 7).

4 - Charts of two storms at Augusta, 1925. (Figures 1 & 2).

5 - Profile of the levee and flood flow lines.

6 - Rating curve of Savannah River at Augusta.

flood of 1796 may have been as large but information is too meagre to ascertain definitely whether such is the case.

EXCESSIVE RAINFALL IN THE SOUTHEASTERN STATES

It is a well known fact that storms that originate in the Caribbean Sea pass north or northwesterly through the Gulf of Mexico and cause heavy precipitation in the southeastern states from Texas to South Carolina. The two rainstorms over the Savannah River watershed in 1929 were of this character. We see no reason why other heavy storms that have swept inland from the Gulf should not some time follow this same path, and with that thought in mind, have compiled all storms in this region having a greater maximum intensity at any station than 5 inches in 24 hours or 9 inches in 48 hours.

The records of the U. S. Weather Bureau show that 211 storms of this intensity or greater have occurred in this region since records have been kept. Of the 211 storms listed, 113 had an intensity for one station of 9 inches or more for three days. Approximately 70 of them had an intensity of 9 inches or more for a single station in two days. The storm of October 1 and 2, 1929, over the Savannah River watershed, which produced the largest flood discharge at Augusta, had a maximum rainfall for one station over the watershed above Augusta of 9.68 inches. This occurred at Washington, just above Augusta, and was recorded as a two day storm. The storm of September 27 and 28, with

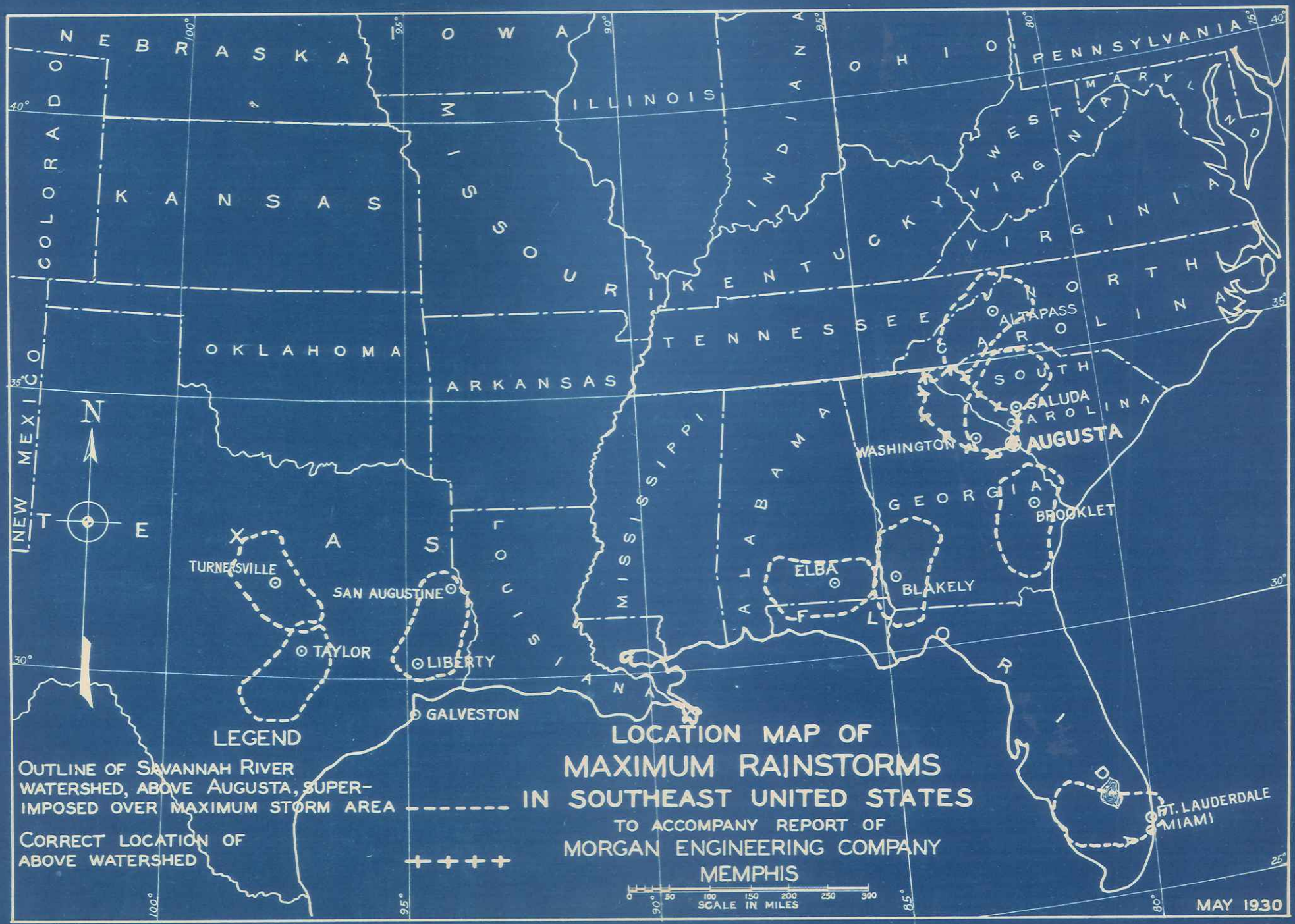
Table No. 7

List of Bridges

Location	Recommended Height of Lowest Steel	Recommended Free Flow Area Through Or Over Approach
13th Street	55.5	22,000
Southern Railway	53.0	40,000
5th Street	52.5	30,000
Sand Bar Ferry	42.5	70,000
C. & W. C. R. R.	41.5	90,000

RATING CURVE

Accompanying this Report is a rating curve showing the discharge of the river that may be expected for readings on the Fifth Street gage for stages above 22 feet, Exhibit No. 6. That part of this rating curve between 22 and 30 feet on the gage is well determined by information from various sources. Between 30 feet and 43 feet several measurements were made in October, 1929, by the Southeastern Engineering Company on declining stages of the second flood. From our own calculations and the known gage heights for the crest of the flood, we have determined the location of the upper end of the curve. The curve is based on the assumption that the bridges will be raised and adjusted in accordance with our recommendations. Should this not be done, the discharges taken from the curve will, for any given gage reading, be decreased somewhat. It will be of interest



LEGEND

OUTLINE OF SAVANNAH RIVER WATERSHED, ABOVE AUGUSTA, SUPERIMPOSED OVER MAXIMUM STORM AREA ------

CORRECT LOCATION OF ABOVE WATERSHED ++++

LOCATION MAP OF MAXIMUM RAINSTORMS IN SOUTHEAST UNITED STATES

TO ACCOMPANY REPORT OF

MORGAN ENGINEERING COMPANY

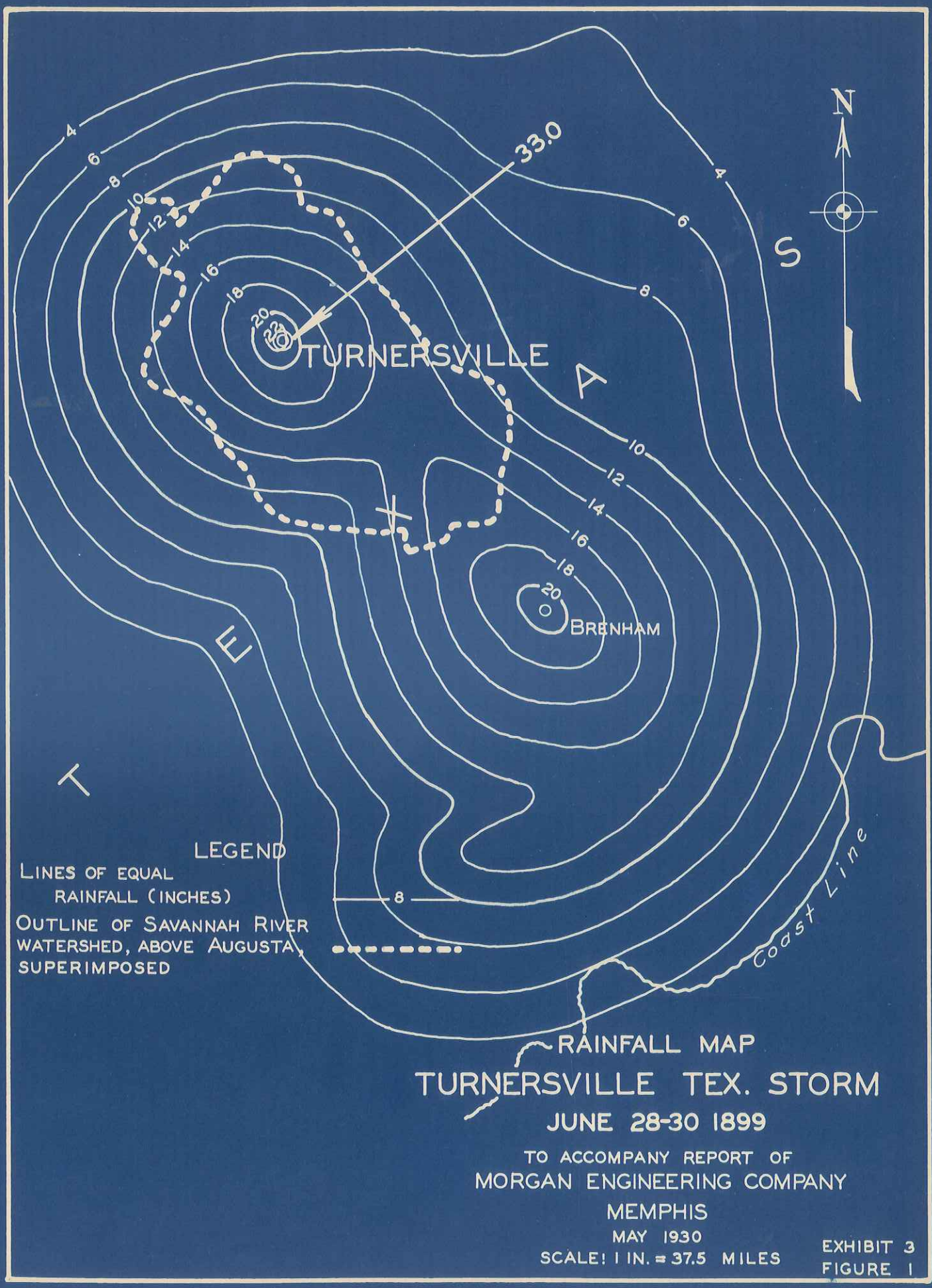
MEMPHIS

SCALE IN MILES 0 50 100 150 200 250 300

MAY 1930

111.02

EXHIBIT 2

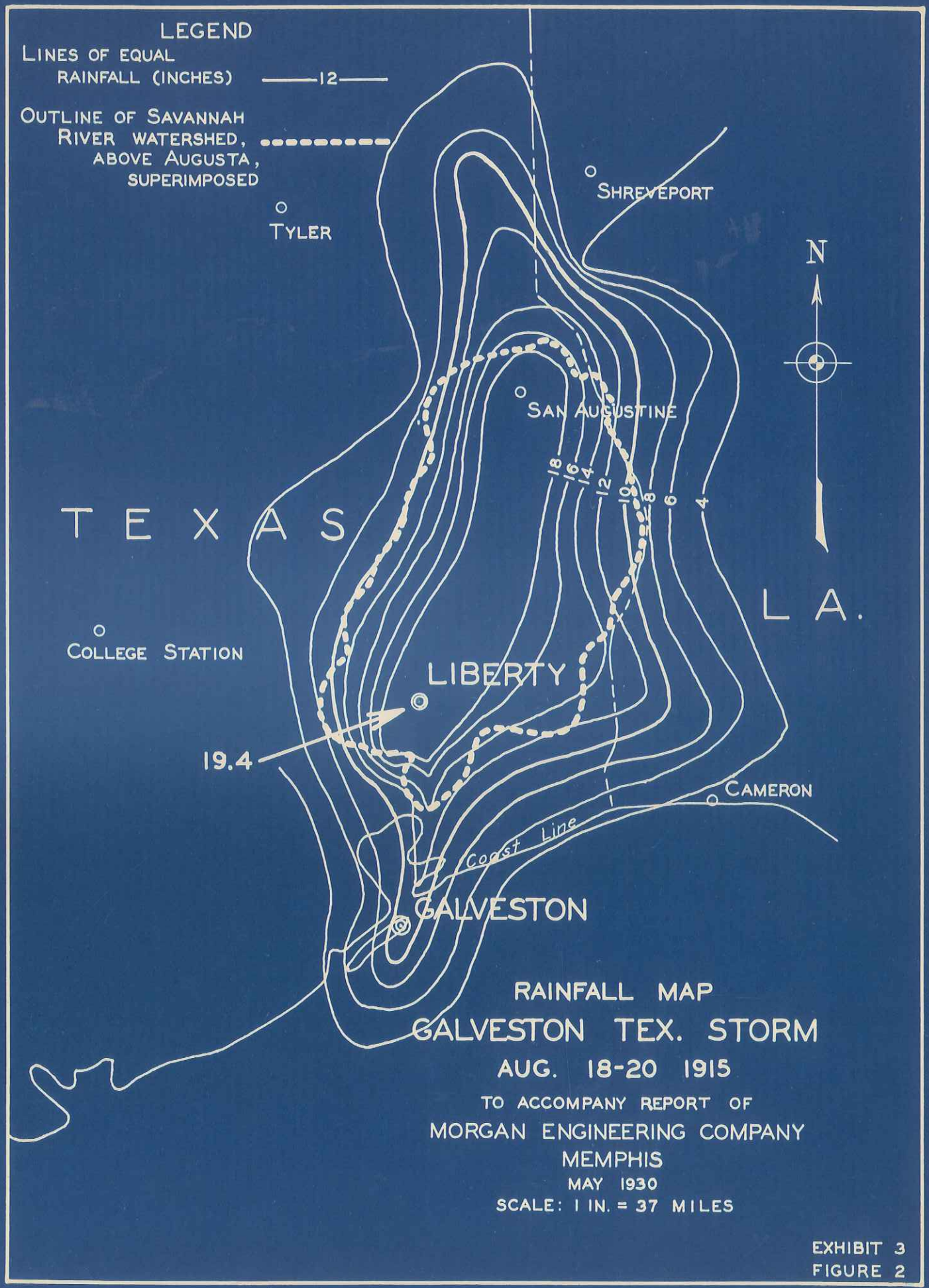


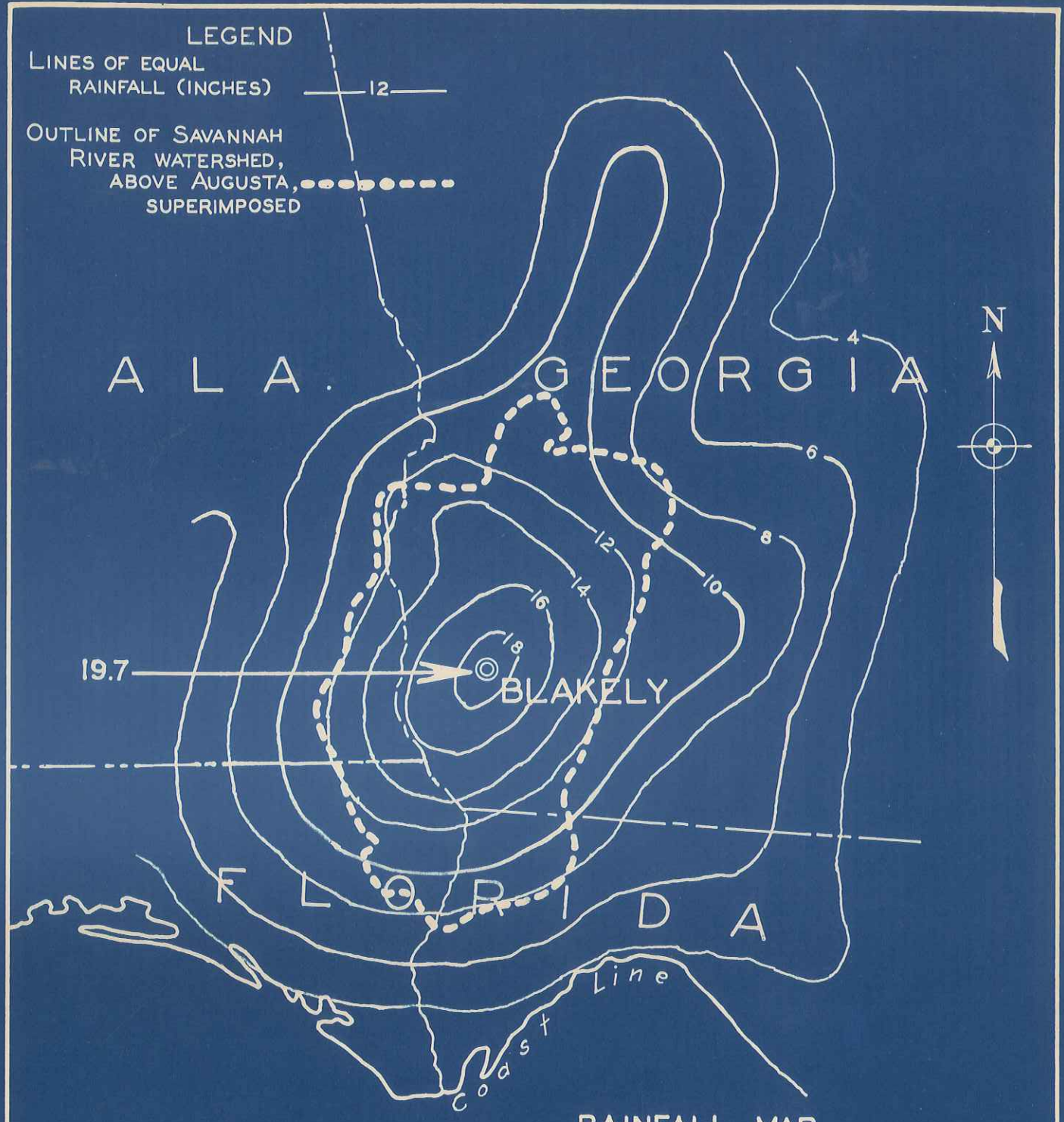
RAINFALL MAP
TURNERSVILLE TEX. STORM
JUNE 28-30 1899

TO ACCOMPANY REPORT OF
MORGAN ENGINEERING COMPANY
MEMPHIS
MAY 1930
SCALE: 1 IN. = 37.5 MILES

EXHIBIT 3
FIGURE 1

111.08


LEGEND
LINES OF EQUAL RAINFALL (INCHES) —12—
OUTLINE OF SAVANNAH RIVER WATERSHED, ABOVE AUGUSTA, SUPERIMPOSED
TYLER
SHREVEPORT
N
SAN AUGUSTINE
18
16
14
12
10
8
6
4
TEXAS
LA.
COLLEGE STATION
LIBERTY
19.4
CAMERON
Coast Line
GALVESTON
RAINFALL MAP
GALVESTON TEX. STORM
AUG. 18-20 1915
TO ACCOMPANY REPORT OF
MORGAN ENGINEERING COMPANY
MEMPHIS
MAY 1930
SCALE: 1 IN. = 37 MILES
EXHIBIT 3
FIGURE 2

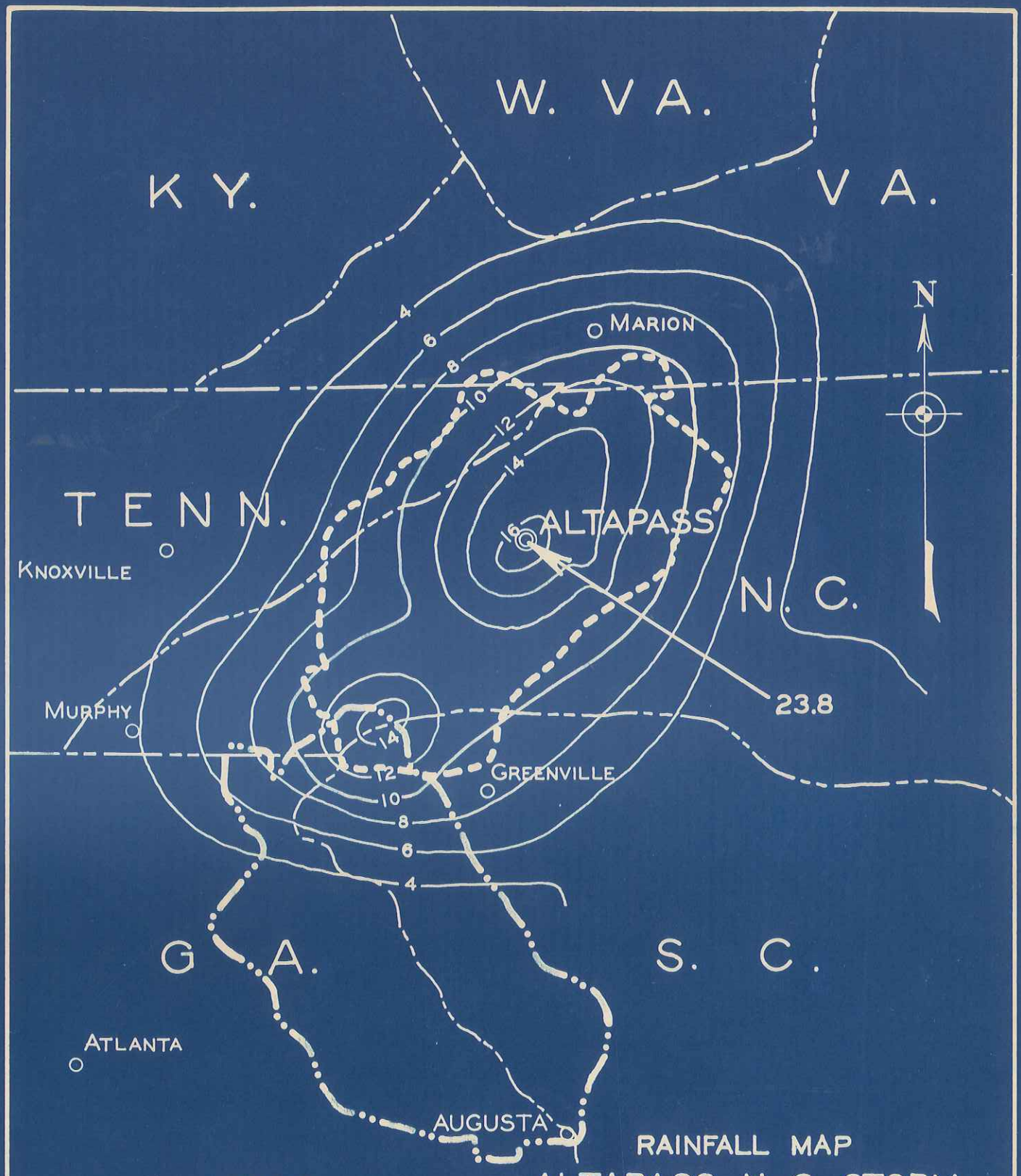


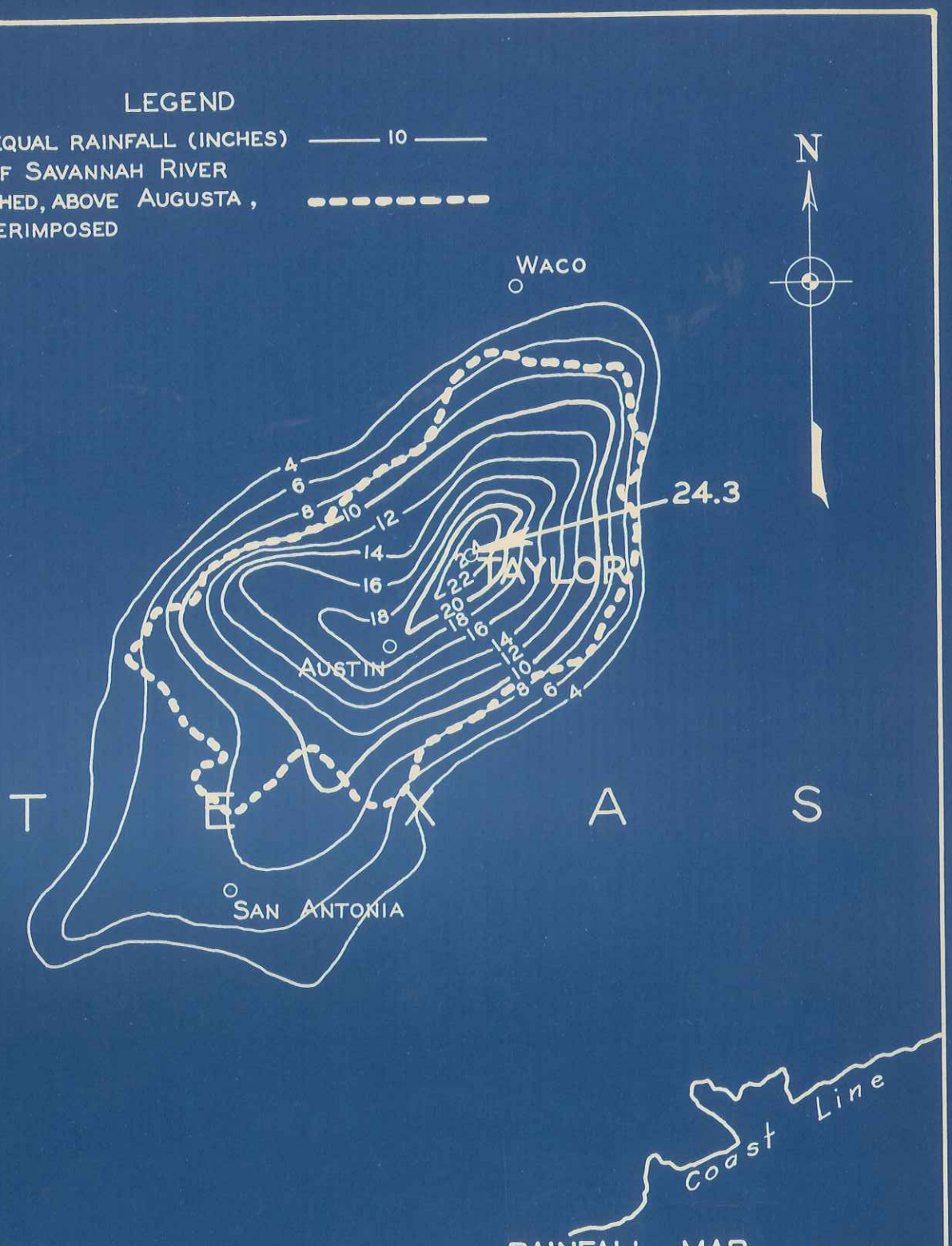
RAINFALL MAP
BLAKELY GEORGIA STORM
JULY 7-9 1916

TO ACCOMPANY REPORT OF
MORGAN ENGINEERING COMPANY
MEMPHIS
MAY 1930

SCALE: 1 IN = 37.5 MILES

EXHIBIT 3
FIGURE 3


W. VA.
KY.
VA.
TENN.
N. C.
G A.
S. C.
MARION
ALTAPASS
KNOXVILLE
MURPHY
GREENVILLE
ATLANTA
AUGUSTA
23.8
N
4
6
8
10
12
14
LEGEND
LINES OF EQUAL RAINFALL (INCHES) —— 8 ——
OUTLINE OF SAVANNAH RIVER WATERSHED, ABOVE AUGUSTA, SUPERIMPOSED
CORRECT LOCATION OF ABOVE WATERSHED
RAINFALL MAP
ALTAPASS N. C. STORM
JULY 14-16 1916
TO ACCOMPANY REPORT OF
MORGAN ENGINEERING COMPANY
MEMPHIS
MAY 1930
SCALE: 1 IN. = 37.5 MILES
EXHIBIT 3
FIGURE 4



RAINFALL MAP
TAYLOR TEXAS STORM
SEPT. 8-10 1921

TO ACCOMPANY REPORT OF

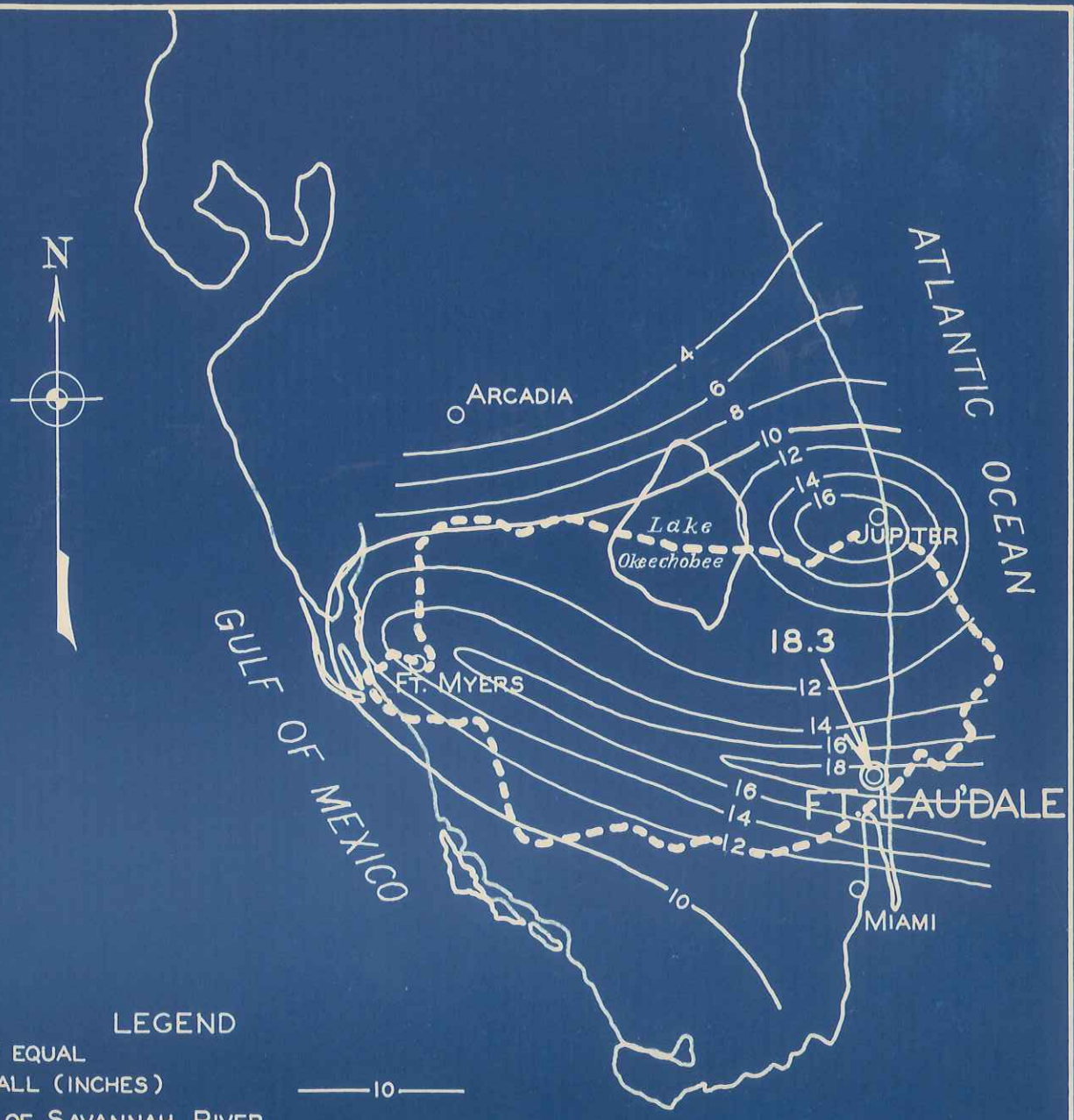
MORGAN ENGINEERING COMPANY

MEMPHIS

MAY 1930

SCALE: 1 IN. = 37.5 MILES

EXHIBIT 3
FIGURE 5



LEGEND

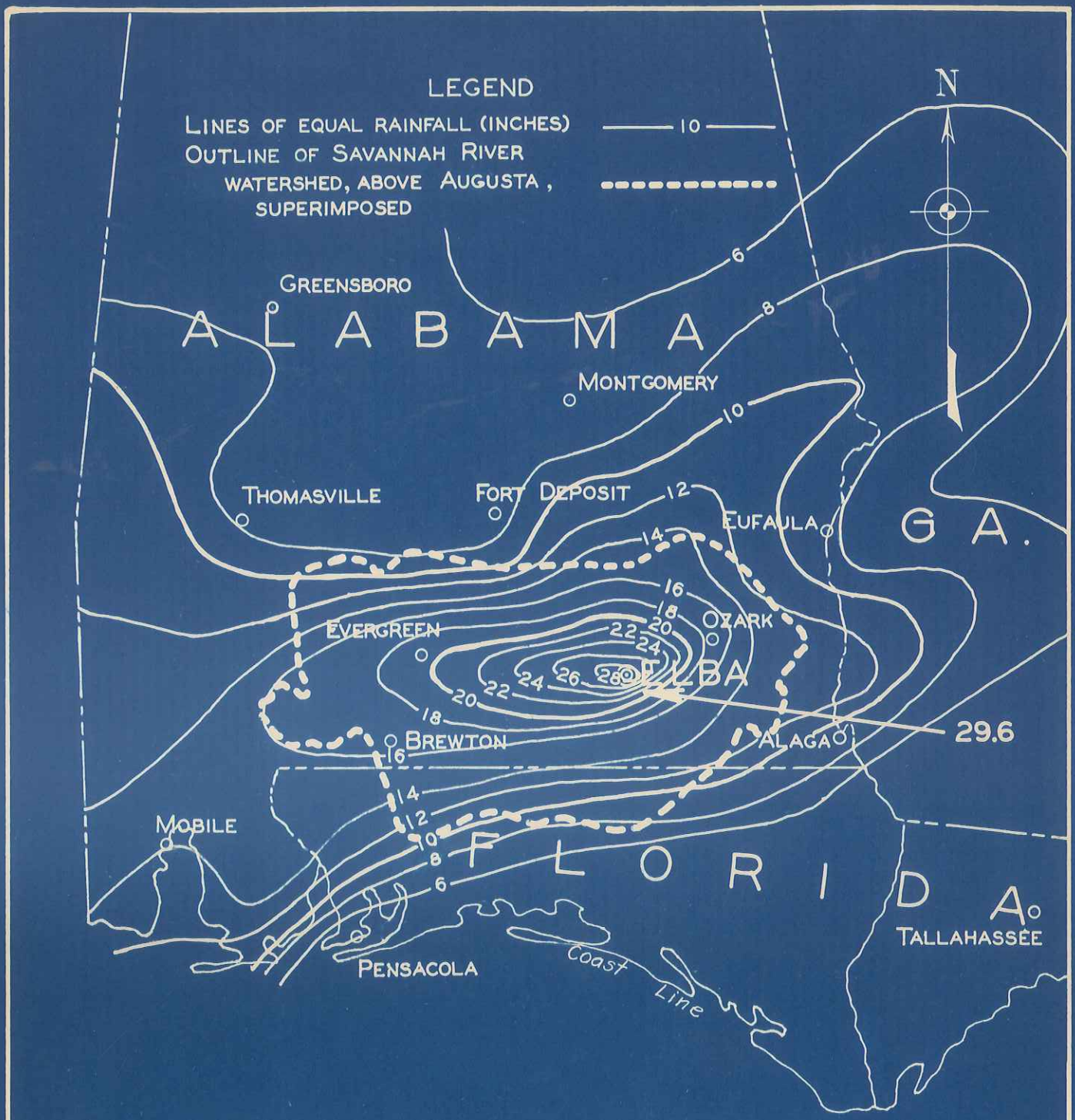
LINES OF EQUAL RAINFALL (INCHES) ——10——

OUTLINE OF SAVANNAH RIVER WATERSHED, ABOVE AUGUSTA, SUPERIMPOSED ●●●●●●●●

RAINFALL MAP
FT. LAUDERDALE FLA. STORM
OCT. 18-20, 1924

TO ACCOMPANY REPORT OF
MORGAN ENGINEERING COMPANY
MEMPHIS
MAY 1930
SCALE: 1 IN. = 37.5 MILES

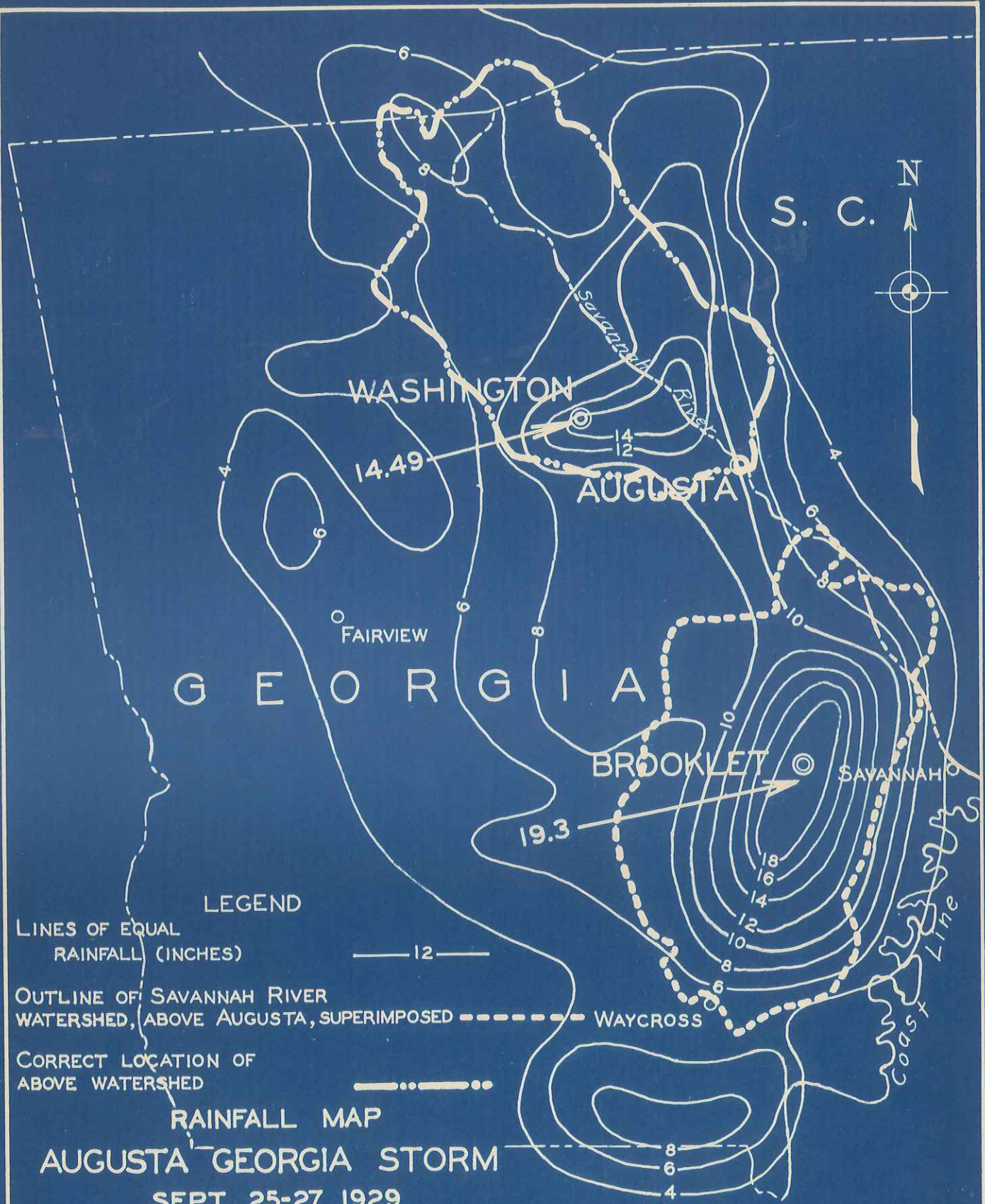
EXHIBIT 3
FIGURE 6



RAINFALL MAP
ELBA ALABAMA STORM
MARCH 13-15 1929

TO ACCOMPANY REPORT OF
MORGAN ENGINEERING COMPANY
MEMPHIS
MAY 1930
SCALE: 1 IN. = 37.5 MILES

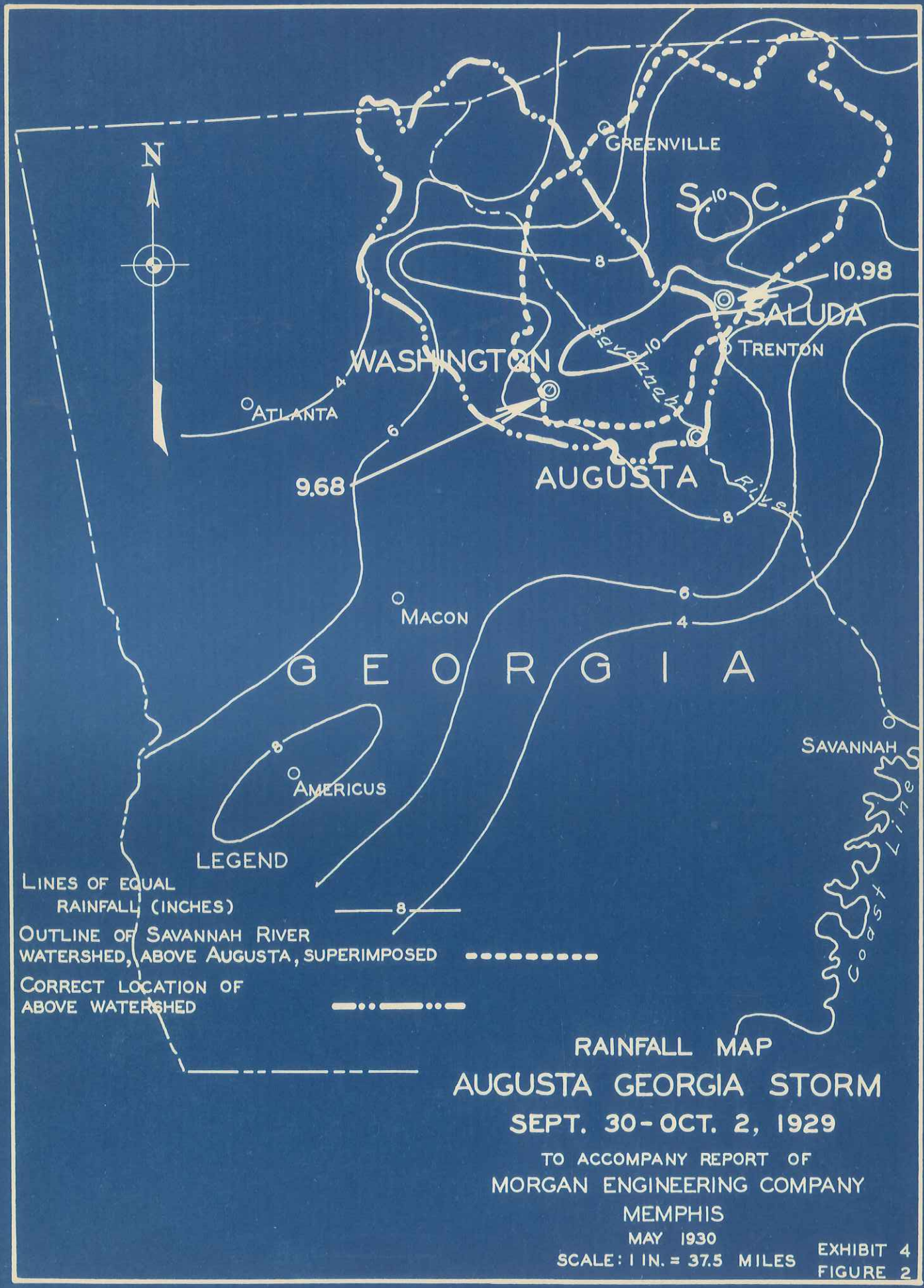
EXHIBIT 3
FIGURE 7



RAINFALL MAP
AUGUSTA GEORGIA STORM
SEPT. 25-27 1929

TO ACCOMPANY REPORT OF
MORGAN ENGINEERING COMPANY
MEMPHIS
MAY 1930
SCALE: 1 IN. = 37.5 MILES

EXHIBIT 4
FIGURE 1



RAINFALL MAP
AUGUSTA GEORGIA STORM
SEPT. 30 - OCT. 2, 1929

TO ACCOMPANY REPORT OF
MORGAN ENGINEERING COMPANY
MEMPHIS
MAY 1930
SCALE: 1 IN. = 37.5 MILES

EXHIBIT 4
FIGURE 2

PROFILE OF
SAVANNAH RIVER LEVEE
AUGUSTA GEORGIA

TO ACCOMPANY REPORT OF
MORGAN ENGINEERING COMPANY
MEMPHIS
MAY 1930

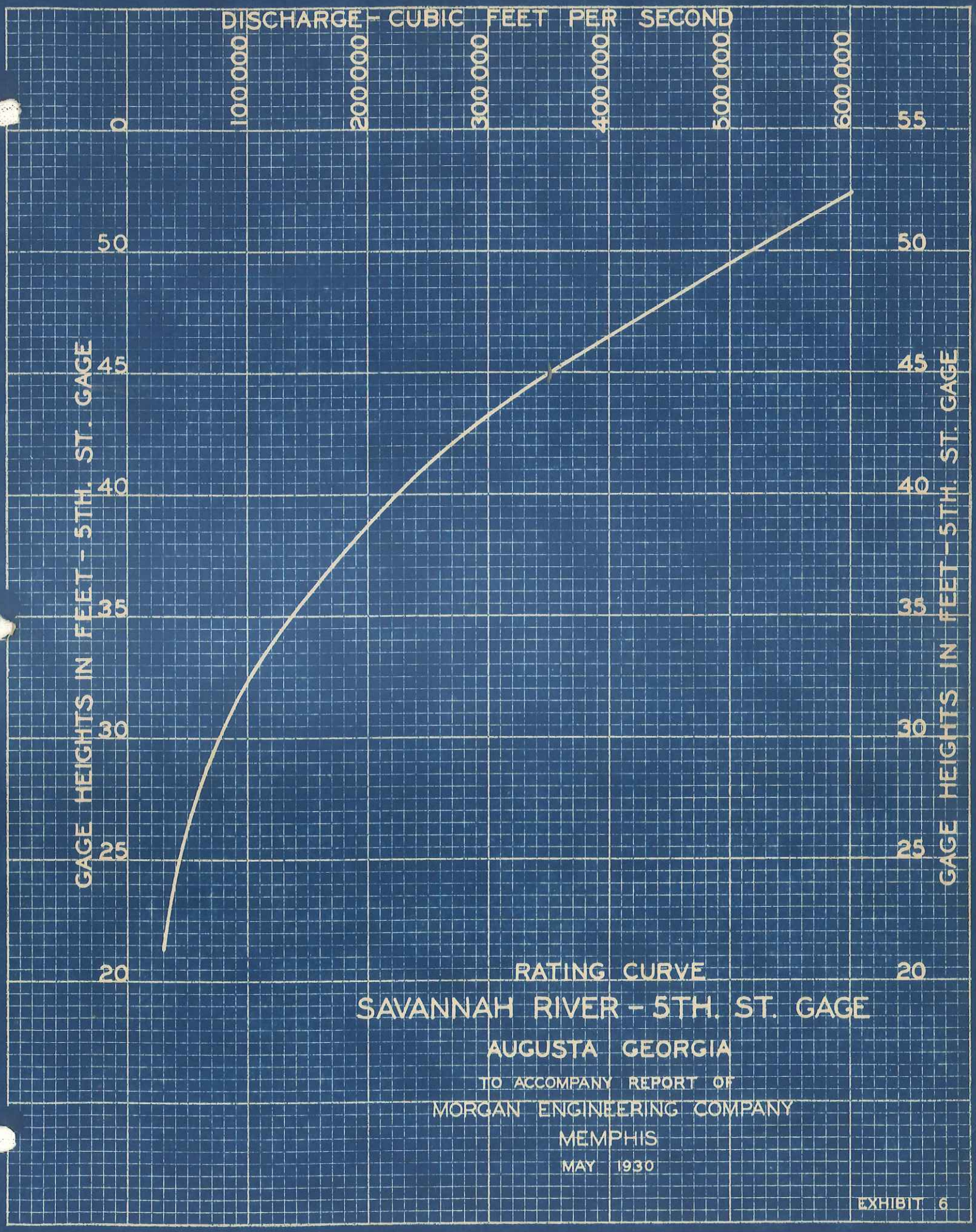
SCALE: HOR. 1" = 1600'; VER. 1" = 4'

LEGEND

TOP OF PRESENT LEVEE
FLOOD LINE, SEPT. 29, 1929 (350,000 CU. FT. PER SEC.)
COMPUTED FLOOD LINE (600,000 CU. FT. PER SEC.)

27

EXHIBIT 5


DISCHARGE - CUBIC FEET PER SECOND
0
100 000
200 000
300 000
400 000
500 000
600 000
GAGE HEIGHTS IN FEET - 5TH. ST. GAGE
20
25
30
35
40
45
50
55
RATING CURVE
SAVANNAH RIVER - 5TH. ST. GAGE
AUGUSTA GEORGIA
TO ACCOMPANY REPORT OF
MORGAN ENGINEERING COMPANY
MEMPHIS
MAY 1930
EXHIBIT 6