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U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—CIRCULAR 104.

A. C. TRUE, Director.

A PRELIMINARY REPORT

ON THE

DRAINAGE OF THE FIFTH LOUISIANA LEVEE DISTRICT,

COMPRISING THE PARISHES OF

EAST CARROLL, MADISON, TENSAS, AND CONCORDIA.

BY

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PREPARED UNDER THE DIRECTION OF

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WASHINGTON:

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., October 24, 1910.

SIR: I have the honor to submit herewith a preliminary report upon the drainage of the Fifth Louisiana Levee District, prepared by engineers of Drainage Investigations of this Office under the direction of C. G. Elliott, Chief.

The examination and report were made to set forth the conditions as at present found and to suggest plans for the reclamation of about 1,500,000 acres of rich alluvial land embraced in the district.

In order that this important work may be intelligently inaugurated and that the drainage district may be formed, it is necessary that the people interested in this large reclamation be fully informed of the conditions as here discussed. I therefore recommend that the report be published as a circular of this Office.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

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PRELIMINARY REPORT ON DRAINAGE OF THE FIFTH LOUISIANA LEVEE DISTRICT.

INTRODUCTION.

A public meeting was held at Tallulah, La., on March 11, 1909, pursuant to a call issued by the board of commissioners of the Fifth Louisiana Levee District to consider measures for inaugurating a much-needed system of drainage in the district. In March, 1910, Mr. J. T. McClellan, president of the board, transmitted to the United States Department of Agriculture a communication from the law committee appointed at this meeting, requesting that Drainage Investigations of that Department make an examination of the district. It was desired that with such information as could be gathered from all available sources, as a basis, the Office should suggest a practical plan for draining the district, and also point out the salient features necessary to effect a complete drainage organization so as to enable the people to effectually drain their lands.

The merits of the proposition were so apparent, involving the drainage of one and a half million acres of land, that the Office complied with the request, and detailed A. E. Morgan, S. H. McCrory, L. L. Hidinger, and O. G. Baxter, drainage engineers, to collect such information as could be obtained in the short time remaining before May 1, and to arrange it for the use of the law committee.

The following report contains suggestions based upon information obtained by the engineers through personal examinations of representative streams, bayous, and sections of the district, and presents the judgment of the engineers as to their respective drainage capacities and requirements. The data relating to the fall in streams and other facts of an engineering character have been obtained from maps and reports courteously furnished by the Vicksburg office of the War Department and by the Mississippi River Commission. Cross sections of the district shown on the river commission maps and on profiles furnished by the Iron Mountain and the Vicksburg, Shreveport and Pacific Railroad companies have proven useful. The records of river gaugings as given in the river commission reports, as well as several recently completed topographical sheets prepared by the United States Geological Survey, have been of assistance.

This report presents the drainage problems as they exist in the Fifth Louisiana Levee District, points out certain general methods of inaugurating and proceeding with its drainage, and submits a crude estimate of the probable cost of main and lateral drainage under the conditions which are described. It discusses the necessity of adequate preliminary surveys and careful stream investigations, submits an estimate of their cost, and also suggests the order in which drainage works may most profitably be developed. It is urged that the drainage organization be so formed that the work can be prosecuted along the general course herein marked out.

It should be understood that as only about six weeks were spent in collecting and arranging the data, the information which is assembled and discussed in the report is not of a precise nature, and that some of the assumptions upon which statements are based may later be found not entirely correct. It is believed, however, that the report will prove helpful in the organization and prosecution of drainage works in the district.

DESCRIPTION OF THE FIFTH LOUISIANA LEVEE DISTRICT.

The Fifth Louisiana Levee District occupies an area of about 1,470,000 acres in the northeast part of Louisiana. (See fig. 1.) It includes East Carroll, Madison, Tensas, and Concordia parishes. As the part of Franklin Parish lying east of Bayou Macon is a part of the same drainage basin, it is included in this report as a part of the district under consideration. Adding this area of 96,000 acres, we have a total of about 1,560,000 acres or about 2,440 square miles. The district thus defined lies between Bayou Macon and the Tensas, Black, Red, and Old rivers on the west, and the Mississippi River on the east. From the state line on the north to Old River at the south extremity the distance is about 135 miles, and the extreme width through Madison Parish, is about 30 miles. The Iron Mountain Railroad extends from the state line to Natchez. At Ferriday it connects with the Texas and Pacific, making a line of railroad through the entire length of the district. The Vicksburg, Shreveport and Pacific Railroad crosses the district in Madison Parish, and a branch of the Iron Mountain extends from Ferriday to the west margin on Black River. Tallulah, the largest town in the district, has a population of about 1,200. Other important towns are Lake Providence, St. Joseph, Waterproof, Ferriday, and Vidalia, all on the Iron Mountain Railroad. The district has a river front of about 245 miles along the Mississippi and about 270 miles along the streams forming the western boundary. The Tensas River, about 175 miles long, extends through the interior of the north half of the district, uniting with Bayou

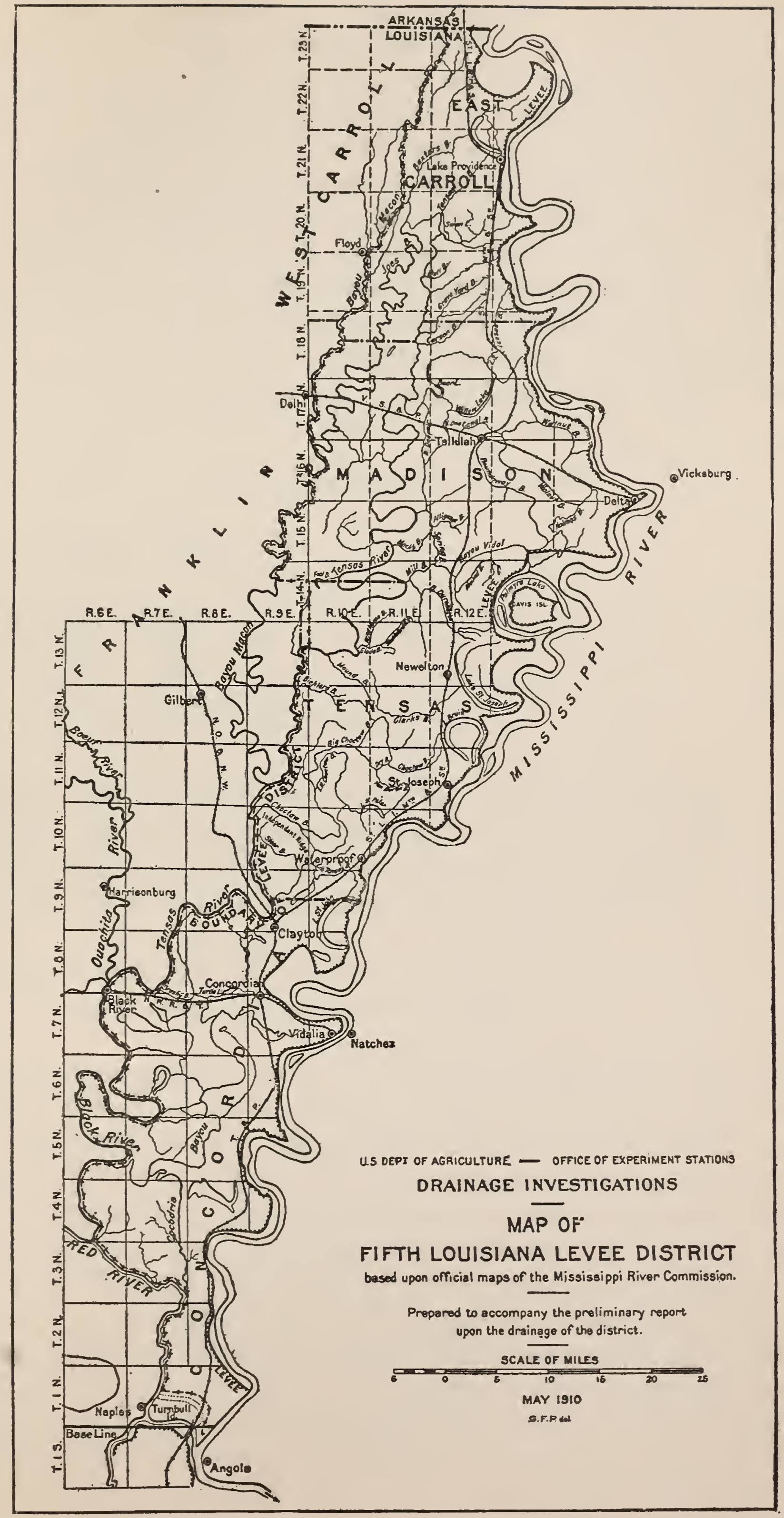

FIG. 1.—Map of Fifth Louisiana Levee District.

Macon to form the western boundary of the lower portion. The entire district is intersected by numerous bayous.

The physical features of the district are typical of the Mississippi Delta region. The highest land is along the larger bayous. From the banks of these the surface slopes back 3 to 10 feet to the mile, the greater part of the fall usually occurring in the first mile or less. Nearly all of the higher land along river and bayou fronts is or has been in cultivation. About one-sixth of the entire district is cultivated, the rest being woodland. Formerly a much larger area was cultivated in Madison and West Carroll parishes, the abandoned parts being now grown up to small timber.

The wild and cultivated areas in the several parishes within the proposed drainage district are as follows:

Wild and cultivated areas in the district.

Parish.	Acres cultivated.	Acres of woodland.	Approximate total.
East Carroll	58,000	242,000	300,000
Madison	76,000	322,000	398,000
Tensas	85,000	277,000	362,000
Franklin	6,000	90,000	96,000
Concordia	74,000	332,000	406,000
Total	299,000	1,263,000	1,562,000

The exact acreage in the district has never been determined, and changes from year to year, as the Mississippi changes its course. In the upper parishes a considerable amount of land with fair drainage is still in woodland, but for the most part such land is too wet for cultivation.

The total surface slope from the lowlands at the north line of East Carroll Parish to the south end of Concordia Parish is about 70 feet or about one-half foot to the mile.

The banks of the Mississippi are 10 to 15 feet higher than the low lands lying to the west, while the east bank of Bayou Macon is slightly higher than that of the Mississippi. Numerous ridges along the intervening bayous approach to within a few feet of the elevation of the Mississippi banks. The elevation above mean gulf level at the north line of the district varies from about 100 to 110 feet, and at the south end of the district from 30 to 45 feet. The lower end of the district at the mouth of Red River is 300 miles by river from the mouth of the Mississippi, the distance to the Gulf along the Atchafalaya being about half as great.

Narrow strips of higher land along the Mississippi River front and along the large bayous, averaging not more than a mile wide, are naturally well drained and are now in cultivation. A part of that along the Mississippi River front is damaged by seepage through and beneath the levees during high water in the river, and needs careful drainage. The methods of handling seepage water under these conditions have not been fully worked out. The remaining lands are nearly all imperfectly drained, some producing crops in favorable seasons, and others being usually under water. There are more than 1,500 miles of natural channels within the district, varying from the Tensas River, 500 feet wide or more near the outlet of Bayou Macon, to small bayous, which disappear in the flatwoods. The channels are nearly all crooked, and except in case of the large streams and the few that are kept clean, they are filled with trees, brush, and débris. In many instances the clearing of these channels alone will greatly benefit drainage conditions.

The climate and crop conditions of north Louisiana are favorable to the production of cotton, corn, rice, alfalfa, and numerous other staple crops. Frosts occur commonly from November to March, and occasionally there are light falls of snow during the winter months. The rainy season occurs during the first half of the year, centering in March as the month of heaviest rainfall; but heavy rains may occur in any month. The average annual precipitation is about 50 inches.

The soil of the district varies from a silt loam near the river to a heavy clay loam, known as buckshot clay in the interior. The soils of the district as a whole are heavier than those of the north part of the Mississippi Delta. They are all of alluvial origin and are uniformly fertile. The heavier types require more careful and thorough drainage and are more difficult to till than the sandy loams. The soils of the district with proper treatment and cultivation are capable of producing almost any crop suitable to the climate.

FLOW IN CHANNELS.

No effort has been made in the past to determine the capacities of natural channels within the district, and during the time occupied by the field examination no high water occurred in any of the interior streams. For this reason the capacities of these channels have not been determined by actual observation, as must be done in making a complete survey. In estimating the capacities of Bayou Macon and Tensas River, Kutter's formula was used, with a large coefficient of roughness, n. An estimate of the loss of head due to bends was made by the use of formula of Humphrey and Abbott, whose investigations are the basis of practically all discussions of this subject in standard works on hydraulics. This formula indicates approximately the loss of the entire velocity head for each 90° of bends in the channel, the velocity head being determined by the formula $V=\sqrt{2gh}$. A velocity of 3 feet per second would require a head of 0.14 foot; and according to the formula a bend of about 90° would cause a rise at the upper side of the bend of 0.14 foot. This formula was developed on the Mississippi, and its applicability elsewhere has not been determined. It was not considered to be authoritative for the case of Tensas River and Bayou Macon, except as indicating that the loss due to bends is not a very important factor in this case.

The loss of head due to inequalities of the channel can only be roughly estimated, but is not so extreme as to be a large factor in affecting velocities. It may be said therefore that the use of Kutter's formula to determine velocities in these two streams should give roughly approximate results, but they are not comparable with actual gaugings.

It is believed that when the entire district is under cultivation and there are no large accumulations of surface water after storms, as is now the case, the run-off from the various drainage areas will be much greater than it is under present conditions. Where the present channel is barely sufficient for carrying the water which now reaches it, it has been considered necessary to plan for considerably greater capacity for the fully improved section. The increase of flow which would result from cleaning the banks of trees and brush was estimated on the ground while making personal examinations of the channels. This increase would result both from diminishing the resistance to flow in the more uniform section of the improved channels and by increasing the cross section by removing trees and brush. It has been found by observation that under the conditions obtaining on these streams there is very little velocity in that part of the channel covered with vegetation.

The smaller bayous are so obstructed by shrubs and trees that the flow of water is greatly impeded. Examination indicates that in many of them the flow could be more than doubled at any given stage by simply clearing away these obstructions.

It should be kept in mind that, except on Bayou Macon and Tensas River, sufficient data were not secured during this examination to serve as a basis for close hydraulic calculations and that of necessity the estimates are crude and doubtless inaccurate in many respects. The estimates simply represent an effort to arrive at the best conclusion possible, after a cursory examination, for the purpose of assisting in the organization of the district.

The capacities of ditches and canals have been estimated by the use of Kutter's formula. On account of the rank growth of vegetation in this latitude, which tends to deterioration of drainage, the factor n, which represents the retarding of flow due to roughness of the channel, has been assumed to be 0.030, which is higher than would be found in drainage channels in good condition farther north.

There are hydraulic factors which should be determined with care in the course of a complete survey, but it is believed that those here assumed are approximately correct.

RUN-OFF.

Of all the water that falls upon a given area as rain or snow a part is returned to the air by evaporation, part sinks deep into the ground, and the remainder flows over or through the ground to the streams, and through them passes out of the country as run-off. The amount of water that is lost by sinking deep into the earth is small in most cases and need not be considered here.

UNITS OF MEASUREMENT.

In discussing run-off in its relation to rainfall it is usual to express the rate in inches in depth in twenty-four hours over the entire watershed, or in cubic feet per second per square mile for the watershed area.

FACTORS AFFECTING RUN-OFF.

The chief factors affecting the rate and amount of run-off are: Rainfall; topography; shape, size, and location of the watershed, with reference to the path of storms; evaporation, including the transpiration of plants; climate and seasons; soil and geological structure; natural reservoirs; and the storage capacity of streams. In addition to these may be named the proportion of forest and open land, the character of the vegetable growth, the manner of cultivation of farm lands, and the particular crops planted, together with artificial improvement affecting drainage.

RAINFALL.

Rainfall is the most important element to be considered in the estimation of run-off. A region of heavy rainfall will have a large run-off, and the variation in rainfall will be reflected in the amount of water that reaches the outlet channels. The following tables give data from such records of rainfall at Natchez, Vicksburg, and Greenville as are available.

Annual precipitation at Vicksburg, Greenville, and Natchez, Miss., 1872–1909.

Year.	Amount.			Year.	Amount.		
	Vicksburg.	Greenville.	Natchez.		Vicksburg.	Greenville.	Natchez.
	Inches.	*Inches.*	*Inches.*		*Inches.*	*Inches.*	*Inches.*
1872	58.28	....	....	1891	50.54	51.24	....
1873	41.45	....	....	1892	52.64	57.80	....
1874	66.10	....	....	1893	47.42	49.73	....
1875	70.05	....	....	1894	53.93	42.61	....
1876	51.85	....	....	1895	40.09	48.87	....
1877	55.11	....	....	1896	37.98	31.64	....
1878	60.83	....	....	1897	46.22	46.36	49.61
1879	52.31	....	....	1898	55.67	52.18	....
1880	84.22	....	....	1899	47.18	33.92	41.95
1881	51.94	....	....	1900	53.33	54.82	64.75
1882	71.56	....	....	1901	57.57	41.75	45.00
1883	63.75	....	....	1902	47.31	45.17	42.59
1884	72.70	....	....	1903	38.04	39.65	57.68
1885	54.28	....	....	1904	41.64	39.66	37.45
1886	55.89	50.15	....	1905	60.48	65.44	60.67
1887	42.25	42.29	....	1906	51.76	54.65	50.93
1888	48.47	54.29	....	1907	51.60	45.99	58.44
1889	41.30	40.99	....	1908	49.22	59.44	56.42
1890	52.23	53.37	....	1909	54.95	50.01	58.02

Monthly and annual precipitation at Vicksburg, Miss., 1871–1910.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1871	......	......	......	......	......	......	......	......	1.85	4.13	7.03	2.05	......
1872	3.24	5.34	7.82	7.79	13.23	3.82	2.11	0.49	.72	1.74	1.65	10.33	58.28
1873	4.87	4.46	2.12	1.76	8.79	4.16	2.81	3.67	1.60	2.20	2.96	2.05	41.15
1874	5.27	3.47	9.86	22.24	.16	3.43	7.39	.06	6.20	.00	3.21	4.81	66.10
1875	5.48	7.01	14.51	5.07	1.69	4.05	1.92	8.85	7.55	3.76	4.55	5.61	70.05
1876	3.81	5.10	11.21	4.89	6.24	1.74	3.48	2.86	1.92	2.21	2.62	5.74	51.85
1877	3.61	3.26	4.83	8.88	.69	3.76	2.95	1.14	6.94	7.16	9.03	2.86	55.11
1878	4.10	2.49	5.24	7.13	4.57	8.81	3.37	6.34	2.15	3.90	5.49	7.24	60.83
1879	6.18	5.63	1.00	4.67	5.95	2.74	3.03	4.49	4.90	1.31	5.96	6.45	52.31
1880	1.85	4.60	11.27	9.09	5.99	6.36	4.89	5.67	10.51	5.75	14.15	4.10	84.22
1881	3.37	7.20	3.53	1.48	4.39	1.94	2.45	2.53	6.11	9.69	6.07	3.18	51.94
1882	13.83	7.15	7.41	5.44	8.30	.40	10.19	4.42	1.47	3.73	4.37	4.85	71.56
1883	7.65	6.70	3.19	6.99	2.16	4.96	3.61	1.86	.84	4.84	11.53	9.42	63.75
1884	8.20	6.73	8.29	4.47	11.76	3.14	5.75	2.16	5.12	1.08	2.48	13.52	72.70
1885	7.69	3.93	2.02	9.00	4.75	2.90	6.61	1.04	9.28	1.01	3.19	2.86	54.28
1886	7.84	4.97	6.07	9.99	1.52	9.63	1.58	2.42	5.13	.64	4.34	1.76	55.89
1887	3.62	4.13	2.77	.75	5.40	2.99	4.11	2.44	4.55	2.99	1.43	7.07	42.25
1888	3.26	4.96	7.92	2.44	3.55	2.18	3.04	11.10	1.32	2.97	2.19	3.54	48.47
1889	4.66	.44	7.02	3.53	1.17	9.83	5.64	2.13	1.14	.16	4.59	.99	41.30
1890	5.31	4.59	5.01	6.32	7.58	5.51	3.56	5.41	2.28	2.87	1.57	2.22	52.23
1891	8.79	4.22	10.51	3.09	1.00	4.55	4.54	.91	.35	.75	8.66	3.17	50.54
1892	4.88	3.52	6.97	6.76	.49	3.71	9.34	5.41	1.48	.18	4.48	5.42	52.64
1893	2.68	4.05	3.91	3.05	9.57	4.84	4.71	2.88	1.01	1.50	4.62	4.60	47.42
1894	6.23	5.83	6.27	4.62	6.71	.91	7.99	2.29	2.75	1.56	2.36	6.41	53.93
1895	6.56	1.70	6.02	1.25	3.02	7.11	2.46	3.77	.14	1.62	2.74	3.70	40.09
1896	3.94	10.13	3.23	2.27	2.40	5.90	1.09	1.11	.26	3.60	2.67	1.38	37.98
1897	6.24	2.67	5.12	1.96	.89	3.93	5.31	3.24	.28	1.94	1.37	13.27	46.22
1898	7.78	2.81	3.99	2.83	1.33	6.17	5.90	2.85	8.93	4.26	5.49	3.33	55.67
1899	10.37	3.81	4.93	1.85	1.04	5.51	2.50	4.46	2.10	.91	.85	8.85	47.18
1900	1.99	4.64	4.42	9.60	3.45	11.33	6.30	.12	2.12	4.41	2.83	2.12	53.33
1901	8.56	5.71	3.12	2.70	9.77	3.73	3.35	3.41	3.54	1.57	2.14	9.97	57.57
1902	2.32	2.42	12.26	2.74	3.18	.61	6.68	1.03	6.47	1.62	3.80	4.18	47.31
1903	4.10	11.45	6.00	1.00	2.75	1.80	2.11	2.82	1.81	.96	.25	2.99	38.04
1904	2.81	1.78	7.30	3.57	2.80	3.72	6.49	6.33	.26	.06	2.95	3.57	41.64
1905	5.33	7.07	4.77	8.70	2.95	4.60	4.47	4.47	4.20	6.23	3.71	3.98	60.48
1906	4.53	1.45	9.17	3.14	3.20	3.92	3.17	4.93	7.07	4.23	2.80	4.15	51.76
1907	1.69	4.58	1.66	6.52	6.91	3.57	10.88	2.72	.50	3.46	5.80	3.31	51.60
1908	3.59	8.39	6.76	4.66	7.35	3.71	3.23	3.71	.97	.04	2.83	3.98	49.22
1909	1.24	7.20	5.43	6.25	11.82	5.06	1.97	3.20	4.96	1.89	1.75	4.18	54.95
1910	3.85	5.40	.53	......	......	......	......	......	......	......	......	......	......
Mean	5.67	4.61	6.25	5.16	4.26	4.49	4.42	3.53	3.34	2.80	4.19	5.02	53.74

Monthly and annual precipitation at Greenville, Miss., 1886–1909.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
	In.	*In.*	*In.*	*In*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1886	7.30	5.51	5.59	4.76	1.20	4.81	2.89	2.99	2.93	2.31	6.89	2.97	50.15
1887	3.62	4.41	2.74	1.91	3.13	4.28	5.62	2.20	3.61	3.76	.97	5.04	42.29
1888	6.11	2.41	9.88	1.65	4.54	3.95	3.28	10.29	2.69	1.61	3.89	3.89	54.29
1889	4.89	2.71	1.89	2.60	4.03	7.09	4.50	1.86	4.05	.40	5.92	1.05	40.99
1890	4.98	6.30	6.63	11.01	4.67	2.31	2.23	2.09	4.94	2.79	1.48	3.94	53.37
1891	3.79	8.38	4.43	2.24	3.42	3.02	12.32	2.44	1.54	.86	5.40	3.40	51.24
1892	5.59	3.60	3.91	9.74	2.93	2.54	9.25	3.50	6.96	.80	2.44	6.54	57.80
1893	4.63	5.27	2.70	5.69	7.39	7.65	2.33	2.87	2.67	.34	6.32	1.87	49.73
1894	7.23	3.18	8.98	4.08	.57	.33	5.15	5.38	1.77	1.36	.34	4.24	42.61
1895	6.33	1.25	7.37	1.70	1.38	11.28	4.61	6.02	.32	1.32	3.72	3.57	48.87
1896	2.59	4.93	7.77	2.30	.92	.92	1.25	1.44	.71	2.89	5.63	.29	31.64
1897	4.50	4.21	11.37	1.97	1.51	1.09	4.43	2.72	.02	1.75	3.67	9.12	46.36
1898	8.38	3.05	3.13	4.18	3.28	2.40	1.69	7.95	5.75	6.03	4.68	1.66	52.18
1899	5.30	4.57	5.21	2.19	4.67	1.51	2.10	.87	1.18	1.15	.94	4.23	33.92
1900	1.94	5.44	5.64	7.11	4.02	9.29	6.11	.93	2.58	5.03	3.30	3.43	54.82
1901	4.61	3.82	4.45	3.17	5.68	1.22	2.23	2.52	4.59	.85	3.69	4.92	41.75
1902	2.58	3.07	7.89	3.11	4.57	.97	2.13	1.31	5.46	2.48	6.64	4.96	45.17
1903	5.04	8.04	5.76	1.12	2.46	2.07	4.50	5.34	.38	.50	.27	4.21	39.65
1904	2.47	1.23	5.41	3.45	1.17	8.52	3.41	1.64	.02	.15	3.32	8.87	39.66
1905	7.31	4.40	4.84	7.73	6.32	6.12	5.47	9.24	2.52	2.37	3.44	5.68	65.44
1906	3.49	1.43	5.44	1.35	6.49	1.43	5.89	2.24	8.80	3.65	8.76	5.68	54.65
1907	2.03	3.66	6.14	5.29	7.55	1.58	2.27	.58	4.40	3.24	4.46	4.79	45.99
1908	4.93	11.28	4.76	4.13	5.63	4.54	4.61	7.12	2.06	.14	3.53	6.71	59.44
1909	1.31	6.29	5.03	6.56	8.69	4.00	3.00	.89	4.35	1.55	1.85	6.49	50.01
Mean	4.62	4.52	5.71	4.13	4.01	3.87	4.22	3.52	3.10	1.97	3.81	4.48	......

Monthly and annual precipitation at Natchez, Miss., 1897–1909.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1897	7.06	1.95	7.65	4.50	1.25	2.35	3.85	6.85	0.85	1.65	3.75	7.90	49.61
1898	8.50	4.50	5.25	3.15	.25	8.30	5.30	5.75	4.35	2.70	7.25	(*a*)	(*a*)
1899	11.05	2.35	4.15	1.80	.00	3.95	2.50	1.60	1.15	1.15	2.55	9.70	41.95
1900	2.80	7.70	4.00	19.15	1.50	5.50	6.90	1.00	1.80	2.75	8.15	3.50	64.75
1901	5.65	6.20	3.70	2.95	.75	1.75	8.55	3.35	1.40	.20	2.40	8.10	45.00
1902	2.40	2.80	5.20	2.00	3.55	1.40	5.25	3.85	6.22	.97	4.70	4.25	42.59
1903	4.20	14.25	8.75	1.05	2.85	6.58	6.40	8.05	.50	.65	Trace	4.40	57.68
1904	2.25	1.82	4.60	2.40	1.10	2.60	10.53	3.95	1.82	Trace	2.40	3.98	37.45
1905	3.78	4.73	4.26	8.27	4.83	4.93	3.92	.88	8.55	2.53	4.69	9.30	60.67
1906	4.02	2.49	12.01	2.36	2.08	3.75	5.92	2.47	4.15	4.85	2.27	4.56	50.93
1907	.88	4.24	1.91	6.15	16.61	1.78	4.19	3.11	2.95	4.59	8.32	3.71	58.44
1908	4.42	11.41	3.45	5.30	3.43	6.00	5.28	6.98	1.94	.38	3.75	4.08	56.42
1909	1.80	8.64	2.78	4.90	10.85	6.39	1.75	3.26	7.40	1.82	3.33	5.10	58.02
Mean	4.52	5.62	5.21	4.92	3.77	4.25	5.41	3.99	3.31	1.91	4.12	5.28	......

[a] Missing.

These records indicate that the annual rainfall for points in the district varies from 31 to 84.22 inches. The normal rainfall for Vicksburg is 53.74 inches. The average at Greenville from 1886 to 1909 is 47.96 inches, and the average at Natchez for the period from 1897 to 1909 is 52.31 inches. Records show the distribution to be extremely variable. Records of monthly rainfall given in the last three tables show this irregular character. The rainfall also varies greatly at different stations for the same month. In April, 1900, Natchez had 19.15 inches, Vicksburg 9.60 inches, and Greenville 7.11 inches. Again, in May, 1907, Natchez had 16.61 inches, Vicksburg 6.91 inches, and Greenville 7.55 inches. In March, 1902, Vicksburg had 12.26 inches, Natchez 5.20 inches, and Greenville 7.89 inches. In May, 1908, 7.35 inches fell at Vicksburg, 5.63 inches at Greenville, and 3.43 inches at Natchez. The records show that it is extremely improbable that maximum rainfall will occur over all parts of the district at the same time. The following table is a record of maximum and minimum rainfalls for each month for a considerable period for the stations at Greenville, Vicksburg, and Natchez:

Maximum and minimum monthly and annual precipitation, Vicksburg, Greenville, and Natchez.

Months.	Vicksburg.		Greenville.		Natchez.	
	Precipitation.	Year.	Precipitation.	Year.	Precipitation.	Year.
January:	*Inches.*		*Inches.*		*Inches.*	
Maximum	13.83	1882	8.38	1898	11.05	1899
Minimum	1.24	1909	1.31	1909	.88	1907
February:						
Maximum	11.45	1903	11.28	1908	14.25	1903
Minimum	.44	1889	1.23	1904	1.82	1904
March:						
Maximum	14.51	1875	11.37	1897	12.01	1906
Minimum	.53	1910	1.89	1889	1.91	1907
April:						
Maximum	22.24	1874	11.01	1890	19.15	1900
Minimum	.75	1887	1.12	1903	1.05	1903
May:						
Maximum	13.23	1872	8.69	1909	16.61	1907
Minimum	.16	1874	.57	1894	.00	1899
June:						
Maximum	11.33	1900	11.28	1895	8.30	1898
Minimum	.40	1882	.33	1894	1.40	1902
July:						
Maximum	10.88	1907	12.32	1891	10.53	1904
Minimum	1.09	1896	1.25	1896	1.75	1909
August:						
Maximum	11.10	1888	10.39	1888	8.05	1903
Minimum	.06	1874	.58	1907	.88	1905
September:						
Maximum	10.51	1880	8.80	1906	8.55	1905
Minimum	.14	1895	.02	1897	.50	1903
October:						
Maximum	9.69	1881	6.03	1898	4.85	1906
Minimum	.00	1874	.14	1908	Trace.	1904
November:						
Maximum	14.15	1880	8.76	1906	8.32	1907
Minimum	.25	1903	.27	1903	Trace.	1903
December:						
Maximum	13.52	1884	9.26	1904	9.70	1899
Minimum	.99	1889	.29	1896	3.50	1900
Annual:						
Maximum	84.22	1880	65.44	1905	64.75	1900
Minimum	37.98	1896	31.64	1896	37.45	1904

The records indicate that March is the month of heaviest rainfall, followed by January, April, and December, whereas September and October have the least precipitation.

The following table shows a number of heavy storms from 1897 to 1909, inclusive:

Excessive precipitation at Vicksburg, Greenville, Natchez, Monroe, Como, and Oak Ridge.

[3 inches or more in twenty-four hours.]

Date.	Amount.					
	Vicksburg.	Greenville.	Natchez.	Monroe.	Como.	Oak Ridge.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Dec. 1, 1897	0.03	0.0	0.25	0.0	(a)	0.0
2, 1897	.98	.16	.50	.26	(a)	.26
3, 1897	5.28	2.24	2.50	3.92	(a)	2.80
4, 1897	.14	1.20	.25	.86	(a)	1.40
Sept. 19, 1898	.0	.0	.0	.0	0.05	.32
20, 1898	3.40	.11	.25	.10	5.20	2.18
21, 1898	.92	2.37	2.65	1.10	.0	.0
22, 1898	.01	.22	.0	.0	.0	.0
Jan. 3, 1899	.04	.0	.0	.0	(a)	.0
4, 1899	.03	.01	.0	.0	(a)	.24
5, 1899	3.10	1.40	3.50	1.03	(a)	3.15
6, 1899	4.46	1.11	3.75	1.73	(a)	2.95
7, 1899	.0	.02	.0	.13	(a)	.0
Dec. 8, 1899	Trace.	.0	.0	.0	.44	.0
9, 1899	.89	.23	1.00	.70	.0	.0
10, 1899	4.22	.08	2.00	.05	4.27	.60
11, 1899	1.34	1.55	4.00	1.57	.0	2.89
Apr. 15, 1900	.38	.0	1.00	.0	4.23	.0
16, 1900	3.62	1.61	6.00	2.72	4.27	2.30
17, 1900	1.50	2.06	6.75	2.36	.0	5.74
18, 1900	.04	.0	.0	.0	.0	.0
Jan. 10, 1901	5.10	.55	.0	.03	5.34	(a)
11, 1901	2.85	2.22	5.00	2.62	.82	(a)
12, 1901	.05	.49	.0	.20	.0	(a)
May 24, 1901	.0	.0	.0	.0	(a)	1.02
25, 1901	4.66	2.30	.0	.80	(a)	.0
30, 1901	.02	.06	.0	.0	(a)	.60
31, 1901	3.85	1.42	Trace.	.86	(a)	.50
June 1, 1901	.01	.04	.0	.0	(a)	.0
Dec. 26, 1901	.01	.02	.0	.0	(a)	(a)
27, 1901	.0	.0	.0	.86	(a)	(a)
28, 1901	3.09	.61	.0	.66	(a)	(a)
29, 1901	.46	.47	.0	.0	(a)	(a)
30, 1901	.0	.0	.10	.0	(a)	(a)
Mar. 23, 1902	.98	.0	.10	2.01	(a)	(a)
24, 1902	.25	.68	.0	.0	(a)	(a)
26, 1902	1.08	.04	1.50	2.51	(a)	(a)
27, 1902	6.32	.63	.50	1.52	(a)	(a)
28, 1902	1.40	1.75	.35	.52	(a)	(a)
29, 1902	.0	2.12	.0	.0	(a)	(a)
Feb. 1, 1903	Trace.	.0	.0	.30	(a)	(a)
2, 1903	1.49	.27	2.25	.52	(a)	(a)
3, 1903	.31	.88	.0	.26	(a)	(a)
4, 1903	.05	.26	.0	.0	(a)	(a)
6, 1903	.90	.05	.75	2.72	(a)	(a)
7, 1903	2.83	1.88	2.00	.06	(a)	(a)
8, 1903	Trace.	.17	.0	.0	(a)	(a)
14, 1905	2.84	.0	.0	.0	(a)	(a)
15, 1905	.17	Trace.	.16	.0	(a)	(a)
Mar. 18, 1906	3.58	.0	.64			
19, 1906	.02	2.30	6.14			
Sept. 19, 1906	.02	.0				
20, 1906	.03	.0	Trace.			
21, 1906	.11	.16				
22, 1906	.07	Trace.	.05			
23, 1906	.08	.05	.04			
24, 1906	Trace.	.0	.02			
25, 1906	1.95	.92	.09			
26, 1906	.07	1.03	.63			
27, 1906	3.19	.52	.26			
28, 1906	.05	3.48	1.02			
29, 1906	.08	.17	Trace.			
30, 1906	.04	.28	.0			
Oct. 1, 1906	.53	.26	.10			
2, 1906	.18	.18	.10			
3, 1906	Trace.	.03	.13			
4, 1906	.18	.0	.0			
5, 1906	2.90	.75	2.96			
6, 1906	.07	1.04	.18			
July 9, 1907	.03	.03	.0			
10, 1907	Trace.	.0	.28			
11, 1907	.10	.02	.0			

a No record.

Excessive precipitation at Vicksburg, Greenville, Natchez Monroe, Como, and Oak Ridge—Continued.

Date.	Amount.					
	Vicksburg.	Greenville.	Natchez.	Monroe.	Como.	Oak Ridge.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
July 12, 1907	0.70	0.10	0.05			
13, 1907	7.99	.0	.76			
14, 1907	.0	.16	.09			
May 5, 1908	3.39	1.66	.51			
6, 1908	.0	.01	.24			
24, 1909	.64	Trace.	.0			
25, 1909	1.62	3.11	.52			
26, 1909	3.48	.48	2.85			
27, 1909	.70	.04	1.78			
28, 1909	.21	.06	1.29			
29, 1909	Trace.	Trace.	.09			
30, 1909	.16	.27	.0			
31, 1909	1.07	1.47	1.45			
June 1, 1909	1.02	.0	.09			
2, 1909	.04	.19	4.15			
3, 1909	.0	.0	.16			
Sept. 19, 1909	.01	.0	.0	0.0		
20, 1909	1.64	.0	.0	.0		
21, 1909	2.07	3.52	5.34	1.98		
22, 1909	.0	.04	.03	Trace.		
23, 1909	.0	.72	.0	.0		

These storms show wide variation between the different stations in the time and amount of precipitation. Of the sixteen storms, two occurred in January, three in March, three in December, and three in September. None of the other months has more than one heavy storm during this period. The records show rainfalls of 7 or 8 inches in twenty-four hours at all three stations.

Of the following tables, the first is a record of heavy rains of one hour or less, and the third is a record of precipitations of 2.5 inches or more, for a period of several years at Vicksburg.

Heavy rainfalls in one hour or less at Vicksburg, 1894–1903.

Amount.	Time.	Date.	Amount.	Time.	Date.
Inches.			*Inches.*		
1.62	1 hour	Feb. 11, 1894	1.04	1 hour	June 8, 1899
1.33	do	Mar. 20, 1894	1.07	do	June 15, 1899
1.60	do	May 11, 1894	1.01	18 minutes	July 23, 1899
1.48	do	May 12, 1894	1.00	53 minutes	Aug. 3, 1899
1.30	do	July 1, 2, 1894	1.88	55 minutes	Dec. 10, 1899
1.00	do	July 31, 1894	1.16	32 minutes	June 1, 1900
1.56	do	Nov. 23, 1894	1.57	50 minutes	June 23, 1900
1.15	do	Jan. 15, 16, 1895	1.56	24 minutes	July 28, 1900
1.73	do	June 18, 1895	1.00	1 hour	Sept. 20, 1900
1.07	do	Apr. 13, 1896	1.11	do	Oct. 21, 1900
1.15	do	June 6, 1896	1.03	47 minutes	Jan. 10, 1901
1.00	do	Jan. 17, 1897	2.01	43 minutes	May 24, 1901
1.70	do	July 10, 1897	2.55	1 hour	May 31, 1901
1.31	do	July 18, 1897	2.58	do	Mar. 27, 1902
1.52	50 minutes	July 20, 1897	1.18	40 minutes	May 19, 1902
1.24	1 hour	Dec. 3, 1897	1.17	16 minutes	July 31, 1902
1.09	48 minutes	June 14, 1898	1.00	44 minutes	Sept. 2, 1902
1.42	25 minutes	Sept. 12, 1898	1.10	25 minutes	Sept. 23, 1902
1.00	49 minutes	Oct. 7, 1898	1.00	19 minutes	Dec. 15, 1902
1.03	30 minutes	Feb. 25, 1899	1.00	34 minutes	Mar. 8, 1903

Excessive rainfalls for periods longer than one hour at Vicksburg.

Amount.	Time.	Date.	Amount.	Time.	Date.
Inches.	*Hrs. min.*		*Inches.*	*Hrs. min.*	
5.30	15 20	Jan. 5, 6, 1899.	3.85	11 15	May 30,31,1901.
4.66	14 55	May 24, 25, 1901.	4.49	2 50	Mar. 27, 1902.

Excessive precipitation at Vicksburg, Miss.

[2.50 inches or more in 24 consecutive hours.]

Amount.	Year.	Date.	Amount.	Year.	Date.	Amount.	Year.	Date.
Inches.			*Inches.*			*Inches.*		
2.61	1872	Apr. 2, 3.	3.09	1880	Apr. 7, 8.	2.82	1888	Mar. 3, 4.
3.33	1872	Apr. 5, 6.	4.27	1880	May 30.	2.75	1888	Aug. 19, 20.
5.36	1872	May 23, 24.	5.24	1880	Sept. 1.	2.50	1889	June 11, 12.
5.11	1872	Dec. 18, 19.	2.71	1880	Oct. 4.	2.53	1890	Jan. 15.
4.46	1874	Apr. 8.	3.18	1880	Nov. 24, 25.	2.73	1890	Mar. 11, 12.
4.18	1874	Apr. 15.	2.93	1880	Nov. 28.	3.25	1890	May 2, 3.
4.86	1874	Apr. 18, 19.	2.81	1880	Nov. 30.	6.47	1891	Mar. 7, 8.
2.73	1874	July 4, 5.	3.85	1881	Sept. 14, 15.	4.28	1891	Nov. 21, 22.
2.95	1874	Sept. 25.	6.44	1881	Oct. 27, 28.	2.70	1892	Feb. 19, 20.
3.76	1875	Jan. 23, 24.	3.44	1881	Nov. 11.	3.79	1892	July 17, 18.
3.26	1875	Mar. 31.	2.68	1882	Feb. 23.	2.80	1893	May 2, 3.
2.63	1875	Apr. 9, 10.	2.76	1882	Mar. 8.	2.68	1895	Jan. 7, 8.
4.99	1875	Sept. 17, 18.	2.84	1882	May 7.	3.59	1896	Jan.31, Feb.1.
2.84	1876	Mar. 6.	3.78	1882	Dec. 19, 20.	5.28	1897	Dec. 2, 3.
3.40	1876	May 7.	4.26	1883	Apr. 6.	3.90	1898	Sept. 19, 20.
3.70	1876	Dec. 23, 24.	4.35	1883	Nov. 10, 11.	6.30	1899	Jan. 5, 6.
3.53	1877	Apr. 7, 8.	4.02	1883	Nov. 22.	2.82	1899	Aug. 3.
2.97	1877	Oct. 17, 18.	4.51	1883	Dec. 29, 30.	5.56	1899	Dec. 10, 11.
2.50	1877	Nov. 1.	2.69	1884	Sept. 3.	4.60	1900	Apr. 16, 17.
2.83	1877	Nov. 7, 8.	5.82	1884	Dec. 29.	2.53	1900	June 23.
4.46	1878	Mar. 9	3.68	1885	Jan. 15, 16.	7.03	1901	Jan. 10, 11.
2.63	1878	Apr. 23.	4.35	1885	Apr. 6, 7.	2.54	1901	Feb. 2, 3.
3.23	1878	Dec. 8, 9.	2.55	1886	Jan. 1, 2.	4.66	1901	May 24, 25.
3.97	1879	Sept. 1, 2.	2.75	1886	Apr. 27, 28.	3.85	1901	May 30, 31.
3.05	1880	Mar. 15.	2.53	1887	Feb. 19, 20.	3.29	1901	Dec. 28, 29.

The heavy storms may be divided into two classes—those of 5 to 8 inches precipitation in twenty-four hours, extending over a small area, and those of 2 to 5 inches, uniform over the entire district. Of the local storms that of July, 1907, is a striking example, when 7.99 inches of rain fell at Vicksburg in twenty-four hours. At Natchez 0.76 inch fell during the same time, and none in Greenville. The heaviest general rain of which we have a record occurred April 16 and 17, 1900, when an average of 3.74 inches fell over the watershed on April 16, followed by 3.44 inches on April 17, making an average over the district of 7.18 inches in forty-eight hours. The next largest precipitation occurred January 5 and 6, 1899. On January 5, an average of 2.67 inches fell over the district, and on the 6th 3.11 inches, or an average of 5.88 inches in forty-eight hours.

No gaugings of which we have any record have been made of the run-off from the land in the Fifth Louisiana Levee District. Judging from the results obtained in other sections of the country, the run-off for areas of not more than 100 square miles should be approximately 20 cubic feet per second for each square mile of area drained, or three-fourths of an inch in depth of water should be removed from the entire surface in twenty-four hours, when the run-off is at its maximum. Before the drainage system is constructed the run-off from the lands in the districts should be studied for at least a year, and longer if possible. If the studies should show that a small run-off per square mile may be provided for with safety, the estimated cost of drainage can be decreased.

PLAN OF IMPROVEMENT.

A general plan for the improvement of the district is submitted, based upon the assumption that the Red River is to be separated from the Mississippi and discharged into the Atchafalaya. Changes in the plan are indicated which may be necessary if the separation is not made.

Figure 2 is a sketch map of the lower end of the district, showing the relations between the Mississippi, Old, Red, and Atchafalaya rivers. An examination of the maps suggests the probability that the Red River once flowed to the Gulf through the Atchafalaya, without any connection with the Mississippi. A bend of the Mississippi formerly existed around Turnbulls Island, and may at some time have cut into the Red River.

Thereafter, Red River water flowed into the Mississippi, or Mississippi water flowed into the Atchafalaya, depending on which stream was highest. In 1832 the Mississippi River made a cut-off across the bend around Turnbulls Island, and since that time it has existed nearly as at present. The part of the bend north of the island has nearly filled with sediment; the part below, known as Old River, now forms a connecting link between the Mississippi, Red, and Atchafalaya rivers. When Red River is higher than the Mississippi, part of its water flows down the Atchafalaya, and part into the Mississippi through Old River. When the Mississippi River is higher, all of the water of Red River and a varying amount from the Mississippi flows down the Atchafalaya. If uncontrolled, the Atchafalaya would enlarge itself and in time carry all of the water of the Mississippi.

As the separation of the Mississippi River from the Red River has been much discussed of late, and is now under consideration by the Mississippi River Commission, no discussion of the subject will be made in this report, except to state that so far as the interests of the Fifth Louisiana Levee District are concerned every consideration favors the proposed separation.

The benefit to be received by the separation is not simply a reduction in the cost of reclamation within the district, but a more complete reclamation than otherwise would be possible.

Those who have given extensive study to the problem of this separation should be authority for estimates of the reduction in head which would occur at the mouth of Red River upon its accomplishment. However, the data at hand during the preparation of this

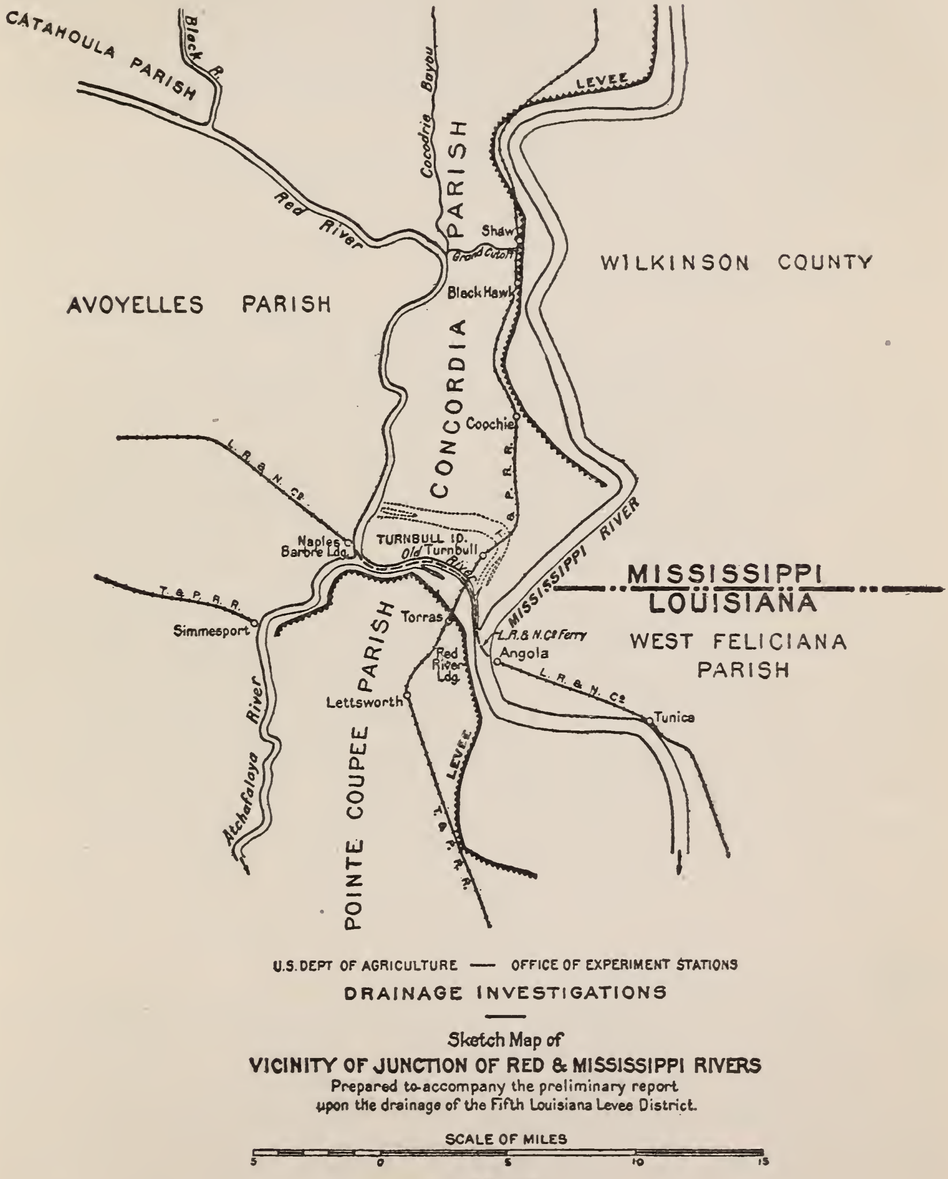

Fig. 2.—Sketch map of vicinity of junction of Red and Mississippi rivers.

report did not include any such estimate, and as one was necessary as a basis for calculations, it was arrived at in the following manner:

The flood discharges of Red River and its tributaries have been measured with reasonable accuracy for several years, but under conditions which will not prevail in the future in all respects. The maximum flood discharge of Red River, as determined by these measurements, is somewhere between 230,000 and 270,000 second-feet.

The Atchafalaya River has likewise been gauged for many years, and the discharge at many stages accurately determined. If, then, we determine the stages in the Atchafalaya at which the discharge will be from 230,000 to 270,000 second-feet, we will have determined with reasonable accuracy what would be the height of water at the mouth of Red River, under the present conditions in the Atchafalaya River, if the division were effected.

By reference to records of the gauge at Barbres Landing, in Atchafalaya River, just below the mouth of the Red, we find the water level when the discharge is from 230,000 to 270,000 second-feet to be 44.4 to 48.2 feet above mean Gulf level. We may, therefore, assume that with the division effected, the stage at Barbres Landing would not exceed 44 to 48 feet above mean Gulf level. As the elevation of extreme high water at Barbres Landing in the past has been 55 feet above mean Gulf level (high water of May 14, 1897), it would appear that the division would result in reducing the extreme high water 7 to 11 feet, even if the capacity of the Atchafalaya should not increase. It is probable, however, that such an increase would occur.

From 1882 to 1890 there was a continual enlargement of the Atchafalaya River due to erosion. With the construction of controlling works at Simmsport this enlargement was checked, and the discharge for a given stage was reduced. The separation of the Red River from the Mississippi would doubtless be accompanied by the removal of the controlling works in the Atchafalaya, so that increase in the size of channel might again take place. This result would not follow of necessity, however, as the diversion would also prevent the high stages which caused the scouring. The closing of Bourgere Crevasse would still further affect the accuracy of this estimate, as a part of the benefit here attributed to the separation has already been secured by closing this crevasse.

The benefit which would accrue from the proposed separation is not restricted to a reduction in the stage of water in the streams of the lower part of the district, for while the floods in the Red River occur with greater frequency than in the Mississippi they are of much shorter duration. In view of the fact that the water of Concordia Parish must be held within the levees during high water, the frequency and duration of floods will have a very large influence upon the success of a drainage system in that parish.

MAIN DRAINAGE.

The reclamation of the district must be accomplished by two classes of work: First, the improvement of existing and the construction of additional main outlet channels and the construction of levees and other protecting works, which will affect the whole or large sections of the entire district and which will be paid for by a uniform tax levied over the entire district; and, second, the detailed or lateral drainage, which will discharge into the main channels and will reclaim the land for agricultural purposes. A complete survey of the district probably will indicate desirable changes in the division here made between main and lateral drainage, as there are a number of channels which may reasonably be considered to fall into either class. It must be noted, also, that the outline of a main drainage system here presented is based upon a very brief examination of the territory and will be materially modified or reconstructed upon the completion of a survey.

The main drainage system will consist of the following principal features:

(1) The improvement of Bayou Macon.

(2) The improvement and relief of Tensas River.

(3) The improvement or construction of main drainage channels in Tensas Parish.

(4) Leveeing Concordia Parish, constructing floodgates, and supplementing Cocodrie Bayou with a main drainage channel.

BAYOU MACON.

This channel is sufficient in its present condition for present requirements. Should Cypress Creek in Arkansas be diverted into it, and other improvements be made in Arkansas which would increase its flow, improvement will be necessary by clearing the banks and by building a levee on the east side for the greater part of its course. The estimated cost of this work is $411,000. It will not be necessary until further development is undertaken in Arkansas.

TENSAS RIVER.

Tensas River at present has not sufficient capacity to allow complete drainage into it, and with the clearing of land in the district it will be still further overtaxed. The channel should be cleared for the greater part of its length by removing brush and timber from the banks and sunken logs and trees from the bottom wherever drifts occur. Such an improvement would perhaps increase the carrying capacity of the channel 10 per cent.

At present a large area in the eastern part of Madison Parish drains through Willow and Roundaway bayous and the lakes made by their enlargements into Tensas River. Very imperfect drainage is secured, high water in the Tensas River at the outlet of Roundaway Bayou being at about the same elevation as the surface of low land within a mile of Tallulah. The plan recommended includes a large canal leaving Lake One (an enlargement of Roundaway Bayou) about a mile below the point where it crosses the Vicksburg, Shreveport and Pacific Railroad, and extending southwesterly 8 miles to its outlet into a group of bayous which enter Tensas River. An earth dam will be required across Roundaway Bayou just south of its junction with Bear Lake, thus reducing the flow through Tensas River and materially lowering the water level in Roundaway Bayou and its tributaries. The water thus diverted will enter Tensas River where the latter will have a sufficient capacity if backwater from the Mississippi is removed by separating the Red from the Mississippi.

On the west side of the Tensas a large channel is recommended, commencing at the Vicksburg, Shreveport and Pacific Railroad and continuing southwesterly to Bayou Macon at a point about 1 mile below Osbornes Ferry, noted as kilometer 54.5 on the War Department map of the bayou. This channel will relieve Tensas River of much of the water which now enters it from the west below the Vicksburg, Shreveport and Pacific Railroad. The run-off from the territory west of the river and north of the railroad will be turned into the river through Henly Bayou. The Tensas River will be further relieved by diverting all the water from the territory tributary to Swan Lake in East Carroll Parish into Bayou Macon through Joes Bayou. These improvements will enable the Tensas River to carry all of the remaining water which will reach it.

The effect on the Tensas of the separation of the Red from the Mississippi will be to lower the flood level several feet in the territory south of Madison Parish, or to enlarge greatly the capacity of the stream by increasing the surface slope and consequent velocity. The lower river will have abundant capacity for carrying all of the water which may reach it, and the difference in stage at high water in the lower Tensas due to the separation will be nearly as great as it will be at the mouth of Red River.

Near the south line of Madison Parish are some large bends in the Tensas River. A first look at the map at once suggests the desirability of making one or more cut-offs across these bends. A careful study of the question, however, leads to the conclusion that no economical results can be secured by this method of improvement. The two cut-offs most evidently desirable would be located about 5 miles north of the south line of Madison Parish. Their construction would cost not less than $50,000. The water level at the upper end of the cut-offs would be lowered perhaps 4 feet. If no other work were done in the river, the effect of this improvement would be lost in the "drop-off curve" a few miles above the cut-off. To carry the benefit of the lower water surface upstream to the mouth of Roundaway

Bayou, where it would first be of large value, would cost perhaps $350,000, making a total of $400,000 for this method of improving the river. A greater improvement can be secured by the large diversion canal from Lake One to Tensas River through Mill Bayou, as previously described, for about one-half this cost. The other cutoffs which suggest themselves are still less feasible.

TENSAS PARISH.

An examination of Tensas Parish indicates that a main drainage system can be secured either by constructing several outlet channels partly within and partly outside the bayous, or by enlarging the bayous. Such improvement should relieve Lake St. John, Lake Bruen, and Lake St. Peter, as well as Clarks and Choctow bayous, and would cost approximately $500,000. The benefit to accrue from main drainage improvements in Tensas Parish will depend to a considerable extent upon the separation of the Mississippi and Red rivers.

CONCORDIA PARISH.

Concordia Parish constitutes the extreme southern portion of the Fifth Louisiana Levee District. It lies between the Mississippi River on the east and Tensas, Black, and Red rivers on the west and south. At the north the boundary of the parish very nearly coincides with the watershed of Bayou L'Argent and tributary bayous.

A strip of land varying from less than half a mile to more than a mile wide is in cultivation along the Mississippi River front, and along the Red, Black, and Tensas rivers. Aside from this narrow line of clearing the entire parish is waste, and is overflowed during high water in the Mississippi to depths varying from a few feet to 20 feet or more. Recently the closing of Bourgere Crevasse has materially lowered the flood stage at the north end of the parish, but not sufficiently to uncover a very large area of land.

No drainage improvements made within the Fifth Louisiana Levee District will have any beneficial effect whatever upon Concordia Parish, except work done within the parish. This work will consist of building a continuous levee entirely around the overflowed river front, constructing an interior drainage system, and providing an outlet through the levee by means of a floodgate to remain open except in time of high water in the Red River. The lowest part of the parish would serve as a storage reservoir to hold rain water during floods in Red River. Should extreme high water in the Red River coincide with a period of most excessive rainfall in the district, a condition which would occur not oftener than once in ten or fifteen years, about a fourth of the parish would be without drainage or partially overflowed for not more than a few weeks. In especially favorable years almost the whole of the parish could be successfully cultivated; but ordinarily perhaps 10 per cent of the area would be flooded each year in acting as a reservoir to store water during floods in Red River.

Should the land ever become sufficiently valuable, a pumping plant might be installed to pump the water over the levees when high water in Red River would require the floodgates to be closed. This would, however, require a pumping plant several times as large as any that has ever been constructed in any country for irrigation or drainage, so at best it is a part of the distant future.

The building of floodgates is the most serious construction problem in the entire drainage project. But without the system of levees and floodgates suggested, Concordia Parish, with the possible exception of a very few square miles along the northern boundary, will receive no benefit whatever from any drainage improvement in other parts of the district, and until the separation of the Mississippi from the Red River is accomplished can gain but little benefit from lateral drainage. The Tensas, Black, and Red rivers need no improvement along the border of the parish.

If the parish is included in the district, it should be benefited by the levees, and floodgates, and by a main drainage channel which will be necessary to supplement Cocodrie Bayou.

An effort to ascertain some other method of securing this diversion than by the use of a floodgate has been almost entirely without results. It might be possible to build two levees across Old River and to carry the water of the district between them and south between the Mississippi and the Atchafalaya. It is very doubtful, however, if there is any merit in this latter suggestion.

By constructing a system of smaller levees on higher ground in the interior of the parish and by abandoning about one-fourth of the lowest lands the remainder can be reclaimed at a much lower cost per acre. A careful survey will be necessary to indicate the possibilities of this plan.

If the separation of the rivers at the lower end of the parish is not made, the same method of improvement may be followed with a few variations. The Tensas River may be further relieved by diverting the run-off of the area between the Macon and the Tensas and north of the Vicksburg, Shreveport and Pacific Railroad away from the Tensas and into the Macon at Osbornes Ferry through the channel provided as heretofore described as a relief to the Tensas River.

The improvement of Concordia Parish would be more expensive on account of the higher levees required. The chief difference between plans with the proposed separation made and those without such separation is not the difference in cost, but in the greater benefit which may be secured with the separation.

The summaries to be found later in this report (p. 28) present the estimated cost of the work as a whole, divided into main and lateral drainage; the additional cost of main drainage which may be necessary if the Red River is not separated from the Mississippi; and an estimate of the part of the work which is now practicable and necessary without the proposed separation and without the necessity of extensive improvements on Bayou Macon.

LATERAL DRAINAGE.

The construction of the outlet drainage system will leave the district in a position to be fully improved by lateral drainage. A considerable part of the district, especially the lands lying within a few miles of the Mississippi River and that part of the district lying north of the Vicksburg, Shreveport and Pacific Railroad, can now be reclaimed by lateral drainage without waiting for the construction of the main outlet system.

A complete survey will indicate natural drainage divisions into which the district may be divided. These natural divisions or drainage units may then be developed independently of each other, as there is demand for reclamation on the part of the landowners. The cost of this lateral drainage should be assessed against the land in the proportion of benefits received. An examination of the conditions of lateral drainage leads to the conclusion that for thorough reclamation lateral ditches should be not more than 1 mile apart. In many instances bayous can be used for drainage channels, though usually they will require clearing. The cost of this work can not be estimated without detailed examination. On account of the high cost of clearing right of way and excavating earth in the bottoms of the bayous, it will frequently be found economical to abandon them entirely and to dig new channels in the lower land. In other instances the bayous will be found to have sufficient capacity in their present condition.

In parts of the district where there are no bayous it is estimated that 1 mile of dredged channel, costing an average of $3,000 per mile, will be necessary for each square mile of land, in addition to enlargements of the ditches necessary to secure outlets. Where there are numerous bayous an estimate of $3,000 per square mile for lateral drainage is made, it being considered that this will cover the cost of new ditches and of clearing and enlarging bayous both for lateral drainage and for secondary outlet channels. Although this estimate is but roughly approximate, it is believed to be a safe and reasonable one.

It is doubtful if a general clearing of the bayous of the district should be undertaken before a complete survey is made. With lateral ditches averaging 1 mile apart, plantation drainage will be a comparatively simple matter. In a few parts of the district where the surface is covered with numerous ridges, ditches may be needed at more frequent intervals.

METHODS AND COST OF CONSTRUCTION.

The fact that a large amount of excavation is included in a single contract usually results in increased competition and lower bids. The very uniform and favorable character of the soil of the flat woodland of the district for dredging operations is also a condition favoring low contract prices.

Considering the project as a whole, water will be abundant for floating dipper dredges. When coal is not easily obtained there is abundant wood upon the right of way for use as fuel. Being in a country where the ground does not freeze, work can continue throughout the year.

On the other hand, much of the work is at a considerable distance from a base of supplies. A large part of the territory is covered with forests, which must be cleared before the excavation can be made. The hot weather of the summer season is a handicap to efficient work, and there is an impression among contractors that the sanitary conditions are not good during a part of the year. The cost of services and the price of supplies are higher than in northern States, and a contractor must take this condition into account. When the excavation is in old channels or bayous the construction becomes much more difficult and can not be estimated upon the same basis as work in flatwoods. In drainage construction in northern States it is customary to demand practical efficiency on the part of the contractor, and little attention is paid to such details as trimming the banks of ditches and removing timber from beneath the waste banks. The custom has prevailed in Louisiana of requiring ditches to be dug with 1½ to 1 slopes and of requiring the contractor to remove all débris from beneath the waste bank. It is probable that as drainage construction increases the custom will prevail here of requiring of the contractors only the essentials of effective work. Otherwise contract prices will be perhaps 20 per cent higher than in the North, the difference in price representing the cost to the contractor of making a better looking, but perhaps no more efficient piece of work.

EXCAVATION.

For digging lateral ditches under conditions found in the wooded parts of the Fifth Louisiana Levee District no machine can compare with the floating steam dipper dredge; and the minimum size of ditch recommended is determined, not by the probable run-off, but by the limitations of this machine. Smaller ditches and smaller dredges are practicable for excavation in prairie countries, but where the dredge must work in woods, taking out stumps and timber as well as earth, one built for a yard, or a yard and a half dipper, and mounted on an 18-foot boat, will probably dig a mile of canal as cheaply as any smaller dredge will dig a mile of ditch of any less size. Such a machine will dig a ditch not less than 12 to 18 feet wide on the bottom, 20 to 22 feet wide on top, and 5 feet deep. The minimum ditch recommended in this report is one with a bottom width of 14 feet, a top width of 22 feet, and a depth of 8 feet. The depth is determined by the necessity of good drainage, and not by the requirements of the dredge. A mile of such ditch can be dug in a flat, wooded country at a cost of $1,000 for removing the earth and $500 a mile for clearing the right of way. The contractors' price to cover installation, operation, repairs, exigencies, and profit would ordinarily be about twice this amount, or $3,000 a mile. The latter figure is used in this report as the cost per mile for minimum ditch construction. This amounts to about 10 cents per yard, with about $200 per mile for clearing right of way. For work in old bayous, where fallen and underground timber is encountered, and where the difficulty of clearing the right of way is greater, a considerably higher price per yard is estimated, depending upon the amount of obstructions which may be encountered. A minimum ditch in fairly good condition and with a fall in the water surface of 6 inches to the mile will remove about 1 inch of water from 7 square miles of drainage area, or three-fourths of an inch from 10 square miles in twenty-four hours.

For larger ditches a contract price of 10 cents per yard should be sufficient, with an added amount for clearing right of way on those having a bottom width of less than 20 feet. The largest excavated channels recommended in this report are to have a bottom width of 80 feet and a depth of 10 feet. It is believed that a contract price of 10 cents per yard need not be exceeded on work of this size, and that 9 cents or less per yard can be secured on ditches with bottom widths of 30 to 50 feet. Ten feet is stated as a desirable depth of excavation. A complete survey may indicate the possibility of securing greater depths without danger of caving banks.

CLEARING AND IMPROVING NATURAL BAYOUS AND CHANNELS.

The cost of excavating earth in the bottom of old bayous will be perhaps 50 to 100 per cent greater than the cost of excavating on level ground, and for that reason very little excavation is recommended in old channels. The clearing of natural channels of trees and brush will cost $200 to $2,000 per mile, and is estimated at $20 to $50 per acre, depending on the amount of work to be done.

For the most part the removal of large trees can best be accomplished by the use of skidding machines, or similar devices used in logging operations. The brush and small trees should be cut by hand and burned.

LEVEES.

The levees necessary along the Red and Black rivers represent ordinary conditions for levee construction. The section adopted has an 8-foot crown and 3 to 1 slopes on both sides. Where the height is between 5 and 9 feet the construction is estimated at 20 cents per cubic yard, and for heights of 9 to 15 feet, 25 cents per yard.

FLOODGATES.

An estimate of the probable cost of the floodgate for discharging the water from Concordia Parish was prepared. It is little more than a guess, as no data were available for use as to the conditions of construction. Before an accurate estimate of the probable cost can be made, a survey of the land near the mouth of the Cocodrie Bayou will be necessary. This survey should include an examination of the site by means of borings to determine how deep it will be necessary to carry the foundations of the structure.

SUMMARY OF COST.

The following gives an itemized summary of cost for the various features of the proposed improvement and also an estimate of the additional cost in case the Red and Mississippi rivers are not separated:

MAIN OUTLET DRAINAGE.

Bayou Macon:		
Levee along Bayou Macon from a point noted on the War Department map of the bayou as being about 4 miles below Osbornes Ferry, in Franklin Parish, to the state line, 106 miles long, 4 feet high, 6 feet top, with 2 to 1 slopes, 11,000 cubic yards per mile, 1,166,000 cubic yards, at 15 cents per yard	$175,000	
Filling old bayous and low places along Bayou Macon, in completing the levee, 91,500 cubic yards, at 15 cents	14,000	
Similar levee, along Joes Bayou, 5 miles long, 11,000 cubic yards per mile, 55,000 cubic yards, at 15 cents per yard	8,000	
Clearing trees and brush from banks of Bayou Macon, 106 miles long, 106 miles, at $1,800 per mile	191,000	
Clearing trees and brush from banks of Baxters Bayou, 13 miles long, 13 miles, at $1,800 per mile	23,000	
		$411,000
Tensas River relief and improvement:		
Clearing banks and bed of Tensas River (mouth of Bull Bayou to mouth of Roaring Bayou), 150 feet on each side, 36 acres per mile, at 50 cents per acre, 107 miles, at $1,800 per mile	193,000	

Tensas River relief and improvement—Continued.		
Clearing banks of Joes Bayou (entire length), 300 feet wide, 35 cents per acre, 65 miles, at $1,260 per mile	$82,000	
Excavating channel through chain of lakes and bayous between Tensas River and Macon Bayou as relief to Tensas River, at $6,000 per mile (no estimate of yardage made, but cost judged sufficient), 10 miles, at $6,000 per mile	60,000	
Excavating ditch from Indian Lake south, to carry water from lake through chain of lakes into Bayou Macon, 11 miles long, 165,000 cubic yards per mile, 1,815,000 cubic yards, at 10 cents per yard	182,000	
Excavating ditch to connect the above-mentioned ditch with Bayou Macon, 2 miles long, 100 feet base, 340,000 cubic yards per mile, 680,000 cubic yards, at 10 cents per yard	68,000	
Outlet channel extending 8 miles southwest from Lake One to bayous, 156,500 cubic yards per mile, 1,252,000 cubic yards, at 10 cents per yard	125,000	
Clearing and improving 20 miles of bayou in southern part of Madison Parish for main outlet, at $5,000 per mile	100,000	
		$810,000
Tensas Parish: Enlarging bayous and constructing channels for outlet drainage		500,000
Concordia Parish:		
Levee along Old and Red rivers, and 15 miles along Black River, 45 miles of levee, 62,000 cubic yards per mile, 2,790,000 cubic yards, at 25 cents per yard	698,000	
Enlarging 40 miles of old levee along Black River, estimated at 20,000 cubic yards per mile, 20 cents per cubic yard, 800,000 cubic yards, at 20 cents per yard	160,000	
Main drainage channel to supplement Cocodrie Bayou, 2,310,000 cubic yards, at 10 cents per yard	231,000	
Flood gates and controlling works	500,000	
		1,589,000
Total		3,310,000

LATERAL DRAINAGE.

East Carroll Parish, 370 miles of minimum ditches, at $3,000 per mile	1,110,000	
Madison Parish, 620 miles of minimum ditches, at $3,000 per mile	1,860,000	
Tensas Parish, 570 miles of minimum ditches, at $3,000 per mile	1,710,000	
Concordia Parish, 635 miles of minimum ditches, at $3,000 per mile	1,905,000	
Total for lateral drainage		6,585,000
Total		9,895,000
8 per cent for cost of administration, engineering, legal expenses, etc.		792,000
Grand total		10,687,000

ADDITIONAL COST OF MAIN DRAINAGE NECESSARY IF THE MISSISSIPPI AND RED RIVERS ARE NOT SEPARATED.

The drainage of the territory between Bayou Macon and Tensas River will be diverted into the Indian Lake channel and thence into Bayou Macon, instead of into the Tensas River through Henley Bayou. Additional cost	$182,000
Additional cost of levees in Concordia Parish	800,000
Total	982,000

There will also be a material increase in the cost of lateral drainage if the diversion is not made, due to reduced slopes in the drainage channels, requiring larger sections. Data was not secured which would enable this increase to be estimated.

OUTLET DRAINAGE NECESSARY AND PRACTICABLE UNDER PRESENT CONDITIONS IN EAST CARROLL, MADISON, AND TENSAS PARISHES.

Bayou Macon drainage:	
Clearing 13 miles of Baxters Bayou (Lake Providence to outlet, 50 feet wide on each side), 36 acres to the mile, at $50 per acre, $1,800 per mile	23,000
Improvement and relief of Tensas River:	
Clearing 107 miles of Tensas River channel (mouth of Bull Bayou to mouth of Roaring Bayou), 36 acres to the mile, at $50 per acre, $1,800 per mile	193,000
Clearing 65 miles of Joes Bayou (entire length) 300 feet wide, at $35 per acre, $1,260 per mile (for relief of Tensas River)	82,000
10 miles of channel through chain of lakes and bayous at $6,000 per mile. Estimated to be sufficient, but yardage not estimated	60,000
11 miles of channel from Indian Lake to Macon Bayou (entering bayou near Osbornes Ferry, noted as kilometer 54.5 on War Department survey). For relief of Tensas River, 80-foot bottom, 10 feet deep, 165,700 yards per mile, at 10 cents per yard	182,000
2 miles of ditch as outlet to above channel into Bayou Macon, 100-foot base, 15 feet deep, 340,000 cubic yards per mile, at 10 cents per yard	68,000
Outlet channel from Lake One and Roundaway Bayou, leaving Lake One 1 mile south of Vicksburg, Shreveport and Pacific R. R., extending southwest 8 miles to bayou, 75-foot bottom, 10 feet deep, ½-1 slopes, 156,500 yards per mile, 1,252,000 yards, at 10 cents per yard (for relief of Tensas River)	125,000
Clearing and improving 20 miles of bayou in south part of Madison Parish as outlet for above-described channel and others, at $5,000 per mile	100,000
Tensas Parish—outlet drainage channels, new channels and bayou improvement for main outlets	500,000
Total estimated cost of main drainage now necessary and practicable in the three parishes	1,333,000

LATERAL DRAINAGE.

East Carroll Parish, 370 miles, at $3,000 per mile	1,110,000
Madison Parish, 620 miles, at $3,000 per mile	1,860,000
Tensas Parish, 570 miles, at $3,000 per mile	1,710,000
Total main and lateral drainage now practicable and necessary	6,013,000

A POLICY FOR THE DISTRICT.

Before any considerable amount of money is spent in drainage improvements, a complete drainage survey of the district should be made and a plan for the improvement be devised. It will then be possible definitely to determine what steps can be taken at first and what order may best be followed in developing the territory.

The following outline of policy must be taken as provisional, with the understanding that it is not presented as an adequate statement. Only about six weeks have been spent altogether in securing data in the field and in the preparation of a report on what is probably the greatest drainage project in the United States. The presentation of any report at all at the present time is justified only by the necessity for having the best information obtainable in the limited time available for use in connection with the organization of the district.

A plan for the reclamation of this region must consist essentially of two principal features: (1) A system of main drainage channels for carrying the waters of the district to the final point of discharge; and (2) a system of lateral channels for the actual drainage of the land. The main channels will complete the drainage of some areas, and some of the lateral channels will perform to a certain extent the function of main outlet channels, but the two functions are in the main distinct.

The completed plan having been prepared, the improvement of the district will consist of two classes of work—the construction of the main drainage system and the completion of the reclamation by means of lateral drainage. These two lines of work in some instances can be carried on simultaneously, for there are many areas which may be improved before the completion of the main system.

The main system should be constructed by taxing the entire district. For purposes of lateral drainage the district should be divided into natural subdivisions, as determined by the complete survey, and the cost in each subdivision should be met by taxing the land in proportion to the benefits received.

It is possible, and in fact very desirable, to construct this work a part at a time as demand for the land increases. The improvement on Bayou Macon need not be undertaken until developments in Arkansas make it necessary, and improvements in Concordia Parish will probably not be practicable until the proposed separation of the Red and Mississippi rivers is made. Therefore, the only parts of the main drainage which are now desirable are the improvements and relief of Tensas River and the main drainage outlets of Tensas Parish. This part of the main drainage system is estimated to cost

$1,333,000, and the lateral drainage of East Carroll, Madison, and Tensas parishes is estimated at $4,680,000, making a total of $6,013,000 for that part of the system which can be carried out satisfactorily under present conditions. The construction of those parts of the main drainage system mentioned above will make possible the complete reclamation of these three parishes, with the exception of a few thousand acres in Tensas and Franklin parishes.

SUGGESTIONS FOR THE DRAINAGE ORGANIZATION.

The following are a few of the provisions which it is desirable to consider for the formation of the drainage organization:

(1) Cooperation with Arkansas should be made possible in planning and constructing drainage works which will affect both States, as well as such cooperation with other parishes, as may be necessary in reclaiming Turnbull Island and parts of Franklin Parish.

(2) Provision should be made so as to allow the different parts of the system to be developed at different times as necessity may require, and the sequence of development should be left to the officers of the district rather than to be defined by statute.

(3) Nearly all important drainage improvement in the United States is paid for in the first instance by proceeds from the sale of bonds, and it is probable that development within the district will be limited to a large degree to improvements which may be financed in this manner. This condition should be considered in making provision for bond issues.

(4) The district should be enabled to construct any manner of drainage works which may be necessary, either by contract or by the purchase and operation of machinery by the district, and the employment of a continuous force for maintenance should be made possible.

(5) The district officers should be given full control over all navigable streams, lakes, and canals in the district, to specify the manner in which they may be dammed or obstructed for irrigation purposes, to prevent their being filled or injured by landowners or others, and to regulate or prevent the rafting of timber upon them. They should also have power to prescribe the size of openings necessary under bridges which may be constructed over such channels.

The foregoing suggestions cover only a few of the points which must be considered in organizing a drainage district.

THE COMPLETE SURVEY.

The object of a drainage survey of the Fifth Louisiana Levee District is to provide a complete, efficient, and economical plan for the drainage of the entire district and to secure such data as will enable that plan to be most effectively carried out. A complete drainage survey should secure the following information:

Hydrographic data and information concerning the existing water-carrying channels. This would include a survey of the channels themselves and observations of stream discharge. A survey of the stream channels should include the location of each channel on the map, with profiles of the bottom of the channel and the top of the bank and with numerous cross sections. Information should also be secured concerning the amount of timber to be removed from the bed of the stream, the clearing required on the banks, the stability of the banks, and their ability to withstand increased velocities without caving.

Observations of the discharge of streams should include continuous gauging of all important channels for not less than a year, and during at least one period of high water. Rating curves for the various channels should be secured and the application of hydraulic formulas to the streams of the district should be carefully worked out.

In addition to data concerning natural channels, the topography of the surface should be developed, either by locating contour lines or by running lines of levels across the district at frequent intervals.

An examination of soil conditions should be made from the standpoint of canal and levee construction, and a careful effort made to determine the rate of run-off from cultivated and from wooded areas, as a basis for determining the proper size of drainage channels.

It has been observed that the character of data secured on a drainage survey often depends to a considerable extent upon the class of data which is habitually collected by the engineers in charge of the survey. For instance, a drainage survey made by a party of engineers whose usual practice is for the purpose of improving channels for navigation may show a very careful survey of stream channels, but little or no interior topography; whereas a drainage survey made by engineers whose practice is in topographical surveying may include a large amount of surface topography, but almost no data which will enable estimates to be made of the capacities of channels. A well-balanced drainage survey will not be limited to any one class of data or to one line of investigation, but will secure information on topography, channel improvement, soil conditions, conditions of run-off, and cost of construction, in the manner that experience in drainage engineering indicates to be necessary for the preparation of plans.

The best result from a drainage survey can be secured only when the various lines of investigations are carried on simultaneously and under a single management. Otherwise there will of necessity be a large amount of duplication of work and a failure to get the best results. Up to the present time surveys have been made within the limits of the district by the War Department, the Mississippi River Commission, the State Board of Engineers of Louisiana (among whom there has been a certain degree of cooperation), the United States Geological Survey, and the United States Drainage Investigations. Even if government aid is to be secured in making a complete survey of the district, it would be desirable to organize a permanent engineering staff with which the various government departments could cooperate, each in its own field, thereby coordinating the work of the different departments so as to eliminate duplication in completing a drainage survey. A permanent engineering staff is necessary also in order to continue observations after the survey is completed, to hold under a single organization the records of the survey, to plan and superintend the details of construction, and to care for the maintenance of the system. Many of the factors involved in so large a reclamation project must be worked out on that project, and this can be done best by a permanent engineering staff in the district. The levees required on the project may be built under the supervision of the Mississippi River Commission or that of the board of state engineers; the navigable streams will doubtless be in charge of the engineers of the United States Army, while permanent gauging stations may be maintained by the Water Resources Branch of the United States Geological Survey. In order properly to coordinate these various lines of work with the general plan for drainage, a permanent staff will be of benefit.

COST OF SURVEY.

Below is given an estimate of the cost of a full and complete survey. The completion of the topographic map of the entire district by the United States Geological Survey would be of material assistance, reducing the cost of the complete survey by about $45,000 or leaving the remaining survey to cost only about two-thirds as much as it otherwise would. That part of Franklin Parish east of Bayou Macon is included in these estimates.

20 gauging stations, at $100 each	$2,000
Reading gauges, two years, $750 per year	1,500
Hydrographer, two years, at $1,500 per year	3,000
Assistant hydrographer, two years, at $1,000 per year	2,000
Operating expenses for hydrographer and party	5,000
Soil borings for construction purposes, and estimate of cost of clearing bayous.	3,000
Survey for location of floodgates	5,000
Rainfall data	1,000
2 draftsmen, at $1,200 each per year	2,400
Commissary and property man	900
Stenographer	900
Chief engineer, at $5,000	10,000
Stationery, supplies, and equipment	1,000

Topographic surveys and surveys of natural channels:	
East Carroll Parish	$10,540
Madison Parish	17,920
Tensas Parish	17,720
Concordia Parish	19,000
Preparing report and estimates	5,000
Consulting engineers	10,000
Incidentals	2,620
Total	120,500

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