LITTLE MISSOURI RIVER, WYO. MONT., S. DAK., AND N. DAK.

LETTER

FROM

THE SECRETARY OF WAR

TRANSMITTING

PURSUANT TO SECTION 1 OF THE RIVER AND HARBOR ACT APPROVED JANUARY 21, 1927, AND SECTION 10 OF THE FLOOD CONTROL ACT OF MAY 15, 1928, A LETTER FROM THE CHIEF OF ENGINEERS, UNITED STATES ARMY, DATED MAY 9, 1933, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, CONTAINING A GENERAL PLAN FOR THE IMPROVEMENT OF LITTLE MISSOURI RIVER, WYO., MONT., S.DAK., AND N.DAK., FOR THE PURPOSES OF NAVIGATION AND EFFICIENT DEVELOPMENT OF ITS WATER POWER, THE CONTROL OF FLOODS, AND THE NEEDS OF IRRIGATION

June 8, 1933.—Referred to the Committee on Rivers and Harbors and ordered to be printed with nine illustrations

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1933

CONTENTS

LETTER OF TRANSMITTAL

War Department,
Washington, May 10, 1933.

The Speaker of the House of Representatives.

Dear Mr. Speaker: I am transmitting herewith a report dated May 9, 1933, from the Chief of Engineers, United States Army, on Little Missouri River, Wyo., Mont., S.Dak., and N.Dak., made under the provisions of House Document No. 308, Sixty-ninth Congress, first session, which was enacted into law with modifications in section 1 of the River and Harbor Act of January 21, 1927, and under the provisions of section 10 of the Flood Control Act of May 15, 1928.

The funds available to the War Department under the appropriation "Printing and binding, War Department", fiscal year 1933, for the printing of reports of this character, the cost of which is chargeable to the above-named appropriation, as required by Public Resolution No. 13, approved March 30, 1906, are insufficient to provide for the printing of this report.

Sincerely yours,

Geo. H. Dern,
Secretary of War.

LITTLE MISSOURI RIVER, WYO., MONT., S. DAK., AND N. DAK.

War Department,
Office of the Chief of Engineers,
Washington, May 9, 1933.

Subject: Report on Little Missouri River, Wyo., Mont., S.Dak., and N.Dak.

To: The Secretary of War.

1. I submit for transmission to Congress, my report with accompanying papers and illustrations, on Little Missouri River, Wyo., Mont., S.Dak., and N.Dak., made under the provisions of House Document 308, Sixty-ninth Congress, first session, which was enacted into law with modifications in section 1 of the River and Harbor Act of January 21, 1927, and under the provisions of section 10 of the Flood Control Act of May 15, 1928.

2. Little Missouri River rises in northeastern Wyoming, flows in a general northeasterly direction through Montana, South Dakota, and North Dakota, and enters the Missouri River 1,583 miles above the mouth of the latter. It is 560 miles long and has an average fall of 4.6 feet per mile. Its drainage basin has an area of about 9,500 square miles. The climate is semiarid, the average annual rainfall being about 16 inches. The maximum discharge at Medora (for 67 percent of the total drainage area) is 33,700 cubic feet per second, the minimum 1.9 cubic feet per second, and the mean 651 cubic feet per second. The area is sparsely populated, the total population being about 25,000, and that of the largest town, Beach, N.Dak., about 1,100. Agriculture and cattle raising are the principal industries.

3. This river is not navigable. The district engineer states that the intermittent and extremely small flow during the low-water season renders its development in the interest of navigation entirely impracticable.

4. Areas in this basin subject to overflow are small and scattered, and, in general, the land is of relatively low value. The district engineer states that the flood damage does not justify the preparation of a general flood-control plan. The municipalities of Marmarth, N.Dak., and Wibaux, Mont. (on Beaver Creek,), are subject to large damages, and he presents plans for their protection by levees and cut-offs. The cost at Marmarth, including annual operation and capitalized maintenance charges at 5 percent, is estimated at $80,700, as compared to a capitalized average annual direct flood loss of $87,000. At Wibaux the cost is estimated at $126,700, and protection would be given to residential and business property valued at about $700,000. He is of the opinion that both projects are justifiable from an economic standpoint.

5. Investigations of the district engineer indicate that the most suitable location for a reservoir for flood control would be at mile 241, near Bullion Butte, where the drainage area is about 5,300 square miles, or 56 percent of the entire basin. The cost for a reservoir with a capacity of 320,000 acre-feet is estimated at $4,830,000, or

$15.10 per acre-foot. If operated for the control of Mississippi River floods, the reduction in flood heights at Cairo would be insignificant, and if operated primarily for the control of Missouri River floods, the stage reduction for major floods at Kansas City would vary from one half to 3 inches. He considered that these benefits would be incommensurate with the cost. He also studied the use of this reservoir for increasing low-water discharge on the Missouri and Mississippi Rivers for the benefit of navigation, but concludes that it would be of little value in a series of critical low-water years.

6. Irrigation at present is confined to a total of only about 1,000 acres of land, in tracts of less than 100 acres each. The only opportunity for any considerable additional development is in the main valley near Alzada, Mont. A project is outlined by the district engineer to comprise about 26,000 acres on the westerly side of the stream, of which, however, only about 3,000 acres in scattered tracts are suitable for development. The estimated cost, including a reservoir, is about $568,000, which would entail an annual charge of $22.85 per acre if financed in accordance with the statutes of Montana, or $5.98 per acre if developed as a Federal project without interest and with repayments over a period of 40 years. The district engineer is of the opinion that the soils and climate of the basin would not justify an annual charge greater than about $2.60 per acre, and that the project is therefore not feasible.

7. There are no existing hydroelectric plants in the basin. The district engineer finds that the most favorable potential development is at the Bullion Butte flood-control reservoir site. A plant there with an installed capacity of 11,000 kilowatts and costing about $5,400,000 would have an average annual output, if operated solely for power, of about 29,000,000 kilowatt-hours, with a cost at the switchboard of 18.7 mills per kilowatt-hour. If operated primarily for the control of Mississippi River floods, intermittent secondary power could be produced at a cost of about 1.7 mills per kilowatt-hour, if all reservoir costs were charged to flood control. The district engineer does not consider either plan to be economically feasible.

8. He concludes that under existing conditions the only feasible plan of development in the Little Missouri Basin is that for the flood protection of the towns of Marmarth and Wibaux, and that there is no Federal interest involved therein.

9. The division engineer concurs generally in the views of the district engineer, but states that the economic justification of the flood-relief plans for Marmarth and Wibaux is a matter to be determined by those municipalities.

10. The Mississippi River Commission, to which the reports were referred, as required by law, states that—

> The effect of the construction of storage reservoirs in the Little Missouri River Basin on the flood heights of the Mississippi River at Cairo would be insignificant and would have no material effect on the plan of flood control for the lower Mississippi River.

11. The reports have been referred, as required by law, to the Board of Engineers for Rivers and Harbors, and its report, agreeing in the views of the division engineer, is submitted herewith.

12. After due consideration of the above-mentioned reports, I concur in the recommendations of the Board of Engineers for Rivers and Harbors. Improvement of this river for navigation is not prac-

ticable. Flood-control works for the protection of two municipalities would seem to be justified, if consideration is given to both economic and humanitarian aspects, but this is a matter for local decision, and no Federal interest is involved sufficient to justify participation therein by the United States. The construction and operation of a reservoir or reservoirs in the basin would be of little value either to flood control or navigation on the Missouri or Mississippi Rivers. The development of the only potential irrigation project of any magnitude does not appear economically feasible, nor can hydroelectric power be economically developed at the present time.

LYTLE BROWN,
Major General,
Chief of Engineers.

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

SYLLABUS

The Board of Engineers for Rivers and Harbors is of the opinion that improvement of this stream for navigation, either alone or in connection with power development, flood control, or irrigation, or any combination thereof, should not be undertaken by the United States at the present time.

[Fourth endorsement]

BOARD OF ENGINEERS FOR RIVERS AND HARBORS,
Washington, D.C., April 7, 1933.

The CHIEF OF ENGINEERS, UNITED STATES ARMY:

1. The following is in review of the report on Little Missouri River, Wyo., Mont., S.Dak., and N.Dak., submitted under the provisions of House Document 308, Sixty-ninth Congress, first session, which was enacted into law with modifications in section 1 of the River and Harbor Act of January 21, 1927, and under the provisions of section 10 of the Flood Control Act of May 15, 1928.

2. Attention is invited to the reports herewith, which contain information concerning existing and prospective developments on this stream for navigation, power development, flood control, and irrigation. The reporting officers concur in the opinion that the improvement of this stream for any purpose by the United States is not advisable.

3. The Mississippi River Commission, to which the reports were referred, as required by law, states that—

> The effect of the construction of storage reservoirs in the Little Missouri River Basin on the flood heights of the Mississippi River at Cairo would be insignificant and would have no material effect on the plan of flood control for the Lower Mississippi River.

4. The Board concurs in the views of the division engineer. There is no warrant for any improvement of the river for navigation at this time. Neither power development nor additional irrigation can be economically justified under existing conditions. Flood-control works for the protection of two municipalities would seem to be justified if consideration is given to both economic and humanitarian aspects, but this is a matter for local decision, and no Federal interest is involved sufficient to justify any participation therein by the United States. The construction and operation of a reservoir or reservoirs in the basin would be of little value either to flood control

or navigation on the Missouri or Mississippi Rivers. The Board therefore reports that, in its opinion, the improvement of this river for navigation either alone or in connection with power development, flood control, or irrigation, or any combination thereof, should not be undertaken by the United States at the present time.

For the Board:

W. J. Barden,
Colonel, Corps of Engineers,
Senior Member.

REPORT OF THE DIVISION ENGINEER

SYLLABUS

There are no agricultural lands of consequence which are subject to damaging floods in the basin of Little Missouri River. Plans for local flood relief are presented for the towns of Marmarth, N.Dak., and Wibaux, Mont. The question of the justification of these plans should be decided by affected interests. The operation of a reservoir or reservoirs in this basin would be of little value to flood and navigation conditions on the Missouri and Mississippi Rivers. The development of the only potential irrigation project of any magnitude would result in costs greatly in excess of the ensuing benefits. The stream offers no possibilities for economical development of navigation or water power. There appears to be no further Federal interest involved. It is recommended that the report be printed.

War Department,
Office of the Division Engineer,
Upper Mississippi Valley Division,
St. Louis, Mo., September 30, 1932.

Subject: Report on Little Missouri River, Wyo., Mont., S.Dak., and N.Dak.

To: The Chief of Engineers, United States Army.

1. *Authority.*—This report on Little Missouri River, Wyo., Mont., S.Dak., and N.Dak., is submitted in compliance with the provisions of the River and Harbor Act of January 21, 1927, which authorized surveys in accordance with House Document No. 308, Sixty-ninth Congress, first session, and under the provisions of section 10 of the Flood Control Act of May 15, 1928.

2. *Description.*—Little Missouri River has its source in northeastern Wyoming and flows in a general northeasterly direction through the States of Montana, South Dakota, and North Dakota to join the Missouri River about 1,583 miles above its mouth. The principal characteristics of the river are: Drainage area, 9,500 square miles; length (source to mouth), 560 miles; average fall, 4.6 feet per mile; and maximum, minimum, and mean discharges at Medora, N.Dak. (drainage area 6,320 square miles or about 67 percent of the basin), 33,700, 1.9, and 651 cubic feet per second, respectively. The picturesque and colorful Badlands form the most distinctive topographic feature of the basin.

LOCAL FLOOD CONTROL

3. *Flood situation.*—The valley of the Little Missouri River contains only small and scattered areas subject to overflow and they consist, in general, of land of relatively low value. There are two towns within the basin that are subject to damage from floods. These are the municipalities of Marmarth, N.Dak. (mile 306, Little Missouri

River), and Wibaux, Mont. (located on Beaver Creek). As a whole, the flood losses along this stream are of such a minor character that general relief measures could not possibly be justified. In view of this, the district engineer has regarded the presentation of a comprehensive plan for the purpose of general flood relief in the Little Missouri Basin as unnecessary. He states that in his opinion the stream is not "subject to destructive floods" within the meaning of section 10 of the act of May 15, 1928. In this I concur.

4. *Plan for flood control at Marmath, N.Dak.*—The district engineer has, however, outlined plans for flood relief at the municipalities of Marmarth and Wibaux. In each case protection would be obtained by the construction of levees, cut-offs, and the installation of pumping facilities for interior drainage. He estimates that works necessary for the protection of Marmarth from floods of 100-year frequency could be built at a cost of about $80,700, including annual operation and maintenance charges capitalized at 5 percent. However, he states that if the project were financed by the issue of long-term bonds, that the total expenditure would be considerably more than that indicated. The average annual direct flood loss at Marmarth (period 1908 to 1930, inclusive) is estimated at $4,350, which if capitalized at 5 percent amounts to $87,000.

5. *Plan for flood control at Wibaux, Mont.*—The district engineer estimates that a project for the protection of the town of Wibaux, Mont., from such an unusual flood as occurred on June 7, 1929, could be constructed at a cost of about $127,000, including annual operation and maintenance charges capitalized at 5 percent but excluding any financing charges. He states that the flood of 1929 inundated property which has an approximate assessed valuation of about $698,000, and that the flood hazard at this locality constitutes a serious menace to human life.

6. *Conclusions, local flood-control plans.*—In the case of the plan for the protection of Marmarth, the estimated direct benefits which would be received are somewhat greater than the estimated cost of the improvement, exclusive of financing charges, and no consideration has been given to the possible indirect benefits obtainable. The district engineer is of the opinion that this plan is economically justified. In the case of the Wibaux plan, while no estimate of the benefits obtainable from this plan has been made, he believes it to be justified when viewed from both its economic and humanitarian aspects.

7. These flood-relief plans are of local rather than of national interest. In my opinion their justification should be decided by the interests concerned before they commit themselves to expenditures for protection. The plans proposed by the district enginer will be made available to the general public by the printing of this report, thus enabling affected parties to take appropriate action.

FLOOD WATER RESERVOIRS

8. *Suggested Bullion Butte Reservoir.*—In compliance with the act of May 15, 1928, the district engineer has investigated the possiblities of the use of reservoirs in the Little Missouri Basin for the control of its flood waters. He has selected as most suitable for this purpose, one potential reservoir located on the main stream (dam site at mile 241)

which he has termed the "Bullion Butte Reservoir." This reservoir would have a capacity of 320,000 acre-feet obtainable at an estimated cost of about $4,830,000, or $15.10 per acre-foot. The drainage area at the site is about 5,290 square miles, or approximately 56 percent of the entire Little Missouri Basin.

9. *Effect of Bullion Butte Reservoir on Mississippi River floods.*—Computations made by the district engineer indicate that the probable reductions in the Cairo peak, obtainable through the operation of this reservoir for Mississippi flood relief, would have varied from less than one tenth to about seven tenths of 1 inch during the major Mississippi floods of 1922 and 1929. While no stream flow records are available in the Little Missouri Basin for other major Mississippi floods, the indications are that the possible effects of this reservoir on those floods would have been of a similar magnitude. The district engineer regards the cost of this reservoir as excessive when compared to the benefits to Mississippi flood control that might be obtained. I concur in his opinion.

10. *Effect of Bullion Butte Reservoir on Missouri River floods.*—With reference to possible operation of this reservoir for the purpose of Missouri River flood control, the district engineer states that, if it had been operated for that purpose during the past 31 years (1900 to 1930), the stages of major floods at Kansas City could have been reduced by amounts varying from about one half an inch to approximately 3 inches. He points out that the adopted method of storage for Mississippi flood relief might be so modified as to store water over both the Mississippi and Missouri River flood danger periods, but that such operation would materially decrease the dependable benefits to both interests. He is of the opinion that the reductions in the stage of Missouri River floods, obtainable through the operation of the Bullion Butte Reservoir for that purpose, would be so small they could have no important bearing upon a general Missouri River flood-control plan. In this I agree.

11. *Effect of Bullion Butte Reservoir on navigation.*—The district engineer has treated, in a general way, the question of the possible improvement of low-water discharges of the Missouri River as a result of regulating the discharge of the Little Missouri River by means of the potential Bullion Butte Reservoir. With this reservoir full at the beginning of the low-water season, an approximate discharge of 1,300 cubic feet per second could be supplied during the period August 1 to November 30, thereby increasing stages at Kansas City during low-water periods about 0.2 of a foot. However, due to the small run-off available, the reservoir could not have been filled during either of the critical low-water years of 1930 or 1931, thus seriously impairing its value for navigation purposes. The Mississippi River, in the vicinity of St. Louis, has characteristics of discharge during low-water periods that correspond, in general, to those of the lower Missouri. The district engineer states that the Bullion Butte Reservoir could be expected to produce a still smaller effect upon the low-water stage of the Mississippi at St. Louis than upon the low-water stage of the Missouri at Kansas City. He concludes that the operation of this reservoir would be of little value to navigation on the lower Missouri and Mississippi Rivers during a series of critical low-water years. I concur in his conclusion.

IRRIGATION

12. *Existing irrigation developments.*—While climatic conditions in the Little Missouri Basin are such that irrigation would materially increase crop production, irrigation at present is confined to a total of only about 1,000 acres of land embraced in tracts of less than 100 acres in area.

13. *Potential irrigation development.*—The district engineer states that the only opportunity for irrigation development in the basin of continuous areas of considerable size is in the wide valley of the main stream near Alzada, Mont. He has studied a project in this vicinity similar to that which the Little Missouri Land and Irrigation Co. proposed to develop as early as 1912. The project, as he has outlined it, comprises approximately 25,700 acres of land on the westerly side of the river. However, a detailed soil classification has shown that only 3,000 acres, located in scattered tracts, are suitable for irrigation development. Stream flow data show that summer discharges of the stream are quite erratic and an analysis indicates that a reservoir would be required to furnish a dependable water supply to the irrigable land. He estimates that the necessary reclamation works, consisting of a diversion dam, diversion canal, reservoir, and distribution canal, would cost about $568,000. This project would necessitate an annual charge of $22.85 per acre, if financed in accordance with the statutes of Montana, or $5.98 per acre if developed as a Federal project without interest and with repayments extended over a period of 40 years.

14. *Conclusions, irrigation developments.*—The district engineer is of the opinion that the soils and climate of the basin would not justify an annual charge greater than $2.60 per acre. Accordingly, he concludes that no economically feasible irrigation potentialities exist within the basin. In this I concur.

NAVIGATION

15. *Navigation situation.*—The Little Missouri River is not navigable under present conditions. The intermittent character of the run-off and the sparsely settled country through which the river flows, render its improvement in the interest of navigation impracticable.

POWER

16. *Existing power developments.*—There are no existing power plants in the Little Missouri River basin. The only important load centers, namely, Marmarth, N.Dak., and Wibaux, Mont., are served by transmission lines from plants located at sources of cheap fuel supply outside of the basin.

17. *Potential water-power developments.*—The district engineer states that the most favorable potentialities for water-power development in the Little Missouri Basin are in connection with the Bullion Butte Reservoir which he has also investigated for control of the flood waters of the basin. His studies indicate that, if this reservoir were developed solely for generation of power with an installed capacity of 11,000 kilowatts, the average annual power output would amount to about 29,000,000 kilowatt-hours which could be produced at an average cost of 18.7 mills per kilowatt-hour for all power produced.

A study of the development of this reservoir, operated primarily for the control of Mississippi floods and secondarily for the generation of power, indicated that during two Mississippi flood years (1922 and 1929), an annual average output of about 27,000,000 kilowatt-hours of incidental secondary power could have been made available. With all items charged against flood control, except the cost of the power facilities, the estimated cost of this secondary power would amount to about 1.7 mills per kilowatt-hour. While this unit cost might possibly place this output in the realm of economic secondary power, the conditions on which the estimate is based are most advantageous and actual unit production costs over a long period would be much greater.

18. *Conclusions, power development.*—Based on the unit production costs indicated by his computations, the district engineer concludes that hydroelectric power development in Little Missouri Basin, either alone or in combination with other forms of development, is not economically feasible. I concur in this conclusion.

PLAN OF DEVELOPMENT

19. *Statement of plan.*—The district engineer presents a plan of development for the Little Missouri Basin which he believes to be the only feasible plan under existing conditions. The improvements proposed under this plan are flood protection works, as previously described, for the towns of Marmarth, N.Dak., and Wibaux, Mont. The district engineer is of the opinion that there is no Federal interest in these plans on the score of flood control and/or navigation benefits on the Mississippi and/or Missouri Rivers.

CONCLUSIONS AND RECOMMENDATIONS

20. *District engineer's conclusions.*—After giving due consideration to all the problems involved in the Little Missouri Basin in connection with flood control, irrigation, navigation, and power development, the district engineer concludes:

(*a*) That Little Missouri Basin is not "subject to destructive floods" within the meaning of section 10 of the act of May 15, 1928, and that the preparation of a general flood-control plan is not justified. That local flood-control works for the towns of Marmarth, N.Dak., and Wibaux, Mont., appear economically feasible.

(*b*) That the operation of a reservoir or reservoirs in the basin would be of little value to flood control and navigation on the Missouri and Mississippi Rivers.

(*c*) That the climatic conditions existing within the basin are such that irrigation would materially increase crop production; but that the development of the only potential irrigation project of any magnitude is economically infeasible.

(*d*) That development of navigation on Little Missouri River is impracticable.

(*e*) That there are no potential hydroelectric developments in Little Missouri Basin which could have costs within the range of economical development even if suitable power markets existed.

(*f*) That the only feasible plan of development in the Little Missouri Basin is the plan discussed under the heading "Plan of Development."

21. *District engineer's recommendation.*—The district engineer recommends that the projects for the protection of flooded areas in Marmarth, N.Dak., and Wibaux, Mont., be adopted by the Department as an approved plan for local flood control in the Little Missouri River Basin, as required by House Document 308, Sixty-ninth Congress, first session, and by section 10 of the act of May 15, 1928, and that the report be printed.

22. *Views of the division and sector engineers.*—The sector engineer, Lt. Col. R. C. Moore, and I concur in general in the opinions and conclusions of the district engineer. However, we believe that the economic aspects of the plans for local flood relief at the municipalities of Marmarth and Wibaux should be fully considered by the interests concerned before they commit themselves to expenditures for the protection proposed by the district engineer. There appears to be no further Federal interest involved.

23. *Recommendation.*—The sector engineer and I recommend that the plan of development outlined by the district engineer be accepted as a compliance with the provisions of the acts authorizing these surveys and that the report be printed in order that the data contained therein, collected at Federal expense, may be made available to the general public.

GEO. R. SPALDING,
Colonel, Corps of Engineers,
Division Engineer.

[First endorsement]

OFFICE CHIEF OF ENGINEERS,
Washington, D.C., October 12, 1932.

To the PRESIDENT MISSISSIPPI RIVER COMMISSION,
Vicksburg, Miss.:

1. For comment and recommendation.

By order of the Chief of Engineers:

JOHN J. KINGMAN,
Lieutenant Colonel, Corps of Engineers.

[Second endorsement]

OFFICE PRESIDENT MISSISSIPPI RIVER COMMISSION,
Vicksburg, Miss., November 30, 1932.

To the CHIEF OF ENGINEERS, UNITED STATES ARMY:

1. From a consideration of the report on the Little Missouri River, Wyo., Mont., S.Dak., and N.Dak., the Mississippi River Commission concludes that—

Improvement of the Little Missouri River for navigation is not practicable.

There is no problem of flood control in the basin of the Little Missouri River with the possible exception of the municipalities of Marmarth, N.Dak., and Wibaux, Mont., for which the district engineer has presented a plan providing flood protection at a cost which appears to be less than the value of the benefits to be derived.

The effect of the construction of storage reservoirs in the Little Missouri River Basin on the flood heights of the Mississippi River at Cairo would be insignificant and would have no material effect on the plan of flood control for the lower Mississippi River.

The cost of further development of irrigation projects under present conditions would be greater than the value of the benefits to be derived therefrom.

The development of water power in the basin of the Little Missouri River is estimated to cost more than the value of the benefits that are apparent.

2. The Mississippi River Commission recommends that the report be published for the benefit of those interested.

For the Mississippi River Commission:

H. B. Ferguson,
Brigadier General, Corps of Engineers,
President Mississippi River Commission.

REPORT OF THE DISTRICT ENGINEER

SYLLABUS

1. The Little Missouri Basin is not "subject to destructive floods" within the meaning of section 10 of the act of May 15, 1928. The agricultural areas, subject to overflow, are small and scattered, and the resulting flood damage does not justify the preparation of a flood control plan.

2. A plan is presented, involving the use of levees and minor channel changes, which contemplates the protection of the towns of Marmarth, N.Dak. and Wibaux, Mont., at an estimated cost of $80,700 and $126,700, respectively.

3. The Little Missouri River flood peaks in the past have not materially affected the peak stage of the Mississippi River at Cairo. The flow of the Little Missouri River has very little effect on major Missouri floods. Tentative results indicate that the operation of the Bullion Butte Reservoir in the Little Missouri Basin would be of little value to navigation on the Missouri and/or Mississippi Rivers.

4. The development of irrigation in the Little Missouri Basin is of minor importance. Existing irrigation is limited to about 1,000 acres of valley lands in small units of not more than 100 acres each. The development at this time of any large project within the Little Missouri Basin is impracticable.

5. The erratic and extremely small flow of the Little Missouri, during the low-water season renders its development in the interest of navigation entirely impracticable.

6. There are no existing water-power plants in the basin, and no potentialities exist for future hydroelectric developments.

7. Considerable bank erosion occurs on the Little Missouri but it is of little importance economically, as most of the erosion occurs in the lower course of the river, which is through badlands.

8. There is no Federal interest in the flood-control plans for the protection of Marmarth, N.Dak., and Wibaux, Mont., on the score of flood control and/or navigation benefits on the Mississippi and/or Missouri Rivers.

9. It is recommended that the proposed schemes for protection of Marmarth, N.Dak. and Wibaux, Mont., be considered as the approved plan for local flood control in the Little Missouri Basin required by section 10 of the Flood Control Act of May 15, 1928, and that this report be printed.

War Department,
United States Engineer Office,
Kansas City, Mo., December 5, 1931.

Subject: Report on the Little Missouri River of Wyoming, Montana, South Dakota, and North Dakota.

To: The Division Engineer, Upper Mississippi Valley Division, St. Louis, Mo.

1. *Authority for report.*—This report is submitted under the provisions of House Document No. 308, Sixty-ninth Congress, first session

(law by Act of Jan. 21, 1927 (H.R. 11616, 69th Cong., 2d sess.)) and section 10, Act of May 15, 1928 (S. 3740, 70th Cong., 1st sess).

2. The report is divided as follows:

Part I. Physical and economic description of the basin.
Part II. Floods in the Little Missouri Basin.
Part III. Effect of Little Missouri River flow on Mississippi and Missouri.
Part IV. Irrigation and navigation.
Part V. Existing and potential power developments.
Part VI. Bank erosion and silt.
Part VII. Conclusions.
Part VIII. Plan of development.
Part IX. Recommendation.

3. Appendix I[1] contains maps and charts referred to in the report; appendix II, tables referred to in the report, except those that are incorporated in the text; appendix III, description of potential irrigation projects; appendix IV[2], photographs of points of interest.

4. The preparation of this report was preceded by field investigations covering the entire basin. A preliminary reconnaissance was made in the fall of 1928 to determine the general situation. A more thorough engineering investigation of the basin was carried on in 1930, followed by a program of field surveys during the same year. During the field investigations a large amount of information was collected directly by the reconnaissance and surveys, or indirectly through contact with Government, State, county, city, and irrigation district officials, as well as private corporations and citizens. Records and reports of the United States Geological Survey, United States Weather Bureau, United States Department of Agriculture, Bureau of Reclamation and other Federal agencies, together with State and county reports, have been obtained and studied. A public hearing was held at Beach, N.Dak., on July 20, 1931, to afford an opportunity for local interests to present their views. Stream-flow records have been compiled from four gaging stations, which were in operation when the investigation began, or had been operated in the past. Two of the four stream-gaging stations were reestablished during the fall of 1928 by the United States Geological Survey under the direction of this office and are still being maintained. The field work was initiated and largely accomplished under the supervision of J. M. Young, first lieutenant, Corps of Engineers. A portion of the field work was done under the supervision of H. W. Collins, captain, Corps of Engineers. The preparation of the final report was under the direct supervision of Captain Collins. The principal assistants were: Mr. G. A. Hathaway, hydraulic engineer, in charge of flood and stream-flow investigations; Mr. G. B. Archibald, civil engineer, in charge of both water-power and irrigation investigations; Mr. H. H. Roberts, civil engineer, in charge of drafting and design; Mr. L. W. Miller, assistant engineer, in charge of silt investigations; and Mr. B. V. Reany and Mr. C. T. Barker, associate engineers, in charge of field investigations and surveys.

---

[1] Only maps 2 and 18, and charts 21–27 printed; see p. 50.
[2] Not printed.

179245—33——2

BIBLIOGRAPHY

5. In the preparation of the report the following sources of information have been referred to:

STATISTICAL DATA

Fourteenth Census of the United States; abstracts of mines and quarries in Montana, North Dakota, South Dakota, and Wyoming. United States Bureau of Census, Department of Commerce, 1919.

Manufactures, United States, by industries and geographical divisions and States, 1919.

Data on agriculture and soils, United States Department of Agriculture.

Population and economic production. Bureau of the Census, United States Department of Commerce.

Prices of farm products received by producers. Statistical Bulletins Nos. 15 and 17, United States Department of Agriculture, 1927.

Climatological data, United States Weather Bureau, Department of Agriculture.

Monthly Weather Reviews, United States Department of Agriculture.

Reports to the Chief of Weather Bureau, United States Department of Agriculture, 1891–1927.

GEOLOGY AND MINERALS

Mineral resources of the United States, 1909; 1915–26.

Annual Reports of the United States Geological Survey, 1883–1930.

Preliminary report on the geological and underground water resources of the central Great Plains. Professional Paper No. 32, United States Geological Survey, N. H. Darton, 1905.

Geology and lignite resources of the Marmarth field, southwestern North Dakota. United States Geological Survey Bulletin No. 775, C. J. Hares, 1928.

Lignite in the western part of the Fort Berthold Indian Reservation south of Missouri River, N.Dak. United States Geological Survey Bulletin No. 726d, C. M. Bauer and F. A. Harold.

Geology and underground waters of South Dakota. United States Geological Survey Water-Supply Paper No. 227, N. H. Darton, 1909.

SOILS

Reconnaissance soil survey of western South Dakota. Bureau of Soils, United States Department of Agriculture, George M. Coffey, 1909.

Land classification of the northern Great Plains, Montana, North Dakota, South Dakota, and Wyoming. Bureau of Soils, United States Department of Agriculture, E. A. Aldons and J. F. Deeds, 1929.

STREAM-FLOW DATA

United States Geological Survey Water-Supply Papers, 1881–1928.

Stream-flow records, W. A. Lamb and Robert Follansbee, district engineers, United States Geological Survey, 1929–31.

Results of discharge observations, Mississippi River and its tributaries and outlets, Mississippi River Commission, 1838–1923; 1928–29.

Stages of the Mississippi River, Mississippi River Commission, 1871–1930.

Daily river stages. United States Weather Bureau, Department of Agriculture, 1894–1929.

IRRIGATION

Annual report on irrigation possibilities in Montana. Montana Irrigation Commission, 1920.

Annual Report of the United States Bureau of Reclamation, 1902–28.

Montana Farm Review edition. Bureau of Agriculture Economics, 1928.

Cottonwood Creek Reservoir Dam, Little Missouri project; by A. P. Parker, C.E., for A. W. Mahon, State engineer of Montana, 1918.

Irrigation requirements of the arid and semiarid lands in the Missouri and Arkansas River Basins. Department of Agriculture, Technical Bulletin No. 36, 1928.

Roosevelt Bad Lands reclamation project, Medora, N.Dak., by Dakota Engineering and Construction Co., 1923.

STATE PUBLICATIONS

State engineer reports, Montana. Fourth, fifth, sixth, seventh, eighth, eleventh, twelfth, and thirteenth biennial reports, 1909–28.
State engineer reports, Wyoming. Fifth to twentieth, inclusive, biennial reports, 1890–1930.
State engineer reports, South Dakota. Third to thirteenth, inclusive, biennial reports, 1911–28.
State engineer reports, North Dakota. First to fourteenth, inclusive, biennial reports, 1904–30.
Report on Marmarth flood, Robert E. Kennedy, State engineer, 1929.
Geology and natural resources of North Dakota. University of North Dakota Departmental Bulletin No. 11, 1930.
The lignite deposits of North Dakota. North Dakota Geological Survey Bulletin No. 4, 1925.

I. Physical and Economic Description of the Basin

6. *Geography.*—The Little Missouri Basin includes parts of northeastern Wyoming, southeastern Montana, western South Dakota, and west-central North Dakota, lying between the Powder and Yellowstone Rivers on the west, the Missouri River on the north, and the headwaters of the Knife, Heart, Cannonball, Grand, Moreau, and Belle Fourche Rivers on the east and south. The basin is about 300 miles in length and averages 40 miles in width, with the major axis in a general southwest to northeast direction. About 720 square miles of the drainage area lie in Wyoming, 3,440 square miles in Montana, 590 square miles in South Dakota, and 4,750 square miles in North Dakota. (See map 1,[2] appendix I.)

7. There are 5 major tributaries—Thompson Creek, Box Elder Creek, Little Beaver Creek, Beaver Creek, and Cherry Creek; and 6 tributaries of lesser importance—Prairie Creek, North Fork, Valley Creek, Deep Creek, Magpie Creek, and Charlie Bob Creek. (See map 2, appendix I.) The lengths and drainage areas of these streams are as follows:

Little Missouri River and tributaries, drainage areas and lengths

Stream	Length in miles		Drainage area (square miles)
	Of stream	From mouth Little Missouri River to point on stream	
Little Missouri River	560	0.0	9,500
Cherry Creek	56	60.5	357
Beaver Creek	120	137.5	793
Beaver Creek at Wibaux		200.0	311
Medora, N.Dak		187.9	6,323
Marmarth, N.Dak		306.4	4,724
Little Beaver Creek	81	307.6	633
Box Elder Creek	119	351.7	1,239
Bullion Butte Reservoir site		241.3	5,292
Camp Crook, S.Dak		409.0	1,931
Willow Creek	42	466.0	204
U.S. Geological Survey gage near Alzada, Mont		467.0	831
Thompson Creek	49	469.0	180
Alzada, Mont		472.5	640
North Fork	31	504.0	187

[2] Not printed.

8. *Topography.*—The Little Missouri Basin lies entirely in that section of the Great Plains Province known as the "Missouri Plateau." From the headwaters to the vicinity of the big bend, near the south-center of McKenzie County, N.Dak., the basin lies in an unglaciated region, consisting of a series of terrace lands and local badlands, developed by erosion on an ancient plateau. From the big bend to the mouth, the river traverses a glaciated region, having characteristics somewhat similar, except for the presence of glacial sediments. Furthermore, due to the change in direction of stream flow caused by the glacier, the present valley throughout this section has been gouged out entirely through the upland with a consequent lack of terraces.

9. In the extreme headwater section, the stream flows through a narrow valley bordered by a semiarid mountainous area, reaching a maximum elevation of 4,300 feet mean sea level formed by the western ramparts of the Black Hills. From the vicinity of Alzada, Mont., to Camp Crook, S.Dak., the valley of the main stream varies from 2 to 5 miles in width, consisting of a narrow flood plain bordered by a series of terraces receding from the river to the bluff line. From Camp Crook, S.Dak., to Medora, N.Dak., the valley averages about three fourths mile in width, bordered by steep rugged bluffs leading upward to gently rolling prairie country. From Medora, N.Dak., to the big bend in McKenzie County, the river follows a winding course through a narrow valley, ranging from one fourth to three fourths mile in width. From the big bend to the mouth, the valley is broader and deeper than in the section just above; the slightly rounded bottom valley varying from 1 to 2 miles in width and the bluff line rising to a maximum of 500 feet above the valley floor.

10. The picturesque and colorful badlands form the most distinctive topographic feature of the basin, extending from the southern boundary of North Dakota to the mouth of the river. Badlands are commonly found in a region of soft materials lying well above the local base level, and located in an arid climate, characterized by short periods of concentrated rainfall. These conditions are fully satisfied in this region. At the North Dakota-South Dakota boundary, the badlands are from 6 to 7 miles in width, increasing to approximately 25 miles at the big bend and decreasing to about 10 miles from the bend to the mouth. The relief along the stream course varies from 80 to 100 feet at the south end of the badland section, and increases to over 500 feet at the big bend. The river follows a very sinuous course throughout nearly its entire length, dividing and subdividing among sandbars, at times flowing slowly through deep pools, or swiftly over broad shoals formed by recently deposited and rapidly shifting sediments.

11. The valleys of the larger tributaries have flat or broadly rounded bottoms, while the minor tributary drainage has formed an intricate pattern of narrow V-shaped ravines and gullies. The less eroded remnants between the gorges rise in grotesque and fantastic shapes to a maximum height slightly below the level of upland plains. However, the limits of excessive erosion are generally well defined and the undisturbed uplands, bordering the basin and forming broader tributary divides, present areas of flat or gently sloping

land of considerable value for dry-farming purposes. For general topography of the basin, reference is made to map 3,[2] appendix I.

12. *Datum.*—The general profile of the Little Missouri River and tributaries (see chart 21, appendix I) was compiled from maps furnished by the State engineer of North Dakota (for the reach from the North Dakota-South Dakota line to the big bend) and from aneroid barometer readings, corrected to mean sea level (U.S. Geological Survey datum). The surveys of the Little Missouri project and the Bullion Butte Reservoir were based on assumed datum planes (see maps [2] 14, 16, and 17, appendix I). The flood-control surveys at Marmarth, N.Dak., and Wibaux, Mont., were based on mean sea level datum furnished by the Chicago, Milwaukee, St. Paul & Pacific, and Northern Pacific Railroads.

13. *Slope.*—The elevation of the valley floor at the extreme headwaters is about 4,300 feet mean sea level and the elevation at the mouth is 1,727 feet mean sea level, giving an average valley slope of 8.6 feet per mile (computed on a valley length of 300 miles) and a channel slope of 4.6 feet per mile (computed on a channel length of 560 miles). (See chart 21, appendix I.)

14. *Geology.*—The surface formations in the Little Missouri Basin range in the geological time scale from the late Cretaceous to the Quaternary period. The occurrence in order of age, the youngest or latest first, is given in the following table:

Geology of Little Missouri Basin

Geological period and formation	Composition	Geographical occurrence
Quaternary:		
Alluvium	Unconsolidated, fine sediments	Along stream course throughout basin.
Glacial drift	Gravel, clay, boulders	Uplands of lower basin.
Tertiary:		
Tertiary gravel	Gravel	Benches of middle basin.
White River formation	Sandstone, shale	Uplands of middle basin.
Fort Union formation	Sandstone, shale, limestone	Uplands and interstream divides, middle and lower basin. Lignite bearing.
Lance formation	Sandstone, shale	Flats and minor uplands of upper and middle basin. Lignite bearing.
Cretaceous:		
Fox Hills formation	Sandstone	Capping on higher divides of middle basin.
Pierre shale	Shale	River flats and benches of upper basin.
Niobrara formation	Chalky limestone	Uplands of upper basin (minor occurrence).
Benton formation	Shale, limestone	Uplands of upper basin.

15. *Mineral resources.*—Lignite is the principal mineral resource of the Little Missouri Basin. Commercial deposits occur in Wibaux County, Mont.; in Billings County, N.Dak.; in Carter County, Mont.; and in Slope and Bowman Counties, N.Dak. Deposits of some value are also found on the Fort Berthold Indian Reservation. The lignite is used for residential heating and for the generation of steam in stationary steam engines and tractors. The availability of higher grade coals from points at no great distance from the basin eliminate the possibility of general use of this grade of lignite as central power station and locomotive fuel. No production estimates are available

[2] Not printed.

for the Little Missouri area. The coal (lignite) production in 1925 in Billings, Golden Valley, and Oliver Counties was estimated by the United States Department of Commerce at 15,567 tons, having a total value of $28,000. Oliver County does not lie in the Little Missouri Basin. The total reserves in the Marmarth field (extending from the North Dakota-South Dakota boundary to a point about 10 miles south of Medora, N.Dak.) are estimated by the United States Geological Survey at 15,756,060,000 tons.

16. Oil and gas have been produced from wells of moderate depth a few miles west of Marmarth, N.Dak. The highly productive oil and gas fields at Baker, Mont., are located just west of the Little Missouri Basin.

17. *Soils.*—The soils bordering the stream bed are composed of sand, gravel, and silt, representing recent alluvial deposits. The terrace soils of the broad upper valley (above Camp Crook, S.Dak.) are principally clay loam and clay, compact in texture with considerable alkali. The uplands and interstream divides of the middle and lower sections of the basin are composed of silt loam, sandy loam and sandy clay.

18. *Weather.*—The climate of the basin is influenced by inland continental conditions. It is semiarid and characterized by a moderately low rainfall, a dry atmosphere, hot summers, cold winters, and a large proportion of sunny days. The summer and winter temperatures are likely to vary greatly, and the seasons frequently open and close at unusual dates. Precipitation is fairly uniformly distributed throughout the basin and the average annual rainfall is about 16 inches for the entire area (see Maps [2] 4 to 7, appendix I, and tables 19 to 54, appendix II).

19. *Population.*—The basin is very sparsely settled, the total for the entire drainage area being estimated at 24,770 (1930 census). The largest town is Beach, N.Dak., with a population of 1,106 (1920 census). Marmarth, N.Dak., was the largest town at the time of the 1920 census (1,318) but has suffered a decrease of about 45 percent (to 721), in recent years, principally due to the removal of the railroad shops. Other towns are Watford City, N.Dak., 768; Medora, N.Dak., 212; Sentinel Butte, N.Dak., 292; Rhame, N.Dak., 302; Camp Crook, S.Dak., 163; Wibaux, Mont., 616; Ekalaka, Mont., 433; Alzada, Mont., 41. (See map 8,[2] appendix I, and table 1, appendix II.)

20. *Transportation and markets.*—Two main line railroads, the Northern Pacific and Chicago, Milwaukee, St. Paul & Pacific cross the basin. United States Highway No. 10 from Bismark, N.Dak., to Glendive, Mont., and United States Highway No. 12 from Moberly, S.Dak., to Miles City, Mont., cross the central part of the basin. An improved road from United States Highway No. 12 at Baker, Mont., leads to Ekalaka, Mont. Other routes are graded dirt roads or mere trails, generally in poor condition and nearly impassable in wet weather. See the following table and map 9,[2] appendix I.

[2] Not printed.

Little Missouri River Basin, railroads and highways

	Length in miles				
	Montana	North Dakota	South Dakota	Wyoming	Total
Railroads	23	84			107
Highways:					
Improved	41	50			91
Main graded		53	10		63
Main dirt	375	313	80	115	883
Total highways	416	416	90	115	1,037

21. The principal markets for grain and the livestock products of the region are Bismarck and Fargo, N.Dak., Aberdeen, S.Dak., and Minneapolis and St. Paul, Minn.

22. *General economic situation.*—Agriculture is the principal industry of the Little Missouri Basin, but the region is not an important agricultural area, due to the large proportion of nonarable land and the semiarid climate. The terrace lands of the upper valley and the uplands of the middle and lower sections are dry farmed and yield fairly good crops of wheat, oats, barley, rye, flax, corn, and potatoes. Cattle raising was practically the only important industry previous to 1900 and continues to be one of the principal sources of income for the greater part of the region immediately bordering the river, especially in the area below Marmarth, N.Dak. (See tables 2 to 18, appendix II.)

23. Manufacturing is of no great importance, the only commodities of this class being flour and creamery products produced for local requirements. No great expansion of agriculture, manufacturing, or mineral production appears probable in the future, due to the high proportion of poor land and lack of first-class raw material.

24. *Federal reservations.*—The Fort Berthold Indian Reservation has been established, by the Federal Government, for the Sioux Indians. It is located on the left bank of the Little Missouri River near the mouth. The area of the reservation is about 1,500 square miles with 650 square miles on the southwest side of the Missouri River and the remainder on the northeast side. About 180 square miles lie in the Little Missouri Basin. The reservation is sparsely settled and roads and farms are but slightly developed. The lignite deposits and potential power sites have been investigated by the United States Geological Survey. Lignite is found in large quantities, but no commercial development has been recommended because of the competition of higher grade lignite from other parts of the State. No worth-while power sites were discovered.

25. Two divisions of the Custer National Forest are located in the basin, one about 5 miles west of Camp Crook, S.Dak., and the other, east and south of Ekalaka, Mont. Rather a sparse growth of pine exists on both divisions of the reserve; however, these probably constitute two of the best stands of timber in this region. (See map 2, appendix I.)

26. *Flow of rivers.*—The streams of the Little Missouri drainage are usually at comparatively high stages during the spring months due to the combined effect of snow-melt and heavy general rains.

June and July rises are also caused, in some years, by general rains. Permanent snow does not exist in the basin, and the snow-melt does not greatly affect the stream flow over extended periods, except in the occasional years of late, heavy snowfall. Occasional high stages in August and the fall months are generally caused by heavy local storms. The winter flow is small, and the river is usually frozen over from November 15 to March 15.

27. Many of the minor tributaries are dry during the summer, as well as the main stream at and above Camp Crook, S.Dak. A very small flow exists in the middle and lower reaches of the river, even during the driest years. Beaver Creek maintains the most dependable summer flow of any of the tributaries. The various streams in the basin have a wide fluctuation of flow, not only between high and low water but also between the maximum flood flow and the normal high water. (See map 10,[2] and charts 23 to 26, inclusive, appendix I, and tables 55 to 61, inclusive, appendix II.)

II. Floods in the Little Missouri Basin

A. FLOOD SITUATION

28. *General.*—The Little Missouri Basin is not "subject to destructive floods", within the meaning of section 10 of the act of May 15, 1928. Available records indicate that a few moderate floods have affected the basin as a whole, but the overflow areas are small and scattered and consist in the main of relatively low-priced land. Excessive rises, resulting from intense local rains, commonly called "cloudbursts" that cover a small area, quite frequently occur on minor tributaries, but they do not materially affect the flow of the main stem. In one case of record, loss of life has resulted from these local floods.

29. Occasional flooding may be expected from the occurrence of ice jams during the early spring months. The basin is treeless and barren. This lack of vegetation and the rolling topography are conducive to rapid and excessive run-off, but the general climatic conditions and the extremely long and narrow shape of the drainage area apparently are the controlling factors in the prevention of excessive floods. The mean annual rainfall averages about 16 inches, with approximately one half occurring during the months of April, May, and June. The run-off from the spring snow-melt is generally quite large, but does not continue over a very long period of time.

30. *Flood flows.*—Very few rainfall stations are located in the Little Missouri River Basin and the data for existing stations cover a relatively short period of time. Therefore, it is difficult to obtain a relation between storm precipitation and run-off that might be used as a guide to determine the maximum discharge for use in connection with the design of flood-protection works. Results obtained from developed theoretical methods for computing maximum flood discharges are very valuable as an aid and guide to the application of judgment in determining the proper values for flood-control design. However, the best basis for the study of flood discharges, is a long-time record of discharge, or if these data are not available (as is usually the case), a long-time record of river stages can be utilized in interpreting the

[2] Not printed.

combined effects of the many variable factors involved in producing floods. Stream-flow records have been obtained on the Little Missouri River at Medora, N.Dak., for 11 years and at Alzada, Mont., 16 years. The maximum discharge of the river at Medora during the period of record is 33,700 second-feet. No records are available in the vicinity of the mouth. The maximum rate of run-off of record in the basin occurred on Beaver Creek at Wibaux, Mont., on June 7, 1929. It was estimated by the United States Geological Survey to be 33,000 second-feet for a drainage area of 311 square miles and was caused by intense rains over a small area, or what is locally termed as a "cloudburst." The estimate of the United States Geological Survey was based on slope and area measurements obtained after the flood had subsided.

31. Sufficient data are not available to obtain the relation of storm precipitation and flood run-off, and a prediction of probable flood effects resulting from storms. Therefore, the existing stream-flow records of the Little Missouri at Alzada and Medora were used to make a flood probability study. The study indicates that a discharge for a 1 percent chance flood at Medora would be 52,000 second-feet (drainage area, 6,323 square miles), while the maximum of record is only 33,700 second-feet. Likewise, a 1 percent chance flood on the Little Missouri River at Alzada, Mont., would be 19,500 second-feet (drainage area, 831 square miles), while the actual recorded maximum is 4,500 second-feet. The discharge of 52,000 second-feet for a 1 percent chance flood at Medora was proportioned in accordance to the drainage area and probable inflow, with an estimated allowance for reduction, due to valley storage, giving a discharge at Marmarth, N.Dak., of 45,000 second-feet to be used in the design of flood protection works for the town. The estimate of 33,000 second-feet by the United States Geological Survey for Beaver Creek at Wibaux, Mont., was used in the design of flood-protection works.

32. *Agricultural areas affected by floods.*—In general, the river valley between bluff lines, from Alzada, Mont., to Camp Crook, S.Dak., averages about 3 miles in width; from Camp Crook, S.Dak., to Medora, N.Dak., about three fourths of a mile; from Medora, N.Dak., to the big bend about one half of a mile and from the big bend to the mouth about one and one half miles. However, available data indicate that the alluvial flood plain between Alzada, Mont., and the mouth does not average over one fourth of a mile in width. The stream bed follows an irregular meandering course, with the principal overflow areas being located in the bends of the river, the size varying from 200 to 600 acres. The frequent shifting of the channel and the extent of damage from the infrequent overflows are of minor economic importance, due to the undeveloped stage and relatively low value of the areas subject to flooding.

33. *Municipalities affected by floods.*—There are two towns within the Little Missouri Basin that are subject to damage from floods. These municipalities are: Marmarth, N.Dak., located on the Little Missouri River (river mile 306.4) about midway between the mouth and the headwaters, and Wibaux, Mont., located on Beaver Creek, a large tributary entering the main stem from the west, about 137 river miles above the mouth of the Little Missouri. The flood situation and past damages are discussed in the following paragraphs.

34. *Marmarth, N.Dak.*—The town is located on the Little Missouri River, just below its confluence with Little Beaver Creek, a tributary entering the main stem from the west and draining an area of 633 square miles. The town site is located in a pocket-like basin of low bottom land in a bend of the Little Missouri River, with a total of 4,724 square miles of drainage area above. The population in 1930 was 721. Damaging floods have been reported for 1913, 1920, 1921, and 1929, although data are conflicting for some of the earlier overflows. Some of the floods have been caused by ice jams. The most serious overflow occurred in 1929, with that of 1920 second in the order of importance.

35. Apparently, the first flood of record at Marmarth, occurred in 1913 and was the result of a sharp rise on Little Beaver Creek. The creek overflowed its banks a short distance east of the Chicago, Milwaukee, St. Paul & Pacific Railroad tracks, the general direction of the overflow following the Milwaukee Railroad yards through the town. (See map 12,[2] appendix I.) Available data indicate the depth of flow was probably about 1 foot. The town was subject to overflow again the same year from the Little Missouri. In general, overflows are caused by backwater entering the main section of town by way of the low-lying area in the general vicinity of the intersection of Fourth Avenue and First Street. No detailed data are available as to the flood loss in 1913, however, it is estimated that the damage did not exceed $10,000. The town was again flooded in 1920 by the Little Missouri. During high stages in the Little Missouri River, considerable damage results from backwater entering the sewage system and flooding most of the basements in the town. The sewage system discharges into the Little Missouri a short distance above the Chicago, Milwaukee, St. Paul & Pacific Railroad Bridge, and inasmuch as backwater from high stages covers a good section of town by surface flooding, even moderate floods cause damage because of backwater in the sewage system. Flood damage for the 1920 overflow was estimated at $15,000 by this office.

36. Two overflows occurred in 1921, the first being caused by an ice jam that deposited large cakes of ice in the main street of town. The second flooding, later in the summer, was caused by backwater from the Little Missouri with consequent damage to the sewage system and basements. The flood loss for the two overflows in 1921, was estimated by this office at $25,000.

37. A general rain over the drainage area of the Little Missouri above Marmarth on May 25 and 26, 1929, raised the river to bankfull stage and saturated the soil to such an extent that a heavy rain, averaging from 2 to 3 inches over the drainage area of Little Beaver Creek on May 28, created excessive stages in the Little Missouri at Marmarth. Approximately 85 percent of the basements in the town were flooded. The damage resulting from the 1929 overflow was estimated by this office at $30,000.

38. The financial condition of Marmarth is seriously impaired, due to the removal of the railroad shops in July 1925 and an additional change in railroad operation in July 1926 that resulted in moving a large number of families away, reducing the population of 1,318 in 1920 to a population of about 721 at the present. Of the 62 blocks plotted in the town, about 24 have been, or must eventually be,

[2] Not printed.

turned back to the county. Approximately 15 percent of the houses are vacant. The present assessed valuation of the town is $600,000, and the bonded indebtedness and outstanding warrants on July 1, 1931, was $103,372.94. Marmarth is a distributing point for the surrounding stock-raising territory, and future prospects for a rapid increase in the population appear to be very remote. The total estimated flood loss during the 23-year period, since the establishment of the town in 1908, is $100,000, or an average annual loss of $4,350. Reference should also be made to map 12,[2] appendix I, and photographs 7 to 10, appendix IV.[2]

39. *Wibaux, Mont.*—The town is located on Little Beaver Creek, a tributary of the Little Missouri River, approximately 62 miles above its confluence with the main stem. About 311 square miles of drainage area of Beaver Creek are above Wibaux. The town is located on the main line of the Northern Pacific Railroad at the crossing of Beaver Creek, and is a distributing point for the surrounding agricultural community. The population in 1930 was 616. Apparently the only damaging flood of consequence occurred in 1929. On June 5 and 6 steady rains fell throughout eastern Montana and western North Dakota, followed by intense rains over the drainage area of Beaver Creek above Wibaux. Ordinarily Beaver Creek is a very small stream, about 10 feet wide between banks, averaging about 4 feet in height. This small stream in the vicinity of Wibaux became a raging torrent, which covered a greater part of the town. (See map 13,[2] appendix I.) Local residents are of the opinion that the flood hazard was considerably increased by the Northern Pacific Railroad embankment. The railroad bridge and part of the embankment was washed out at the crossing of Wibaux Creek, and also part of the embankment adjacent to the underpass on Wibaux Street. The crest of the flood was reached about 10 a.m. on June 7, with a maximum stage of approximately 25 feet above low water. Four lives were lost. Five small frame residences were completely washed away. Twelve more were removed from their foundations, and numerous small frame barns and sheds were completely wrecked. Approximately 200 homes were damaged to some extent, and 75 percent of the population were forced to leave their homes. The business district, consisting of about three blocks, was completely flooded to a depth averaging about 5 feet. Two small highway bridges were wrecked, one being the United States Highway No. 10 Bridge at Wibaux.

40. Accurate and detailed data of the 1929 flood loss at Wibaux are not available, although local residents estimated the loss to be about $300,000. Reference should also be made to map 13,[2] appendix I, and photographs 18 to 27, appendix IV.[2]

B. FLOOD-CONTROL PLANS

41. *General.*—The agricultural lands in the Little Missouri Basin are not "subject to destructive floods." The areas subject to overflow are small and scattered, and the resulting flood damage does not justify the preparation of a flood-control plan.

42. Flood-control plans were prepared for the protection of the municipalities of Marmarth, N.Dak., and Wibaux, Mont. The

[2] Not printed.

100-year flood on the Little Missouri at Marmarth was used as a basis of design, while the very unusual flood on Beaver Creek that occurred on June 7, 1929, was used as a basis of design for the town of Wibaux, Mont. Levees were adopted as a means of protecting the towns from overflow and a freeboard of 3 feet over and above the adopted flood was used, thus providing a factor of safety.

43. The cost of raising highways, bridges, streets, and buildings, to conform with the proposed levee grade, has been included in the estimates. Channel excavation was estimated to cost from 15 to 25 cents per cubic yard, according to the nature of the material, and levee construction was estimated at 25 cents per cubic yard. The standard levee section adopted provides for a slope of 3 to 1 on the land side, a crown of 6 feet, a 4- by 6-foot muck ditch along the center line of levee, except where the existing levees are raised; a slope of 2½ to 1 on the river side and a berm of not less than 40 feet between the toe of the levee slope and the edge of the borrow pit. Borrow pits are 1 to 1, to a depth of 5 feet from the level of the berm, thence with a 5 to 1 slope away from the levee, to a maximum depth not to exceed 15 feet. The plans also provide for borrow pit traverses 15 feet wide at intervals of at least 500 feet, to prevent a current along the levee.

44. The right of way cost was estimated in detail, according to the values of the various properties to be purchased. Pumping plants were designed to handle drainage from the total contributing area, assuming a run-off of one half inch per 24 hours from the adjacent lands outside of the municipalities, and 1 inch per 24 hours from the urban area. In addition to the computed labor and fuel cost, a depreciation charge of 5 percent was placed against the pumping plants. Annual maintenance was estimated at 1½ percent of the sum of levee construction, channel excavation, interior drainage and engineering, and contingencies cost. Engineering and contingency costs were taken as 20 percent of the construction cost of the unit. Operation and maintenance was capitalized at 5 percent and added to the construction cost to obtain the total cost.

FLOOD PROTECTION PLAN FOR MARMARTH, N.DAK.

45. *General.*—The general flood situation and the damage resulting from floods within the town of Marmarth, N.Dak., has been discussed in paragraphs 34 to 38, inclusive. The Chicago, Milwaukee, St. Paul & Pacific Railroad changed the location of the channel of Little Beaver Creek, diverting it into the Little Missouri south and west of town, instead of allowing the stream to follow the original channel along the bluff line west of town. (See map 12,[2] appendix I.) Part of the old channel west of the railroad tracks is being utilized as a storage reservoir by the railroad company. A small levee has been constructed from the Chicago, Milwaukee, St. Paul & Pacific Railroad tracks in the NW¼NE¼ sec. 36, T. 133 N., R. 106 W., parallel to the new channel of Little Beaver Creek, to high ground in the SE¼NW¼ sec. 31, T. 133 N., R. 105 W. The flow of Little Beaver Creek is thus diverted around the town.

46. *The adopted plan.*—To obtain complete protection at Marmarth, it would be necessary to raise the existing levee, beginning at the bluff line in NW¼NE¼ sec. 36, T. 133 N., R. 106 W., for a distance of 3,050

[2] Not printed.

feet. The proposed levee would then be located north of the existing levee, in order to provide an additional setback between the toe of levee and the left bank of the Little Missouri River; thence generally parallel to Seventh Street in a northeasterly direction to a point near the intersection of Third Avenue East and Seventh Street; thence generally parallel to the left bank of the Little Missouri to the Chicago, Milwaukee, St. Paul & Pacific Railroad embankment at its intersection with Fourth Avenue East. A short levee on the west side of the railroad track would tie to high ground near the intersection of Main Street and Stone Avenue. The cut-off between Little Beaver Creek and the Little Missouri River in the SE¼NW¼ sec. 36, T. 133 N., R. 106 W. (see paragraph 45) has enlarged during recent years and at the present time has a greater carrying capacity than the creek channel above. This enlargement of the cut-off has lowered the maximum flood plane in that vicinity. However, it would be necessary to raise the existing levee, constructed by the Chicago, Milwaukee, St. Paul & Pacific Railroad, an average of 1 foot, in order to give the required 3-foot freeboard and provide adequate protection to the town from Little Beaver Creek floods. All existing buildings would be protected by the proposed levee. The cost estimates provide for an automatic outlet gate, to take care of the overflow from the small railroad reservoir; a pumping plant to take care of interior drainage and sewage during periods of high water, and the necessary appurtenances to prevent backwater in the sewage system. The total length of the levee would be approximately 2.04 miles, and the average height 6.5 feet. A grade crossing would be provided for traffic between the east and west sides of town at the intersection of First Avenue East and the Chicago, Milwaukee, St. Paul & Pacific Railroad track. The standard levee section has been used in estimating quantities. (See par. 43.) A freeboard of 3 feet has been allotted above the computed maximum water surface of a flood equal to 45,000 second-feet. The plan is shown on map 12,[2] appendix I. Also map 18, appendix I.

47. *Cost estimates.*—The cost estimates for the plan are summarized in the following tabulation:

Summary of costs, Marmarth flood protection plan

Total construction cost, including engineering and contingencies	$60, 700
Annual operation and maintenance charges of $1,000, capitalized at 5 percent	20, 000
Total cost	80, 700

48. *Economics of proposed plan.*—The total cost of the plan is $80,700. If financed by the issue of long-term bonds, the total expenditure would be considerably more, depending upon the discount on the bonds, interest rate, and period to maturity.

49. The average annual flood loss at Marmarth during the 23-year period (1908–30, inclusive) was estimated at $4,350, which if capitalized at 5 percent amounts to $87,000. It should be noted that the estimated annual flood loss of $4,350 does not include indirect and intangible losses such as interruption to traffic, loss of business, and depreciation of real estate values. However, the plan is believed to be feasible from an economic standpoint, solely on the basis of capitalized direct damages, which exceed the construction cost of the adopted plan.

[2] Not printed.

FLOOD PROTECTION PLAN FOR WIBAUX, MONT.

50. *General.*—The flood situation and the damage resulting from floods within the town of Wibaux, Mont., has been discussed in paragraphs 39 and 40.

51. *Adopted plan.*—No flood-protection works have been constructed at Wibaux, although the bridge opening in the Northern Pacific Railroad embankment has been enlarged considerably since the disastrous flood of June 1929. Practically the entire town is located within the alluvial flood plain of Beaver Creek, and in order to obtain complete protection from a flood similar to that of 1929, it would be necessary to construct levees on both sides of Beaver Creek south of the Northern Pacific Railroad tracks and on the west side, north of the tracks. Under the adopted plan, the levees proposed on the right bank would begin at high ground near the southern limits of the town, following approximately parallel to the right bank of Beaver Creek to the Northern Pacific Railroad tracks. This levee would protect all of the municipal area of importance east of Beaver Creek. The left bank levee would begin at high ground near the intersection of C Street and Second Avenue, following approximately parallel to the left bank of Beaver Creek to connect with the Northern Pacific Railroad embankment about 100 feet east of the depot; thence continuing from the north side of the embankment parallel to the creek 1,500 feet north, where the levee would turn westward to connect with high ground. The left bank levee would encompass all the municipal area of importance. The right bank levee would be 0.76 mile in length and average 9 feet in height, while the left bank levee would be 0.93 mile in length and would average 9 feet in height.

52. The cost estimates provide for pumping plants to remove the interior drainage and raising and lengthening of United States Highway No. 10 Bridge on First Avenue. The standard levee section has been used in estimating quantities (see par. 43). A freeboard of 3 feet has been allotted above the computed maximum water surface of a flood equal to 33,000 second-feet. The plan is shown on map 13,[2] appendix I. Also see map 18, appendix I.

53. *Cost estimates.*—The cost estimates for the plan are summarized in the following tabulation:

Summary of costs, Wibaux flood-protection plan

Total construction cost, including engineering and contingencies	$104, 700
Annual operation and maintenance charges of $1,100, capitalized at 5 percent	22, 000
Total cost	126, 700

54. *Economics of proposed plan.*—The total cost of the plan is $126,700. If financed by issue of long-term bonds, the total expenditure would be greater than the construction cost, depending upon the discount on the bonds, interest rate, and period to maturity.

55. The assessed valuation of all of the municipal area, including railroad and gas company property, was $636,513 in 1921 and $775,514 in 1929. Approximately 90 percent of all assessed property was flooded in 1929. In other words, property having an assessed valuation of approximately $698,000, would be affected by another

[2] Not printed.

flood similar to that of 1929. Furthermore, due to the present location of the residential and business district, the flood hazard constitutes a serious menace to human life. In view of the small cost of the proposed flood-protection works compared to the total assessed valuation of the property to be protected, and the existing menace to human life, the plan would appear to be justifiable from an economic and humanitarian standpoint.

C. CONCLUSIONS

56. The conclusions, in connection with the floods in the Little Missouri Basin, may be stated as follows:

(*a*) The Little Missouri Basin is not "subject to destructive floods" within the meaning of section 10 of the act of May 15, 1928. The areas, subject to overflow, are small and scattered, and the resulting flood damage does not justify the preparation of a flood-control plan.

(*b*) The flooded area within the town of Marmarth, N.Dak., can be protected from the 100-year flood, by means of levee construction, at an estimated cost of $80,700. The average annual flood loss at Marmarth, during the 23-year period (1908–30, inclusive), was estimated at $4,350, which if capitalized at 5 percent amounts to $87,000. The capitalized annual flood loss exceeds the estimated cost and the plan is believed to be feasible from an economic standpoint.

(*c*) The overflow area, within the town of Wibaux, Mont., can be protected from a flood of 33,000 second-feet (the greatest of record) by means of levee construction at an estimated cost of $126,700. The total assessed valuation of the municipal area in 1929 was $775,514. Approximately 90 percent of the municipality, or $698,000 worth of business and residential property, was affected by the 1929 flood. In view of the small cost of the plan compared to the total assessed valuation of the property to be protected, and the existing menace to human life, the plan appears to be justifiable when viewed in both its economic and humanitarian aspects.

III. Effect of Little Missouri River Flow on Mississippi and Missouri

A. EFFECT ON MISSISSIPPI FLOODS

57. *General.*—The Little Missouri River enters the Missouri about 1,583 miles above the mouth and about 1,791 miles (1890 mileage) above Cairo on the Mississippi. The approximate time of water travel between the mouth of the Little Missouri and Cairo is 18 days.

58. The danger of Mississippi floods in the vicinity of Cairo is fairly well confined to the period, February 15 to May 15, inclusive. Allowing for the time of water travel, the period that the Little Missouri River would contribute directly to possible Mississippi floods, is from January 28 to April 27. No major floods are on record in the Little Missouri River Basin during this period, although a minor rise may generally be expected in the latter part of March or early in April, because of the melting of the winter snow blanket.

59. Stream-flow data are available on the Little Missouri River during two of the six Mississippi floods of the past 20 years; namely, 1922 and 1929, and during these floods the Little Missouri did not

contribute an appreciable volume of water that would have coincided with the Mississippi peak at Cairo. The average flow of the Little Missouri River at the mouth, corresponding to the 1922 and 1929 Mississippi flood periods (Jan. 28 to Apr. 27), was 1,040 and 3,880 second-feet, respectively. The flows were computed from the streamflow records at Medora, N.Dak., on a drainage area basis and may be somewhat in error. It is obvious that the effect of the Little Missouri upon Mississippi floods is of minor importance, as the average flow, corresponding to the Mississippi danger period (Jan. 28 to Apr. 27), including all available records, is only 1,600 second-feet. However, in order fully to investigate all reservoir flood-control possibilities of the basin, a brief study was made of the existing sites and probable reductions on the Cairo gage.

60. *Reservoir site selected.*—There are no existing reservoirs of any consequence in the basin that would have an appreciable effect upon any plan, for the control of Mississippi floods. No sites are available in the basin for storing all, or the greater part, of the discharge of the Little Missouri during the Mississippi flood period. The Bullion Butte Reservoir site, located on the main stem about 241 river miles above the mouth and about 53 river miles upstream from Medora, N.Dak., is the best for the control of Little Missouri floods.

61. The Bullion Butte Reservoir, as planned, would be created by the construction of a dam on the Little Missouri River, 4 miles south of Bullion Butte in section 2, township 136 north, range 103 west, Slope County, N.Dak. The reservoir at normal pool level (elevation 1,270 feet, assumed datum, see par. 12) would have a surface area of 7,200 acres and a capacity of 320,000 acre-feet. The pool would extend approximately 29 miles up the river. The dam would be an earthen embankment with a concrete core wall, and would have a total crest length of 2,960 feet. At the maximum section, the dam would be 120 feet above the stream bed; the minimum top width to be 20 feet and the maximum base width 800 feet. The upstream side would slope at 3 to 1 for 50 feet below the crest, and 3¼ to 1 from this point to 100 feet below the crest, and 3½ to 1 from this point to the foundation. The downstream side would slope, for corresponding depths, at 2 to 1, 4 to 1, and 5 to 1, respectively. A reinforced concrete core wall would be provided, which would be founded on rock, and the upstream slope of the embankment would be protected by a blanket of riprap. The top of the embankment would be at elevation 1,280 feet (assumed datum), thereby providing a freeboard of 10 feet above the reservoir surface, corresponding to a spillway discharge of 80,000 second-feet.

62. The flood flow would be discharged through two concrete tunnels of the horseshoe type, each 27 feet in diameter. The water would be conducted to these tunnels through a vertical shaft after passing over a weir having a net length of 250 feet. The top of the weir would be at elevation 1,250 (assumed datum). Ten 20- by 25-foot Taintor gates, between 5-foot piers, would be installed above the spillway (weir) crest to maintain the normal pool elevation of 1,270 (assumed datum). The water would be discharged from the tunnels approximately 600 feet below the downstream toe of the slope of the earthen embankment. The spillway was designed to pass a flood of 80,000 second-feet or about double that of a 1 percent chance occurrence. Water impounded in the reservoir below the elevation

of the spillway crest (1,250, assumed datum) would be discharged by means of a concrete lined outlet tunnel, 13 feet in diameter, which would discharge into the spillway tunnels and thence into the stream below the dam. The flow would be regulated by two 7- by 6-foot high-pressure gates installed at the entrance to the spillway tunnels. The bottom of the tunnel would be at elevation 1,170 feet (assumed datum). The total capacity of the reservoir could be discharged through this tunnel outlet and over the spillway in about 30 days.

63. The total cost of the dam, spillway, and outlet works is estimated at $4,719,000. In addition, the cost of overflowed land is estimated at $108,000, making the total estimated construction cost of the reservoir $4,827,000, or $15.10 per acre-foot. For further details see maps 14[2] and 18, appendix I.

64. *Method of reservoir operation.*—The difficulties and uncertainties connected with any attempt to forecast the time and extent of floods on the Mississippi more or less limit the method of operating the reservoir for Mississippi flood control. In view of the great distance of the reservoir from the Mississippi flood region, the length of the Mississippi crest and the extent of the floods, indications are that the reservoir should store water for a period of 90 days, effective at Cairo from February 15 to May 15, or approximately January 26 to April 25 at the reservoir. It is to be noted that the storage period in the Little Missouri Basin (January 26 to April 25) is mostly within the frozen period, as the spring break-up of ice in the streams and the snow-melt generally do not occur before March 15. The method involves a uniform daily storage, beginning with the reservoir empty on the first day of the danger period (January 26) and impounding water at a rate as nearly constant as possible, so that the reservoir would be completely filled on the last day of the danger period. In the event that the storage during any part of the period is less than the amount allowed by the uniform storage rate, an adjustment would be made by causing water to be stored for the remainder of the period at a rate equivalent to the capacity available in the reservoir, divided by the number of days remaining until the end of the danger period. Flows in excess of this rate would be passed through the reservoir. There is considerable uncertainty regarding the exact behavior of the Little Missouri crest, corresponding to a discharge of 5,000 to 10,000 second-feet, and lasting 2 or 3 days, in traveling through the 1,791 miles (1890 mileage) of Missouri and Mississippi River channel to Cairo. It is certain that the effect of valley storage will materially reduce these crests. No detailed data are available to compute the valley storage effect. Furthermore, it is impracticable to do so without the computations having a probable error in excess of any apparent results that might be obtained. All of the factors that would enter into a valley storage study (total capacity of water channel from the reservoir to Cairo at various stages, inflow into the Missouri and Mississippi Rivers between these points, discharge of the Missouri, Ohio, and Mississippi at various points) are of great magnitude and have probable errors considerably in excess of the net effect of contributions of the Little Missouri to the Mississippi. Therefore, it has been assumed that the reduction of stage during Cairo peaks

[2]Not printed.

179245—33——3

would be represented by a mean reduction of flow, or storage, over a period approximately equal to the time of water travel between the two points. The average time of water travel between the reservoir on the Little Missouri and Cairo is about 20 days; therefore, the mean rate of storage in second-feet over a period of 21 days was used in computing the Cairo reduction; the middle day of the period corresponding to the day of the Cairo peak. The discharge of the Mississippi River at Cairo during a great flood like that of 1927 is approximately 1,600,000 second-feet, and although the flow of the Little Missouri may fluctuate considerably during the flood period, it is believed that the many factors affecting valley storage in the 1,791 miles of river travel are much greater than the assumed flattening that would result from the averaging of the Little Missouri discharge for a period of 21 days. Therefore, it is believed that the results obtained by computing the reduction of the stage during Cairo peaks, by using the mean rate of storage, comes close enough to the truth of the matter for all practical purposes. Certainly, it gives results of the proper order of magnitude.

65. In this study, 63,000 second-feet was taken as representing 1 foot change of stage on the Cairo gage during a major confined Mississippi flood.

66. *Effect of Little Missouri.*—Approximate flow records for the Little Missouri River at the mouth and Bullion Butte Reservoir site, were computed from the Medora records for the 1922 and 1929 Mississippi flood periods (January 28 to April 27 at the mouth and January 26 to April 25 at the reservoir). In order to obtain an index of the effect of the total flow of the Little Missouri on Mississippi floods, and a comparison with the probable results obtained by the operation of Bullion Butte Reservoir, computations were made to determine the effect on the Mississippi, providing the entire flow of the Little Missouri could have been stored during the 1922 and 1929 flood periods. The estimated time of travel from the mouth of the Little Missouri to Cairo is 18 days, and the daily discharge is averaged over a 19-day period. The results are summarized in the following tabulation:

Little Missouri discharge, Mississippi flood period

Cairo peak	Cairo stage, feet	Average flow of Little Missouri 19 days, second-feet	Probable reduction Cairo peak, if total flow were stored, inches	Total run-off during 90-day period, acre-feet
Mar. 26, 1922	53.6	687	0.13	185,000
Apr. 25, 1922	53.5	1,990	.38	
Mar. 20, 1929	51.8	357	.07	
Apr. 5-6, 1929	51.5	6,070	1.16	691,000
May 19, 1929	52.7	1,710	.33	

67. If the entire flow of the Little Missouri were stored, the probable reductions on the Cairo peak would vary from 0.07 (Mar. 20, 1929) to 1.16 (Apr. 5-6, 1929) inches. The maximum run-off of 691,000 acre-feet occurred during the 90-day storage period, in 1929.

68. *Effect of operation of Bullion Butte Reservoir.*—The total drainage area of the Little Missouri Basin is 9,500 square miles. The total drainage area above the Bullion Butte Reservoir site is 5,292 square

miles, or a little more than one half of the drainage area. The probable results that might be obtained by the operation of the Bullion Butte Reservoir, were computed for the 1922 and 1929 Mississippi flood periods. The results are summarized in the following tabulation:

Cairo stage reductions, Bullion Butte Reservoir

Cairo peak	Cairo stage, feet	Average rate of storage, 21 days, second-feet	Probable reduction, Cairo peak, in inches	Total storage, 90-day period Jan. 26–Apr. 25), acre-feet
Mar. 26, 1922	53.6	350	0.07	102,000
Apr. 25, 1922	53.5	1,090	.21	
Mar. 20, 1929	51.8	200	.04	
Apr. 5-6, 1929	51.5	3,480	.66	257,400
May 19, 1929	52.7	960	.18	

69. The probable reductions of the Cairo peak that would have resulted from the operation of Bullion Butte Reservoir, vary from 0.04 of an inch, during the March 20 peak of the 1929 flood, to 0.66 of an inch during the April 5–6 peak of the 1929 flood. The maximum average rate of flow for the 21-day period, removed from the Cairo crest, is about 3,480 second-feet. A total of 102,000 acre-feet would have been stored during the 1922 flood and 257,400 acre-feet during the 1929 flood. The computations indicate that it would have been necessary to waste about 128,000 acre-feet during the middle of the 90-day period in 1929, in order to keep below the uniform storage rate line. The total run-off at the site during the period, was 389,000 acre-feet. No run-off data are available for the 1927 Mississippi flood, the greatest of record. It is estimated that the Bullion Butte Reservoir would cost $4,827,000. The cost is excessive, compared to the probable benefits that might be obtained.

B. EFFECT ON MISSOURI FLOODS

70. *General.*—There are about 1,583 river miles (1890 mileage) of Missouri Valley below the mouth of the Little Missouri River. The upper Missouri Valley is not subject to overflow, although the section in the vicinity of Kansas City and below, is subject to overflow from excessive floods. The floods on the lower Missouri generally occur during the period May 16 to July 15, inclusive, and allowing 11 days for the time of water travel from the mouth of the Little Missouri to Kansas City, the period that the Little Missouri River flow would affect Missouri floods, is from May 5 to July 4, inclusive.

71. The regular floods on the lower Missouri River are generally two in number. The first is usually in April and is of short duration; rarely lasting over a week or 10 days, and is generally caused by the melting snows over the great plains area of the middle and upper river. It seldom exceeds flood stage by more than 1 or 2 feet at Kansas City. The second regular flood, known as the June rise, is

normally higher and of longer duration. It originates from melting snows in the headwaters of the Missouri Basin and reaches serious proportions in the lower basin, if accompanied by heavy general rains over that area. Occasional small rises of short duration may be expected late in the fall, although they rarely exceed flood stage. During the past 31 years (1900–30) flood stage has been exceeded at Kansas City 17 times. Flood stage has been exceeded by 3 feet, or more, on 8 different occasions. The highest stage of the period occurred in June 1903, when flood stage was exceeded by 13 feet at Kansas City. Of the 17 Missouri River floods at Kansas City, 3 occurred before the normal Missouri River flood period (May 16 to July 15), 12 during the period, and 2 following. The records of stage obtained on the Missouri River at Kansas City for the past 58 years (April 21, 1873, to date), show only 2 floods after July 15, their occurrence being July 15–25, 1907, and July 13 to August 10, 1915.

72. The operation of the Bullion Butte Reservoir for the benefit of Mississippi floods (see par. 64), would involve a uniform daily storage rate over the 90-day period (approximately, Jan. 26 to Apr. 25, at the reservoir), comparable to February 15 to May 15 at Cairo. If an early Missouri flood coincided with the Mississippi flood period, the Missouri would receive some minor benefits from the operation of the reservoir. However, Missouri floods during the Mississippi period, are so infrequent and of such a minor nature that the benefit to the Missouri, from the operation of the Bullion Butte Reservoir for Mississippi flood control, would be of no consequence. If a late Missouri flood came in the year without a Mississippi flood, some of the storage capacity in the reservoir might be available for the use of the Missouri, but the amount of storage capacity would vary considerably and would be undependable.

73. All the evidence at hand, points to the probability that the combined operation of the Bullion Butte Reservoir, for both Mississippi and Missouri flood protection, could not be successfully accomplished, since the adopted storage method for Mississippi flood control would require that the reservoir be filled at the end of the Mississippi period. However, the adopted storage method might be changed to provide a uniform rate of storage over both the Mississippi and Missouri flood periods, which would considerably decrease the benefits to be derived by the Mississippi.

74. Any definite statement as to the probable effects and benefits, that might be derived from controlling the flow of the Little Missouri River, on Missouri floods, would be premature at this time. The flood problem in the lower Missouri is now under study, but this investigation has not proceeded far enough for any definite conclusions. However, the matter may be treated in a general way.

75. The major Missouri floods, during the past 31 years, were those of 1903, 1908, and 1915, and all were caused by excessive rains over the lower basin. The following table summarizes the flow of the Little Missouri River at the mouth that would have passed Kansas City during the Missouri flood period (May 16 to July 15) for 1903, 1908, and 1915.

Little Missouri discharge, at mouth

Year	Mean flow May 5 to May 31	Mean flow June 1 to July 4	Mean flow for Missouri flood period May 5 to July 4
	Second-feet	*Second-feet*	*Second-feet*
1903	623	402	498
1908	1,080	2,570	1,950
1915	480	1,210	890

76. The above table shows that the flow of the Little Missouri has had very little effect on major Missouri floods, during the past 31 years. Computations were also made to determine the probable effect of the flow of the Little Missouri on the Kansas City gage, during the 1903, 1908, and 1915 Missouri River floods. The setback for time of water travel of 11 days was used. A period of 11 days was also adopted for averaging the mean rate of flow, or storage, to be used in computing reductions on the Kansas City gage; the middle day of the 11-day period corresponding to the day of the Kansas City peak. The results indicate probable reductions on the Kansas City gage that vary from 0.07 to 0.41 of a foot, provided the entire flow was stored, and from 0.04 to 0.23 of a foot, with the Bullion Butte Reservoir operating on a 61-day storage plan. It is obvious that the reductions of such a small amount would have no important bearing upon a general flood-control plan for the Missouri. However, the question will be fully covered in the report on the Missouri River to be submitted at a later date. Meanwhile, the matter must be held in abeyance until a comprehensive plan for the control of floods on each of the larger tributaries of the Missouri have been completed.

C. EFFECT ON MISSOURI AND MISSISSIPPI NAVIGATION

77. *General.*—The navigation season on the Missouri is from about March 1 to November 30. Ordinarily, there is a short low-water period during March, usually about 10 days in the vicinity of Kansas City, when an additional supply of water would be useful. Following the March low water and continuing until the middle of July, is the normal high water. The low-water season ordinarily begins about August 1, and generally continues until the end of the navigation season, or about November 30, although about half of the time August stages are not especially low. However, during the low-water years, stages during the month of July, are sometimes quite low. The stage records of the Missouri at Kansas City indicate that it would be desirable in the usual case, to increase the flow throughout the period, August 1 to November 30, inclusive, and during part of July, for certain low-water years. An extreme low stage in the month of May occurred in 1931; it would thus appear that it might be desirable to release water in the spring months when especially low stages obtain.

78. Theoretically, the most effective plan for the utilization of reservoirs for navigation purposes would provide (1) for varying rates of both storage and discharge to minimize stage fluctuations and (2) the release of impounded water, on a large scale, during the

periods of lowest stage. Therefore, the best method of operating reservoirs, solely for navigation purposes on the Missouri, would be to store all the available flow above the reservoirs (less the minimum flow) during the entire period that the Missouri is closed to navigation, which is normally from December 1 to February 28; release some of the stored water during the Missouri low-water period of March and possibly May; store until the beginning of the low-water season, about August 1; and finally release storage during the low-water season at varying rates, depending upon the stages obtaining. The actual development of such a method of operation in detail requires an exhaustive and complicated study of the characteristics of the Missouri River. It would be quite important that the detailed study be based on the characteristics of the Missouri as they obtain in the improved river.

79. This matter will be further investigated in a later report on the Missouri River as a whole, which will include a plan for a reservoir system for navigation purposes, including an evaluation of the navigation benefits that might accrue from reservoirs utilized for other purposes, either in whole or in part. Consequently, a detailed analysis cannot be made at this time, but the question may be treated in a general way.

80. In order to obtain an index of the average contribution of the Little Missouri to the flow of the Missouri, the mean monthly discharge in second-feet at the mouth and at Bullion Butte Reservoir site, has been compiled from stream, flow records obtained at Medora, N.Dak., during the periods 1903–08, 1922–26, and 1928 to September 30, 1930. These data are summarized in the following tabulation:

Discharge data, Little Missouri River

[1903 to 1908, 1922 to 1926, and 1928 to Sept. 30, 1930]

Month	Mean monthly flow in second-feet		Month	Mean monthly flow in second-feet	
	Bullion Butte Reservoir site	At the mouth		Bullion Butte Reservoir site	At the mouth
January	24	42	September	229	409
February	222	397	October	238	424
March	1,280	2,290	November	74	132
April	975	1,740	December	38	68
May	762	1,360			
June	1,700	3,030	Mean annual run-off in acre-feet	394,000	705,000
July	591	1,050			
August	452	806			

81. The computed mean annual run-off of the Little Missouri is 705,000 acre-feet at the mouth (drainage area, 9,500 square miles), and 394,000 acre-feet at Bullion Butte Reservoir site (drainage area, 5,292 square miles). If it be assumed that storage in the Bullion Butte Reservoir would be held over, in order to insure a supply of 320,000 acre-feet (capacity of reservoir) at the beginning of the low-water year on the Missouri and that the storage were released at a uniform rate over the 122-day period (August 1 to November 30, inclusive), the reservoir would supply an approximate flow of 1,300 second-feet, which is equivalent to an increase of about 0.2 of a foot

on the Kansas City gage (during low-water periods). The run-off above the reservoir site available for navigation storage (December 1, 1928, to July 1, 1929), was 794,000 acre-feet, or sufficient to have filled the reservoir prior to the beginning of the present Missouri low-water period. However, the run-off in 1930 and 1931 that would have been available for navigation storage, was 145,000 and 38,000 acre-feet, respectively. The reservoir with a capacity of 320,000 acre-feet, would not have filled during either of the critical Missouri low-water years, thus, seriously impairing its value for navigation purposes.

82. *Effect on Mississippi.*—The Mississippi River, in the vicinity of St. Louis, about 18 miles below the mouth of the Missouri, has characteristics of flow during low-water periods that correspond, in general, to those of the lower Missouri. The navigation season, for that part of the Mississippi River, between the mouth of the Missouri River and Cairo, is from March 1 to November 30; the river may be open for a short time after December 1, but river traffic ordinarily stops during the first part of December. It would be desirable, during years of extreme drought, to increase the low-water flow of the Mississippi; however, as stated in paragraph 81, the Bullion Butte Reservoir, in the Little Missouri River Basin, could be expected to produce a still smaller effect upon the low-water flow of the Mississippi at St. Louis, than upon the low-water flow of the Missouri at Kansas City.

D. CONCLUSIONS

83. As a result of the investigation of the effect of the Little Missouri River flow on Mississippi and Missouri Rivers, the following conclusions may be stated:

(*a*) The Little Missouri flood peaks of record have not materially affected the peak stage of the Mississippi River at Cairo.

(*b*) Had the entire flow of the Little Missouri been stored during the 1922 and 1929 Mississippi flood periods, the reductions of the maximum Cairo peaks would have varied from 0.07 (March 20, 1929) to 1.16 (April 5–6, 1929) inches. The run-off of the Little Missouri during the 90-day period (January 28–April 27) was 185,000 acre-feet in 1922 and 691,000 acre-feet in 1929.

(*c*) The Bullion Butte Reservoir (capacity 320,000 acre-feet) could be constructed on the Little Missouri River to store the run-off from approximately one half of the total drainage, at a cost of $4,827,000. Computations indicate that the probable reductions of the Cairo peak that would have resulted from the 90-day storage operation (January 26–April 25) of the Bullion Butte Reservoir during the 1922 and 1929 flood periods, vary from 0.04 (March 20, 1929) to 0.66 (April 5–6, 1929) of an inch. The total storage would have been 102,000 acre-feet in 1922 and 257,400 acre-feet in 1929. The cost of the reservoir is excessive, compared to the probable benefits that might be obtained.

(*d*) The flow of the Little Missouri has had very little effect on any major Missouri River flood during the past 31 years. Computations indicate probable reductions on the Kansas City gage varying from 0.07 to 0.41 of a foot, provided the entire flow were stored, and from 0.04 to 0.23 of a foot, with the Bullion Butte Reservoir operating on a 61-day storage plan. Reductions of such a small amount, even though they could be accomplished, would have no important bearing upon a general flood-control plan on the Missouri River.

(*e*) Tentative results indicate that the operation of the Bullion Butte Reservoir in the Little Missouri Basin, would be of little value to navigation on the lower Missouri and Mississippi Rivers during a series of critical low-water years, such as 1929, 1930, and 1931.

IV. Irrigation and Navigation

A. EXISTING IRRIGATION DEVELOPMENT

84. The existing irrigation development within the Little Missouri Basin is practically negligible. The records of the four States, drained by this stream, indicate that water-right filings for numerous small tracts, totaling about 5,500 acres of land, have been granted. However, the land classification of the Northern Great Plains, published in 1929 by the United States Departments of Agriculture and Interior, show only eight small tracts of irrigated land within the basin, all of which are located in Harding County, S.Dak. It is estimated that about 1,000 acres, in tracts of less than 100 acres each, are irrigated annually from the Little Missouri River and its tributaries.

B. ECONOMICS OF EXISTING IRRIGATION DEVELOPMENTS

85. There are no available data regarding the cost of construction or operation and maintenance of the small developments. However, unit costs of such small private enterprises are always quite low.

C. POTENTIAL IRRIGATION DEVELOPMENTS

86. *General.*—The only opportunity for irrigation development of large continuous areas is in the wide valley near Alzada, Mont. Below Alzada the river enters the Badlands country and the areas susceptible of irrigation are small isolated tracts, varying in size from 100 to 400 acres, and located in the meanders of the river. A study of the existing stream-flow data shows that any development, large or small, would be dependent upon storage reservoirs for a dependable water supply.

87. Several investigations have been made regarding the possibility of using lignite coal or natural gas as a fuel for pumping water to the smaller tracts in the lower basin. However, the necessity of developing storage for a dependable water supply would make such a plan economically impracticable.

88. The Bureau of Reclamation has studied the feasibility of diverting water from the Little Missouri River to the Belle Fourche River. Besides the necessity of providing storage for such water, the transfer of stream flow from a Montana stream to a stream in South Dakota, would introduce serious interstate complications that might defeat such a project.

89. *Little Missouri project.*—This project is located in the wider portion of the valley of the Little Missouri Valley near Alzada, Mont. (See maps [2] 15 and 18.) As early as 1912 the Little Missouri Land & Irrigation Co. proposed to develop this area under the Carey Act. Reference is made to appendix III for the history and present status of this early development.

[2] Map 15 not printed.

90. The project, as outlined in this report (for details see appendix III), comprises approximately 25,700 acres of land on the westerly side of the river. Detailed soil classification shows only about 3,000 acres, located in scattered tracts, suitable for irrigation development. The irrigable soil is a brown to grayish-brown heavy clay loam, while the prevailing soil (classed as nonirrigable) is a heavy gray to yellowish-gray clay.

91. Stream-flow data show that the summer flow is quite erratic, and an analysis of the data (see table 62, appendix II) based on a water duty of 1.5 acre-feet per acre per annum on the land, indicates that a reservoir of 4,890 acre-feet capacity would be required to furnish a dependable water supply to the 3,000 acres of irrigable land. A reservoir site on Cottonwood Creek can be developed to the desirable capacity. The reclamation works, consisting of a diversion dam on the Little Missouri River, 6 miles of diversion canal, Cottonwood Creek Reservoir, and 24 miles of distribution canal, would cost $568,000, or $189.33 per acre.

D. ECONOMICS OF POTENTIAL IRRIGATION DEVELOPMENT

92. *General.*—There are no data available to show the annual charges that can be successfully paid by the landowners of this basin for the benefits of irrigation. However, the Federal Yellowstone project is located in a similar and adjacent basin, and charges made upon that project amount to the following: Construction repayment, $1.50; operation and maintenance, $1.10; total charge, $2.60 per acre per annum.

93. *Little Missouri project.*—The ultimate cost of this project, if built with private capital, would amount to about twice the original construction cost. Assuming that the project be financed in accordance with the statutes of Montana; namely, 20-year, 6 percent bonds to be sold at 90, the total repayment cost would amount to $393.30 per acre, or an annual repayment charge of $21.85 per acre for construction alone. Allowing $1 per acre for the cost of operation and maintenance, would make the annual charge amount to $22.85 per acre, or about nine times the charge considered economically feasible.

94. If developed as a Federal project without interest and with a repayment period of 40 years, the prevailing period on most Government projects, the annual charge, including an operation and maintenance charge of $1.25 per acre, would amount to $5.98 per acre, or more than double the amount considered economically practicable.

95. State and Federal records show that annual charges as high as $5 per acre per annum have been successfully met by owners of irrigated land within the Missouri Basin. However, such high charges can only be carried by lands having the best climatic and soil conditions; less favorable climate or soils necessitate a reduction in the maximum annual charges that can be paid. It is believed that the soils and climate of the Little Missouri would not justify payments greater than on the Lower Yellowstone project, where the annual charges have been set at $2.60 per acre. Neither is it believed that conditions are such as to permit a reduction in the probable annual return below the figure quoted above.

96. To develop the project at the annual cost considered economically feasible; namely, $2.60 per acre, would require a repayment period of 140 years.

E. CONCLUSIONS

97. As a result of this investigation the following conclusions may be stated:

(*a*) Existing irrigation in the basin is confined to a few small and partially irrigated tracts of valley land, the aggregate area of which amounts to approximately 1,000 acres.

(*b*) The erratic nature of the stream flow, during the irrigation season, precludes the possibility of any irrigation development without storage regulation.

(*c*) Future irrigation development within this basin is limited to the Little Missouri project (irrigable area 3,000 acres) and to a few small individual tracts.

(*d*) Pumping and storage charges on the smaller tracts would be prohibitive; furthermore, this type of private development does not properly fall within the scope of this report.

(*e*) Annual cost on the Little Missouri project amount to $22.85 per acre for private development, or $5.98 per acre if built as a Federal development. Although charges of $5 per acre per annum have been met on some of the most favorable projects in the Missouri Basin, it is not believed that the soils and climate of the Little Missouri project are such as to justify an annual charge in excess of $2.60 per acre.

Either of the estimated annual charges for the Little Missouri project exceeds the limit of economic feasibility by a considerable margin.

(*f*) Irrigation, as now practiced, is a minor consideration, and no feasible potential projects exist within the basin.

F. NAVIGATION

98. The investigation has disclosed no evidences of navigation on this stream. During the low-water season the water in the river lies in pools separated by shoals. During periods of extreme drought there is no flow except the underground seepage between adjacent pools. Commercial navigation on a stream of this character is impracticable.

V. Existing and Potential Power Developments

A. EXISTING POWER DEVELOPMENTS

99. There are no existing power plants in the Little Missouri River Basin. The only important load centers; namely, Marmarth, N.Dak., and Wibaux, Mont., are served by the Montana-Dakota Power Co. by transmission lines from plants located at sources of cheap fuel supply, outside of the basin. The plant serving Marmarth, located at Baker, Mont., has a gas engine installation of 1,300 horsepower driving alternating-current generators of 1,250 kilovolt-amperes total capacity. Wibaux is served from a plant located at Glendive, Mont., with steam-turbine installation of 4,020 horsepower driving alternating-current generators of 3,750 kilovolt-amperes aggregate capacity.

B. POTENTIAL WATER POWER DEVELOPMENTS

100. *General.*—A field reconnaissance of the basin disclosed three sites which might be utilized for power development. As two of these sites fall within the pool limits of the third they were abandoned from consideration in preference to the more favorable downstream site. The latter, or Bullion Butte site, is located on the main stem of the Little Missouri River approximately 20 miles south of the town of Medora, N.Dak. (See map 18, appendix I.)

101. This project was also investigated in connection with the control of Mississippi River floods. (See paragraphs 57 to 69 of this report.) The possibilities of its development as an individual power project and the possibilities of incidental secondary power production, in combination with flood control operation, were investigated in sufficient detail to determine the economic status of the project under both conditions of operation.

102. *Power possibilities.*—The following table presents the results of the potential power project studies:

Bullion Butte power project

Gross head (feet)	104
Normal head (feet)	90
Total storage (acre-feet)	320, 000
Useful storage (acre-feet)	216, 900
Installed capacity (kilowatts)	11, 000
Average annual power output for maximum development: [3]	
Kilowatt	3, 330
Kilowatt-hour	29, 150, 000
Estimated cost of output, mills per kilowatt-hour, at plant switchboard [4]	18. 7

103. *Power in combination with flood control.*—The probable results which might have been obtained by the operation of the potential Bullion Butte Reservoir for Mississippi flood control are presented and discussed in paragraphs 68 and 69 of this report. A study of incidental power development in connection with the flood-control project, based on the hypothetical operation for 1922 and 1929, indicated that a power installation of 9,200 kilowatts could have produced an annual average (for the 2 years) of 26,685,000 kilowatt-hours of intermittent secondary power. Charging against flood control all items except the cost of the power plant, generating machinery, and appurtenances, the capital cost of the 9,200 kilowatt plant is estimated at $386,400. At 10 percent per annum, the fixed charge on the plant would be $38,640. The annual cost of operation and maintenance is estimated at $6,100, placing the total annual charges against power production at $44,740. Under the above premises, the cost of the intermittent secondary power would be 1.7 mills per kilowatt-hour. While this unit cost might possibly place the output in the neighborhood of economical secondary power, the conditions on which the estimate was based are the most advantageous. Since the frequency of yearly flows of corresponding magnitude is about 1 year in 4, the average output over a continuous period would be much less than that indicated by the two flood years.

[3] Based on mean flow for all complete hydraulic years of record.
[4] Assuming that all power developed could be marketed as primary.

With annual charges remaining constant, it is apparent that the power output cost would actually be much greater than 1.7 mills per kilowatt-hour.

C. CONCLUSIONS

104. As a result of this investigation of potential power sites the following conclusions may be stated:

(*a*) There are no existing power developments in the basin.

(*b*) Present market is served by the Montana-Dakota Power Co. by transmission lines from plants located outside the basin.

(*c*) The estimated cost of prime-power production for the Bullion Butte site is 18.7 mills per kilowatt-hour at the plant switchboard, which is above the range of economical development.

(*d*) Power development in combination with flood control would produce only secondary power at widely separated intervals. With the cost of power house and electrical equipment charged against power, and all other charges for flowage, dam, and appurtenances, allocated to flood control, the cost of such intermittent secondary power would still be too high for economical production.

VI. Bank Erosion and Silt

A. GENERAL

105. The Little Missouri River transports a moderate amount of sediment in suspension. However, the average concentration of suspended sediment in this stream is very high, being approximately two and one half times as great as that of the Missouri at Kansas City.

106. The amount of sediment transported per square mile of drainage area by the Little Missouri is approximately equal to two thirds of the average for the entire Missouri River Basin. The Little Missouri is very flashy in its discharge of suspended sediment. The water discharge may vary from a few second-feet to several thousand second-feet within a day, and since a large portion of the drainage basin is made up of badlands, which erode very easily, the amount of sediment discharged varies within extremely wide limits. The Little Missouri contributed approximately 1.4 percent of the sediment transported in suspension by the Missouri past Kansas City during the period September 19, 1929, to July 31, 1931.

107. The suspended sediment discharge by the Little Missouri into the Missouri is much finer in mechanical composition than that of the Missouri, and is transported downstream by the latter without appreciable deposition. It is not believed that the bed sediment of the Little Missouri, which is very similar in composition to that of the Missouri, is discharged in sufficient quantities to seriously affect the latter.

108. Investigations to determine the nature and quantity of sediment transported by the Little Missouri were begun by this office on September 19, 1929, and continued up to July 31, 1931.[5] The studies included field, office, and laboratory work.

[5] No data was obtained during the period Dec. 1, 1930, to Apr. 2, 1931.

B. EROSION

109. *Bank erosion.*—Considerable bank erosion occurs in the drainage area of the Little Missouri. However, this erosion is of little importance, economically, as most of it occurs in the lower course of the river, which is through badlands. The suspended sediment discharge of the river is greatly augmented by bank erosion.

110. *Bed scour.*—The channel of the Little Missouri is very unstable in its lower course. With every high water, large changes in the elevation of the bed occur. Both scouring and deposition occur in considerable magnitude. At Medora, N.Dak. (mile 187.9), the United States Geological Survey has found it necessary to take discharge measurements very frequently to correct their rating curve for the changes constantly occurring in the control.

C. SUSPENDED SEDIMENT

111. *Quantity of suspended sediment.*—Field investigations to determine the quantity of sediment transported in suspension by the Little Missouri consisted of two types of measurements, as follows:

(*a*) *Precise measurements.*—These consisted in gathering water samples at five different depths from the water surface at stations distributed at uniform intervals transverse to the stream. The depths chosen were 1 foot, two tenths depth, five tenths depth, and eight tenths depth from the surface, and 1 foot from the stream bed. Stream velocity measurements were made at the same points at which samples were obtained. After the quantity of suspended sediment in the various water samples had been determined, vertical curves were drawn representing the quantity of solid matter transported at various depths of the stream. Precise computations of the amount of sediment transported in suspension were based upon the area under these curves and the cross-sectional area of the stream.

(*b*) *Surface measurements.*—These were made by gathering daily, one sample from the center of the stream near the water surface. The sediment concentration in this sample, when multiplied by the "section distribution factor" as determined by this office and the water discharge as determined by the United States Geological Survey, gives the sediment discharge. The section distribution factor is the ratio of the mean sediment content for the river cross-section and the sediment concentration in the surface samples.

112. Precise measurements were made at Medora, N.Dak., on 4 days, May 9 to 12, 1931, inclusive. Surface samples were taken during the periods September 19, 1929, to November 30, 1930, and April 3, 1931, to July 31, 1931. All field measurements were made from bridges.

113. Using the data compiled by this office and daily United States Geological Survey water discharge records, the daily suspended sediment discharges past Medora were computed.

114. A comparison of the sediment transported in suspension by the Little Missouri past Medora, N.Dak., and the Missouri past Kansas City, during the period September 19, 1929, to July 31, 1931, is made in the following tabulation:

Comparison of suspended sediment discharge of the Missouri River past Kansas City with the Little Missouri River past Medora, N.Dak.

Station	Medora, N. Dak.	Kansas City, Mo.	Percent of Missouri River suspended sediment discharged by the Little Missouri River
Mileage	187.9	380.7 (1929).	
River	Little Missouri	Missouri.	
Month	Suspended sediment discharge	Suspended sediment discharge	
	Tons	*Tons*	
1929:			
September [1]	200	693, 000	0. 029
October	41, 200	3, 900, 000	1. 060
November	900	4, 837, 000	. 019
December	400	1, 049, 000	. 038
1930:			
January	100	2, 207, 000	. 005
February	30, 400	8, 741, 000	. 348
March	151, 000	24, 524, 000	. 615
April	32, 700	18, 498, 000	. 177
May	19, 200	43, 424, 000	. 044
June	1, 330, 000	31, 415, 000	4. 220
July	47, 400	7, 702, 000	. 615
August	152, 000	4, 325, 000	3. 510
September	191, 500	11, 550, 000	1. 660
October	3, 400	6, 484, 000	. 052
November	200	5, 980, 000	. 003
December	[2] 2, 300	1, 510, 000	. 152
1931:			
January	[2] 2, 400	923, 000	. 260
February	[2] 14, 200	3, 032, 000	. 468
March	[2] 13, 100	2, 856, 000	. 458
April	[2] 26, 800	5, 924, 000	. 452
May	700	3, 780, 000	. 019
June	530, 000	16, 663, 000	3. 180
July	374, 000	8, 611, 000	4. 340
Total	2, 964, 100	218, 628, 000	[3] 1. 350
Mean monthly	132, 000	9, 760, 000	[3] 1. 350
Maximum monthly	1, 330, 000	43, 424, 000	4. 340
Minimum monthly	100	923, 000	. 003

[1] Sept. 19 to 30, inclusive.
[2] Sediment discharge during the period Dec. 1, 1930, to Apr. 2, 1931, taken from water discharge-sediment discharge curve.
[3] These figures are based on the total and mean sediment discharges; not on the percentage data in the column above.

115. The above table shows that the suspended sediment discharge of the Little Missouri varies widely. During June 1930 the Little Missouri discharged 44.8 percent of the suspended sediment discharged during the period September 19, 1929 to July 31, 1931. The ratio of the maximum monthly suspended sediment discharge to the minimum was 13,300 to 1 during the period September 19, 1929 to July 31, 1931. The corresponding ratio for the Missouri at Kansas City is only 47 to 1. During the same period the Little Missouri discharged 1.35 percent of the suspended sediment discharged by the Missouri past Kansas City. At times the suspended sediment discharge of the Little Missouri may be approximately 5 percent of that of the Missouri past Kansas City. Thus, during June 1930 and July 1931 the Little Missouri discharged respectively 4.22 and 4.34 percent of the sediment transported in suspension past Kansas City by the Missouri. However, in November 1930 the Little Missouri contributed only 0.003 percent of the suspended sediment transported past Kansas City.

116. The sedimentary load of the Little Missouri is transported downstream by the Missouri with only slight deposition occurring.

This is true because the suspended sediment of the Little Missouri is finer in mechanical composition than that of the Missouri.

117. The following table is arranged to give some conception of the relation of the sediment discharge of the Little Missouri past Medora and the Missouri past Kansas City. The relations presented are not intended to give any index concerning the seriousness of erosion, but they do show the relative quantities of solid material transported away from the respective drainage areas.

Comparison of relative quantities of suspended sediment transported by the Missouri and Little Missouri Rivers

[Period, Sept. 19, 1929 to July 31, 1931]

River	Little Missouri	Missouri.
Location	Medora, N.Dak	Kansas City, Mo.
Mileage	187.9	380.7 (1929).
Ratio of total sediment discharge to total water discharge by weight.	1:131 (7,630 parts per million).	1:307 (3,250 parts per million).
Sediment discharge per square mile of drainage area in tons.	469	444.
Amount (depth in inches) of erosion over drainage area represented by suspended sediment discharge, assuming 100 pounds of sediment to represent 1 cubic foot of natural earth deposit.	0.0040	0.0038.

118. The above table shows that the average suspended sediment concentration of the Little Missouri (7,630 parts per million by weight) was approximately two and one half times as great as that of the Missouri (3,250 parts per million). The high suspended-sediment concentration of the Little Missouri results because of the high rate of erosion of the badlands which make up a large portion of its drainage basin. The amount of suspended sediment discharged per square mile of drainage area and the average depth of erosion were about the same for the Little Missouri above Medora as for the entire Missouri Basin above Kansas City during the period of comparison, September 19, 1929, to July 31, 1931.

119. *Character of suspended sediment.*—Investigations of the character of the suspended sediment transported by the Little Missouri were confined to studies of the mechanical composition, because the size of sediment particles, or rather, the rate at which they settle through still water, largely determines the facility with which a stream can transport them.

120. Suspended-sediment samples were analyzed for their mechanical composition by elutriation. The details of the process are given in the report on sediment and erosion of the Missouri River.

121. Two types of suspended-sediment samples were analyzed, namely:

(*a*) Composite samples made up from the sediment samples sent in to the laboratory for quantitative analyses. Such composite samples were made up for each sampling station to cover the entire period of sampling.

(*b*) Individual samples taken from the stream at various depths. The results of these analyses indicate the mechanical composition of the suspended sediment at various depths of the stream at the time the samples were gathered.

122. These data for the Little Missouri River Basin are summarized in table 63, appendix 2, and chart 27, appendix I.

123. The sediment transported in suspension by the Little Missouri River is much finer in mechanical composition than that transported past Kansas City by the Missouri. Chart 27, appendix I, compares the mechanical composition of a composite sample made up of daily suspended-sediment samples taken on the Little Missouri River at Medora with a similar sample made up from suspended-sediment samples gathered daily from the Missouri River at Kansas City, which are represented by curves 1 and 2, respectively. The mean sizes of particles carried by the Missouri past Kansas City and the Little Missouri past Medora are 0.0178 millimeter and 0.00434 millimeter, respectively. The amount of material which classifies as silt or finer (diameter of particles less than one sixteenth mm) is 72.2 percent for the Missouri and 96.8 percent for the Little Missouri at the above stations. The composition of the suspended sediment transported by the Missouri in the vicinity of the Little Missouri, however, is considerably finer than that at Kansas City, and is only slightly coarser than that of the Little Missouri. This is indicated by the analysis of a composite sample obtained at Williston, N.Dak., upstream of the Little Missouri and below the Yellowstone River, which showed 89.8 percent of the sediment to be finer than one sixteenth millimeter. It is believed, however, that the sedimentary load of the Little Missouri is transported away with little deposition. This is true because the sedimentary load of the Missouri above the Little Missouri is limited by the amount of sediment it receives rather than by its capacity to transport the sediment.

D. BED SEDIMENT

124. *Character of bed sediment.*—The sediment forming the bed of the Little Missouri River increases in coarseness with the distance from the mouth. The lower course of the stream is through badlands and the bed is composed of material which is finer in comparison to the bed material upstream than ordinarily obtains. The bed material of the Little Missouri in the vicinity of Medora is quite similar to that of the Missouri below Kansas City.

125. Investigations of the character of the bed consisted of collecting and analyzing samples of the bed sediment to determine the mechanical composition.

126. Two sets of bed sediment samples were obtained from the Little Missouri River at Medora, N. Dak., in May 1931. Each set consisted of 9 samples taken on a section transverse to the river channel, extending from high-water mark to high-water mark.

127. In order to determine the average composition of the bed sediment of a stream, it is necessary to obtain samples throughout the length of the stream, unless there is a large amount of bed sediment movement downstream. When the stream bed shifts and changes rapidly, the movement of bed sediment is usually large, and the composition of the bed is much more uniform throughout the stream than in the case of a stream with a more stable bottom. In the case of the Little Missouri, a moderate amount of movement of the bed material is indicated. It is believed that the samples obtained are quite representative of the bed material throughout the lower course of the

river. But there is a possibility that the samples secured represent only the section of the stream bed where the samples were taken.

128. The following table gives a comparison of the average of 1,315 bed-sediment samples taken from the Missouri River between Kansas City and the mouth in August and September 1929 and the average of the samples taken from the Little Missouri at Medora, N.Dak., described in paragraph 126.

Comparison of average bed sediment of Missouri River with average bed sediment of Little Missouri River

River	Missouri	Little Missouri
Period	August to September 1929.	May 1931.
Location	Kansas City to mouth.	Medora, N.Dak.
Mileage	0.0 to 380.7 (1929)	187.9.
Number of samples in average	1,315	28.
Percent smaller than 1/64 mm	1.8	7.9.
General classification	e	e.
(a) Clay (smaller than 1/256 mm)	0.2	3.7
(b) Silt:		
Fine and very fine (1/256 to 1/64 mm)	1.6	4.2
Medium and coarse (1/64 to 1/16 mm)	4.0	8.6
(c) Very fine sand (1/16 to 1/8 mm)	6.0	8.4
(d) Fine sand (1/8 to 1/4 mm)	34.0	20.2
(e) Medium sand (1/4 to 1/2 mm)	24.2	27.8
(f) Coarse sand (1/2 to 1 mm)	14.2	9.4
(g) Very coarse sand (1 to 2 mm)	6.4	3.8
(h) Granule gravel (2 to 4 mm)	4.0	2.3
(i) Pebble gravel (4 to 64 mm)	5.3	11.6
(j) Cobble gravel (larger than 64 mm)	.1	.0
Total	100.0	100.0

129. The above table indicates that the Little Missouri River bed sediment is very similar to the bed material of the Missouri. This relation is also shown graphically by curves 3 and 4 on chart 27, appendix I. An examination of these curves shows that the Little Missouri sediment contains slightly more pebble gravel and silt than the Missouri River bed sediment. The general classification of both sediments is medium sand and their mean sizes are approximately the same.

130. *Bed sediment transportation.*—The character of the stream bed of the Little Missouri indicates that there is a moderate amount of bed sediment movement downstream. It is believed that this material is transported away by the Missouri without appreciable deposition. This is indicated by the fact that the Little Missouri bed sediment is of approximately the same mechanical composition as that of the lower Missouri.

E. SILTING OF RESERVOIRS

131. *General.*—With the data obtained regarding the transportation of suspended sediment by the Little Missouri River as a basis, computations were made to determine the rate of silting to be expected in several proposed reservoirs in the Little Missouri River Basin.

132. Determinations of silt content of the river water were made on a weight basis, this procedure being more accurate as well as more convenient than determinations on a volume basis. The conversion from weight to volume involves a number of uncertainties. Where

sediment is collected in a reservoir the weight per unit volume of the deposited material is different at different points. The heavier particles will be deposited near the upstream end of the reservoir; farther downstream very light and sometimes even flocculent deposits will be found. The pressure of later deposits upon material which is first deposited causes an unknown amount of compacting of the lower layers. Alternate drying and wetting of the material results in further changes in volume. Hence, there is considerable uncertainty in the choice of the proper conversion factor.

133. Studies of the deposits of the Colorado River indicate the weight to range from a minimum of 32 pounds to over 105 pounds per cubic foot.[6] The unit weight of these deposits depended upon such factors as size of particles, composition, manner of mixing, consolidation, and, especially, moisture content. The average dry weight per cubic foot of sediment deposited in settling basins as determined from settling basins in the Imperial Valley of California was 42 pounds. The average dry weight per cubic foot of 10 samples taken from the settling basins of the Kansas City, Kans., waterworks on the Missouri River was 45.3 pounds. This figure seems reasonable for very freshly deposited sediment which has not been subjected to alternate drying and wetting nor to the superimposed loads of subsequent deposits.

134. In the computations to determine the rate of silting of potential reservoirs in the Little Missouri River Basin, 50 pounds of sediment, dry weight, was assumed to occupy a cubic foot when deposited under water in a reservoir. The weight of the deposit several years after deposition was taken as 75 pounds per cubic foot. It was also assumed, unless otherwise indicated, that the entire suspended load of the river would be deposited in the reservoir into which the stream flows.

135. *Cottonwood Creek Reservoir.*—A computation was made to determine the rate of silting to be expected in the potential Cottonwood Creek Reservoir site. This site is located on Cottonwood Creek, near its mouth. Cottonwood Creek enters the Little Missouri at mile 465. This reservoir will catch all of the sediment discharged by Cottonwood Creek and that carried in the water diverted from the Little Missouri into the reservoir. Assuming the same rate of run-off to obtain in the drainage basin of Cottonwood Creek above the reservoir as occurs in the drainage basin of the Little Missouri above Cottonwood Creek, the average annual water discharge of Cottonwood Creek is approximately 8,000 acre-feet. The average sediment concentration of the Little Missouri River was 7,630 parts per million by weight during the period of sampling by this office. For this computation the average sediment concentration of the water discharged by Cottonwood Creek is assumed to be about the same as that of the Little Missouri or 8,000 parts per million. The average annual sediment discharge of Cottonwood Creek is approximately 87,000 tons, which is equivalent to 80 acre-feet of freshly deposited sediment. It is believed that only a small amount of coarse debris or bed sediment would be deposited in the reservoir. Assuming 10,000 acre-feet to be the average annual amount of water diverted from the Little Missouri into the reservoir and the average sediment concentration of this water to be 8,000 parts per million, 109,000 tons or 100 acre-feet of freshly deposited sediment would be deposited in the reservoir by

[6] Fortier, Samuel, and Blaney, H. F., Silt in the Colorado River and its Relation to Irrigation. U.S. Department of Agriculture Technical Bulletin No. 67.

the diverted water. The total average annual amount of sediment that may be expected to deposit in the reservoir is 196,000 tons or 180 acre-feet of freshly deposited sediment. This is equivalent to 120 acre-feet of sediment that has been deposited a number of years. On the basis of an effective average annual deposition of 120 acre-feet of sediment this reservoir would be completely filled with sediment in 41 years if no provisions were made for sluicing out the sediment deposit.

136. *Bullion Butte Reservoir.*—A computation was made to determine the amount of sediment that can be expected to deposit in the Bullion Butte Reservoir. This reservoir, which is located at mile 241 on the Little Missouri River, has a capacity of 320,000 acre-feet. Based on the suspended sediment discharge records for the Little Missouri at Medora, a sediment discharge—water discharge curve was constructed. Suspended sediment discharges were obtained from this curve to supplement the periods of measurement so that sediment discharges were had for the period October 1, 1921, to September 30, 1931. It appears from this estimate covering approximately 10 years that the average annual sediment discharge of the Little Missouri past Medora is approximately 8,600,000 tons. This is equivalent to 7,900 acre-feet of freshly deposited sediment or 5,270 acre-feet of sediment that has been deposited a number of years. During years of high-water discharge, the suspended sediment discharge is much higher than the average figure given above. For instance during the year October 1, 1928, to September 30, 1929, the suspended sediment discharge was approximately 22,000,000 tons or approximately two and five tenths times as great as the average annual suspended sediment discharge. A moderate amount of bed sediment would probably be deposited in such a reservoir. It is believed that the volume of bed sediment deposited would not exceed 5 percent of the volume of the suspended sediment. Based on the above figures, the ultimate silting of this reservoir would occur in approximately 61 years, if no provisions were made for sluicing out the sediment deposit. Assuming bed sediment equal to 5 percent of the volume of the suspended sediment, the ultimate silting of the reservoir would result in only 58 years.

F. CONCLUSIONS

137. The following conclusions may be drawn from the silt investigation on the Little Missouri River:

(*a*) The amount of sediment discharged by the Little Missouri into the Missouri was quite small during the period of observation, September 19, 1929, to July 31, 1931, being approximately 1,600,000 tons annually. However, an estimate for the 10-year period 1921 to 1931, places the average annual figure at 8,600,000 tons.

(*b*) The suspended load of the Little Missouri is composed of finer sediment than that transported by the Missouri; consequently the sedimentary load contributed by the Little Missouri is readily carried in suspension by the Missouri.

(*c*) The Little Missouri has only one important tributary, Beaver Creek, and this tributary does not appreciably influence the sedimentary characteristics of the main stream.

(*d*) The average amount of sediment discharged per square mile of drainage area by the Little Missouri past Medora, N.Dak., during the period of investigation, was approximately the same as that discharged by the Missouri per square mile of drainage area above Kansas City.

(*e*) A moderate amount of sediment is indicated to be transported along the bed of the Little Missouri, the bed sediment being quite similar in composition to that of the Missouri. It is not believed that the material transported along the bed exceeds 5 percent of the suspended load.

(*f*) Studies made to determine the silting that may be expected in reservoirs in the Little Missouri Basin indicate that silting is of extreme importance in a consideration of such reservoirs. An average of 196,000 tons, not including bed sediment (which is thought to be negligible in this instance), or 180 acre-feet of freshly deposited sediment assumed equivalent to 120 acre-feet of sediment that has been deposited a number of years, may be expected to deposit in the potential Cottonwood Creek Reservoir. At such a rate of deposition, this reservoir would silt up completely in approximately 41 years, if no desilting works were installed. Studies indicate that an average annual amount of 8,600,000 tons of suspended sediment which is assumed equivalent to 5,270 acre-feet of sediment that has been deposited a number of years, might be expected to deposit in the potential Bullion Butte Reservoir. At this rate of deposition, the reservoir would silt up completely in approximately 61 years. Assuming the volume of bed sediment to equal 5 percent of the suspended load, the average annual volume of sediment deposit would be 5,530 acre-feet. At such a rate of deposition the reservoir would be filled with sediment in approximately 58 years.

VII. Conclusions

138. *Flood control in the Little Missouri Basin.*—The Little Missouri Basin is not "subject to destructive floods" within the meaning of section 10 of the act of May 15, 1928. The areas subject to overflow are small and scattered, and the resulting flood damage does not justify the preparation of a flood-control plan.

139. The flooded area within the town of Marmarth, N.Dak., can be protected from the 100-year flood by means of levee construction at an estimated cost of $80,700. The average annual loss at Marmarth during the 23-year period (1908–30, inclusive) was estimated at $4,350, which if capitalized at 5 percent, amounts to $87,000. The capitalized annual flood loss exceeds the estimated cost and the plan is believed to be feasible from an economic standpoint.

140. The overflow area within the town of Wibaux, Mont., can be protected from a flood of 33,000 second-feet (the greatest of record), by means of levee construction, at an estimated cost of $126,700. The total assessed valuation of the municipal area in 1929 was $775,514.

141. Approximately 90 percent, or $698,000 worth of business and residential property, would be affected. In view of the menace to human life and the cost of the proposed flood-protection works compared to the assessed valuation of the property to be protected, the plan appears to be justifiable from an economic standpoint. (See pt. II, A and B.)

142. *Irrigation.*—The development of irrigation in the Little Missouri Basin is of minor importance. Existing irrigation is limited to about 1,000 acres of valley lands in small units of not more than 100 acres each.

143. The climatic conditions existing within the basin are such that the practice of irrigation would materially increase crop production. However, the possibility of any large development is limited to that part of the valley lying within the vicinity of Alzada, Mont. This area, called the "Little Missouri project", consists of about 25,700 acres of land on the westerly side of the river, only 3,000 acres of which are suitable for irrigation. To develop the above area would require a reservoir of 4,890 acre-feet. It is estimated that the cost of constructing the irrigation works would amount to $189.33 per acre.

144. The development of the Little Missouri project by private enterprise would necessitate an annual charge of approximately $22.85 per acre, while the annual charge under Federal development would amount to $5.98 per acre. Both of these are considerably in excess of the amount considered economically feasible in this basin; namely, $2.60 per acre. Therefore, the development of the only large project within the Little Missouri Basin is impracticable.

145. While irrigation development of small isolated areas along the river valley below Alzada, Mont., are possible, the costs of pumping and construction of the necessary storage facilities would prove prohibitive.

146. *Navigation.*—The erratic and extremely small flow of the Little Missouri River during the low-water season renders its development in the interest of navigation entirely impracticable.

147. *Water power.*—There are no existing power plants within the Little Missouri Basin. The present requirements are limited to the city lighting loads of Marmarth, N.Dak., and Wibaux, Mont., and are supplied by the Montana-Dakota Power Co.'s transmission lines from plants located outside of this basin. At the present time there are no additional power markets within the basin, and any additional power developments would depend upon the requirements of areas adjacent to this basin for their market.

148. There is a site for hydroelectric development on the Little Missouri River near the town of Medora, N.Dak. It would produce an average output of approximately 29,150,000 kilowatt-hours at a cost of 18.7 mills per kilowatt-hour at the plant switchboard, which is above the range of economical development. The cost of power development in connection with flood control is too costly to be considered as feasible.

149. This investigation has revealed no power projects, the cost of which would be within the range of economical development.

150. *Bank erosion and silt.*—A moderate amount of bank erosion occurs in the Little Missouri River Basin. However, this erosion is of little importance, economically, as most of it occurs in the lower course of the river which is through badlands. There is considerable scouring and shifting of the bed.

151. The average annual suspended sediment discharge of the Little Missouri was approximately 1,600,000 tons, or 1.4 percent of that transported by the Missouri past Kansas City, during the period September 19, 1929, to July 31, 1931. At times, however, the suspended sediment discharge of the Little Missouri was approximately 5 percent of that of the Missouri. (See table shown in par. 114 for data on suspended sediment discharge of Little Missouri and Missouri Rivers.) An estimate of the suspended sediment discharge of the Little Missouri during the 10-year period, October 1, 1921, to September

30, 1931, based on a water discharge-sediment discharge curve, places the average annual suspended sediment discharge of the Little Missouri at 8,600,000 tons. The suspended load of the Little Missouri is composed of a much finer sediment than that transported by the Missouri. Consequently, the sedimentary load contributed by the Little Missouri is held in suspension and transported downstream by the Missouri without appreciable deposition.

152. Studies indicate that the average annual amount of sediment that may be expected to deposit in the potential Cottonwood Creek Reservoir is approximately 196,000 tons, or 120 acre-feet, of sediment that has been deposited a number of years. These figures for the potential Bullion Butte Reservoir are 8,600,000 tons, or 5,270 acre-feet, of sediment that has been deposited a number of years. Assuming the bed sediment load to equal 5 percent of the suspended load, 5,530 acre-feet of sediment may be expected to deposit in the Bullion Butte Reservoir annually. Where practicable, desilting works should be included in the construction of reservoirs in the Little Missouri Basin.

153. *Special data required by section 10 of the act of May 15, 1928.*— "The effect * * * of further flood control of the lower Mississippi River, to be attained through the control of flood water in the 'Little Missouri Basin' by establishment of a reservoir system." The Little Missouri flood peaks in the past have not materially affected the peak stage of the Mississippi River at Cairo. Had the entire flow of Little Missouri River been stored during the 1922 and 1929 Mississippi flood periods, the reductions of the maximum Cairo peaks would have varied from 0.07 (Mar. 20, 1929) to 1.16 (Apr. 5–6, 1929) inches. The run-off of the Little Missouri during the 90-day period (Jan. 28–Apr. 27), was 185,000 acre-feet in 1922 and 691,000 acre-feet in 1929.

154. The Bullion Butte Reservoir (capacity 320,000 acre-feet) could be constructed on the Little Missouri River, to store the run-off from approximately one half of the total drainage area, at a cost of $4,827,000. Computations indicate the probable reductions of the Cairo peak, that would result from the 90-day storage operation (Jan. 26–Apr. 25) of the Bullion Butte Reservoir during the 1922 and 1929 flood periods, vary from 0.04 (Mar. 20, 1929) to 0.66 (Apr. 5–6, 1929) of an inch. The total storage would have been 102,000 acre-feet in 1922 and 257,400 acre-feet in 1929. The cost of the reservoir is excessive compared to the probable benefits that might be obtained.

155. The flow of the Little Missouri River has had very little effect on any major Missouri flood during the past 31 years. Computations indicate probable reductions on the Kansas City gage, varying from 0.07 to 0.41 of a foot, provided the entire flow were stored, and from 0.04 to 0.23 of a foot with the Bullion Butte Reservoir operating on a 61-day storage plan. Reductions of such a small amount, even though they could be accomplished, would have no important bearing upon a general flood-control plan on the Missouri River.

156. Tentative results indicate that the operation of the Bullion Butte Reservoir in the Little Missouri Basin would be of little value to navigation on the lower Missouri or Mississippi Rivers during a series of critical low-water years, such as 1929, 1930, and 1931. (See pt. III, A to D, inclusive.)

157. "The benefits that will accrue to navigation and agriculture from the prevention of erosion and siltage entering the stream." There is no commercial navigation on the Little Missouri River, nor are there prospects of any. Considerable bank erosion occurs in the drainage area of the Little Missouri. However, this erosion is of little importance economically as most of it occurs in the lower portion of the river, which flows through badlands. The suspended sediment discharge of the river is greatly augmented by bank erosion. However, the holding back of the sediment of the Little Missouri River would have little effect on navigation on the Missouri River. Agriculture suffers no damage from "siltage entering the stream" other than from the washing of soils by heavy rains. The conditions of surface erosion, of course, occur all over the United States and are apparently outside the scope of the investigation by the Department, under the existing laws. (See pts. IV and VI.)

158. "A determination of the capacity of the soils of the district to receive and hold waters from such reservoirs." The larger part of the soils of the Little Missouri Basin are derived from the Pierre shales. These soils offer very little opportunity for the retention of reservoired water. (See pt. I.)

159. "The prospective income from the disposal of reservoired waters." Due to the large cost of irrigation and power development within the Little Missouri Basin and the impracticability of constructing such plants, there could be no income from the disposal of reservoired waters. (See pts. IV and V.)

160. "The extent to which reservoired waters may be made available for public or private uses." If costs be disregarded and complete control of the Little Missouri River assumed, reservoired waters in combination with natural flow could be made available for the development of 3,000 acres of irrigable land in the Little Missouri project, and an annual output of 3,330 kilowatts of primary power at the Bullion Butte power site. If the above developments were undertaken, the benefits to navigation would be insignificant. The above power development clearly falls in the classification described in paragraph 2, subparagraph (c), House Document 308, first session, Sixty-ninth Congress. The benefits to navigation derived from this project would be negligible. (See pts. IV and V.)

161. "Inquiry as to the return flow placed on these soils from the reservoirs and as to their stabilizing effect on stream flow as a means of preventing erosion, siltage, and improving navigation." A phenomenon of irrigation development, commonly known as "return flow", would not be appreciably noticed from any possible irrigation development within the Little Missouri River Basin. The possible development of water-power plants within the basin also would have no considerable effects upon the stream flow. Development of the Bullion Butte site, either in the interest of power or flood control, would not have a decidedly beneficial effect on erosion in the Little Missouri Basin, as this site is located within the lower portion of the basin. (See pts. III A, IV, and V.)

VIII. Plan of Development

162. Under existing conditions it appears that the only feasible plan of development in the Little Missouri Basin would include local flood-protection plans for the towns of Marmarth, N.Dak., and Wi-

baux, Mont., outlined in paragraphs 45 to 55, inclusive. The estimated total cost for Marmarth, N.Dak., is $80,700 and for Wibaux, Mont., $126,700. Both plans are considered feasible from an economic standpoint.

163. *Federal interest.*—There is no Federal interest in the flood-control plans for the protection of Marmarth, N.Dak., and Wibaux, Mont., on the score of flood control and/or navigation benefits on the Mississippi and/or Missouri Rivers. What interest the Federal Government might have in subsidizing or cooperating in a local flood-control plan here or elsewhere is unknown to this office. This is a matter of national policy for Congress to determine.

IX. Recommendations

164. It is recommended that the projects for the protection of flooded areas in Marmarth, N.Dak., and Wibaux, Mont., as outlined in paragraphs 45 to 55, be adopted by the Department as an approved plan for local flood control in the Little Missouri Basin, as required by House Document 308, Sixty-ninth Congress, first session (law by act of January 21, 1927 (H.R. 11616, 69th Cong., 2d sess.)), and by section 10 of the act of May 15, 1928 (S. 3740, 70th Cong., 1st sess.); and that this report be printed.

Theodore Wyman, Jr.,
Captain, Corps of Engineers,
District Engineer.

Appendix I

List of Maps and Charts

[Only maps 2 and 18 and charts 21–27 printed. Blueprint copies of the illustrations not printed, may be procured at cost of reproduction, from the District Engineer, United States Engineer Office, Kansas City, Mo.]

MAPS

No.

1. Missouri River Basin—Location of Little Missouri River Basin.
2. Tributaries, towns, and public land lines.
3. Topography and mapped areas.
4. Weather Bureau stations and precipitation.
5. Annual mean temperatures.
6. Spring and fall killing frosts.
7. Average days without frost.
8. Population density by counties.
9. Highways and railways.
10. Gaging stations.
11. Storm of May 25–29, 1929.
12. Flood protection plan—Marmarth, N.Dak.
13. Flood protection plan—Wibaux, Mont.
14. Bullion Butte proposed flood control dam.
15. Little Missouri potential irrigation project with soil classification.
16. Little Missouri potential irrigation project—Cottonwood Creek Storage Dam.
17. Little Missouri potential irrigation project—Diversion dam.
18. Existing and potential flood control, irrigation, and power projects.

CHARTS

21. Profile.
22. Duration of records—Discharge, river stage, and precipitation stations.

23–24. Daily hydrograph of Little Missouri River at Medora, N.Dak.

25–26. Daily hydrograph of Little Missouri River near Alzada, Mont.

27. Comparison of sediment in Little Missouri River and Missouri River Basins.

Appendix II

General Tables

CONTENTS

GENERAL AND ECONOMIC STATISTICS

CLIMATIC DATA

TABLE 1.—*Population, rural*

State and county	1900	1910	1920	1930	County area in basin	Density population
					Square miles	*Per square mile*
Montana:						
Carter			2,900	3,020	2,496	1.2
Custer	1,970	2,360				
Dawson	20	130				
Fallon			1,590	1,600	595	2.7
Wibaux			1,180	1,050	348	3.0
Total	1,990	2,490	5,670	5,670	3,439	1.6
North Dakota:						
Billings	660	7,640	2,130	2,140	802	2.7
Bowman		1,910	1,950	2,100	490	4.3
Dunn		1,430	2,380	2,580	582	4.4
Golden Valley			4,540	3,870	961	4.0
McKenzie		2,170	3,630	3,700	1,114	3.3
Mercer	140					
Slope			3,160	2,650	800	3.3
Stark	1,140					
Total	1,940	13,150	17,790	17,040	4,749	3.6
South Dakota:						
Harding		930	870	790	595	1.3
Butte	230					
Total	230	930	870	790	595	1.3
Wyoming: Crook	410	840	1,270	1,270	690	1.8
Grand total	4,570	17,410	25,600	24,770	9,473	2.6
Other counties					27	
Total area					9,500	

TABLE 2.—*Land and farm area*

State and county	County area in basin	Improved, in farms	Woodland, in farms	Unimproved, in farms	Not in farms
1910					
Montana:	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Custer	2, 089, 600	31, 150	7, 740	194, 010	1, 856, 700
Dawson	111, 360	1, 830	120	4, 120	105, 290
Total	2, 200, 960	32, 980	7, 860	198, 130	1, 961, 990
North Dakota:					
Billings	1, 640, 320	163, 550	930	209, 280	1, 266, 560
Bowman	313, 600	56, 400	290	34, 890	222, 020
Dunn	372, 480	36, 880	1, 010	76, 330	258, 260
McKenzie	712, 960	36, 210	2, 770	66, 610	607, 370
Total	3, 039, 360	293, 040	5, 000	387, 110	2, 354, 210
South Dakota, Harding	380, 800	10, 390	210	41, 140	329, 060
Wyoming, Crook	458, 880	13, 540	11, 200	59, 610	374, 530
Grand total	6, 080, 000	349, 950	24, 270	685, 990	5, 019, 790
1920					
Montana:					
Carter	1, 597, 440	61, 150	12, 570	333, 260	1, 190, 460
Fallon	380, 800	60, 140	170	141, 560	178, 930
Wibaux	222, 720	53, 310	200	74, 230	94, 980
Total	2, 200, 960	174, 600	12, 940	549, 050	1, 464, 370
North Dakota:					
Billings	513, 280	71, 090	2, 850	250, 520	188, 820
Bowman	313, 600	71, 940	1, 630	130, 180	109, 850
Dunn	372, 480	85, 010	1, 270	122, 590	163, 610
Golden Valley	615, 040	222, 770	16, 470	272, 750	103, 050
McKenzie	712, 960	138, 230	6, 390	323, 300	245, 040
Slope	512, 000	140, 130	800	171, 370	199, 700
Total	3, 039, 360	729, 170	29, 410	1, 270, 710	1, 010, 070
South Dakota, Harding	380, 800	22, 760	1, 610	245, 570	110, 860
Wyoming:					
Crook	441, 600	29, 120	31, 410	157, 960	223, 110
Other counties [1]	17, 280				
Grand total	6, 080, 000	955, 650	75, 370	2, 223, 290	2, 808, 410
1925					
Montana:					
Carter	1, 597, 440	184, 300	11, 770	442, 240	959, 130
Fallon	380, 800	99, 450	670	106, 990	173, 690
Wibaux	222, 720	58, 710	340	40, 970	122, 700
Total	2, 200, 960	342, 460	12, 780	590, 200	1, 255, 520
North Dakota:					
Billings	513, 280	115, 220	1, 270	144, 400	252, 390
Bowman	313, 600	102, 600	110	91, 710	119, 180
Dunn	372, 480	138, 270	2, 030	122, 950	109, 230
Golden Valley	615, 040	193, 190	500	151, 260	270, 090
McKenzie	712, 960	147, 800	6, 660	185, 360	373, 140
Slope	512, 000	140, 600	2, 470	103, 690	265, 240
Total	3, 039, 360	837, 680	13, 040	799, 370	1, 389, 270
South Dakota, Harding	380, 800	133, 260	1, 050	143, 000	103, 490
Wyoming:					
Crook	441, 600	50, 140	33, 930	180, 760	176, 770
Other counties [1]	17, 280				
Grand total	6, 080, 000	1, 363, 540	60, 800	1, 713, 330	2, 925, 050

[1] Portions of counties too small to tabulate.

TABLE 3.—*Agricultural production—Barley*

State and county	Acres			Bushels			Value, 1925
	1910	1920	1925	1910	1920	1925	
Montana:							
Carter		10	1,090		20	17,690	$13,800
Custer	180			3,570			
Dawson	10			430			
Fallon		200	1,460		350	29,970	23,380
Wibaux		240	680		640	16,450	12,830
Total	190	450	3,230	4,000	1,010	64,110	50,010
North Dakota:							
Billings	2,100	430	2,750	61,190	930	57,020	34,210
Bowman	740	270	2,010	18,410	490	43,190	25,910
Dunn	460	1,740	3,020	11,150	9,920	66,880	40,130
Golden Valley		650	3,160		2,140	75,990	45,590
McKenzie	420	610	1,750	13,480	3,580	47,100	28,260
Slope		370	2,490		1,890	51,700	31,020
Total	3,720	4,070	15,180	104,230	18,950	341,880	205,120
South Dakota, Harding	90	140	540	2,130	480	12,380	7,550
Wyoming, Crook	140	50	380	3,510	690	6,150	5,350
Grand total	4,140	4,710	19,330	113,870	21,130	424,520	268,030

TABLE 4.—*Agricultural production—Corn*

State and county	Acres			Bushels			Value, 1925
	1910	1920	1925	1910	1920	1925	
Montana:							
Carter		130	3,250		810	39,100	$41,840
Custer	690			17,820			
Dawson	30			780			
Fallon		80	1,300		120	17,190	18,390
Wibaux		40	300		490	4,620	4,940
Total	720	250	4,850	18,600	1,420	60,910	65,170
North Dakota:							
Billings	870	40	90	26,100	190	1,630	1,220
Bowman	420	170	860	9,460	990	14,260	10,700
Dunn	540	190	480	13,580	2,240	5,560	4,170
Golden Valley		210	500		1,400	7,300	5,480
McKenzie	510	190	620	13,080	2,070	10,910	8,180
Slope		220	500		1,290	7,910	5,930
Total	2,340	1,020	3,050	62,220	8,180	47,570	35,680
South Dakota, Harding	390	400	630	7,870	1,450	11,070	8,860
Wyoming, Crook	400	160	860	8,150	1,280	11,240	11,460
Grand total	3,850	1,830	9,390	96,840	12,330	130,790	121,170

TABLE 5.—*Agricultural production—Flaxseed*

State and county	Acres			Bushels			Value, 1925
	1910	1920	1925	1910	1920	1925	
Montana:							
Carter		10	2, 590		20	12, 930	$30, 510
Custer	1, 610			22, 110			
Dawson	140			1, 710			
Fallon		110	3, 240		100	19, 630	46, 330
Wibaux		530	4, 250		710	28, 550	67, 380
Total	1, 750	650	10, 080	23, 820	830	61, 110	144, 220
North Dakota:							
Billings	24, 660	1, 000	6, 230	350, 380	1, 480	37, 740	92, 090
Bowman	3, 260	30	7, 370	36, 170	70	48, 340	117, 950
Dunn	2, 620	3, 020	7, 500	28, 830	7, 490	52, 820	128, 880
Golden Valley		1, 430	18, 640		2, 140	106, 900	260, 840
McKenzie	4, 820	2, 450	9, 120	46, 970	5, 020	76, 550	186, 780
Slope		390	10, 820		1, 150	67, 400	164, 460
Total	35, 360	8, 320	59, 680	462, 350	17, 350	389, 750	951, 000
South Dakota, Harding	160	30	930	1, 770	40	8, 300	20, 090
Grand total	37, 270	9, 000	70, 690	487, 940	18, 220	459, 160	1, 115, 310

TABLE 6.—*Agriculture production—Hay and forage*

State and county	Acres			Tons			Value, 1925
	1910	1920	1925	1910	1920	1925	
Montana:							
Carter		12, 620	37, 020		3, 950	31, 390	$313, 270
Custer	10, 450			12, 400			
Dawson	460			390			
Fallon		4, 550	7, 830		1, 300	7, 080	70, 660
Wibaux		10, 600	4, 860		2, 960	4, 690	46, 810
Total	10, 910	27, 770	49, 710	12, 790	8, 210	43, 160	430, 740
North Dakota:							
Billings	20, 090	25, 940	17, 060	16, 030	8, 420	13, 920	114, 700
Bowman	7, 780	12, 320	15, 970	4, 990	3, 560	12, 140	100, 030
Dunn	16, 470	25, 830	23, 270	10, 740	8, 630	19, 120	157, 550
Golden Valley		40, 820	20, 780		11, 120	19, 260	158, 700
McKenzie	14, 600	41, 070	23, 230	14, 140	20, 560	25, 940	213, 750
Slope		20, 350	14, 730		6, 970	12, 810	105, 550
Total	58, 940	166, 330	115, 040	45, 900	59, 260	103, 190	850, 280
South Dakota, Harding	4, 230	12, 210	13, 040	3, 660	2, 990	9, 470	94, 980
Wyoming, Crook	5, 810	10, 150	12, 560	7, 820	5, 100	11, 290	116, 510
Grand total	79, 890	216, 460	190, 350	70, 170	75, 560	167, 110	1, 492, 510

TABLE 7.—*Agricultural production—Oats*

State and county	Acres			Bushels			Value, 1925
	1910	1920	1925	1910	1920	1925	
Montana:							
Carter		40	5, 160		150	111, 940	$60, 450
Custer	2, 800			99, 850			
Dawson	260			9, 160			
Fallon		270	3, 800		860	98, 220	53, 040
Wibaux		1, 190	4, 730		4, 680	132, 410	71, 500
Total	3, 060	1, 500	13, 690	109, 010	5, 690	342, 570	184, 990
North Dakota:							
Billings	26, 810	1, 240	7, 700	1, 053, 770	5, 420	194, 840	64, 300
Bowman	4, 750	790	7, 530	185, 350	1, 950	200, 690	66, 230
Dunn	4, 280	4, 430	10, 140	160, 480	34, 300	302, 120	99, 700
Golden Valley		5, 310	20, 980		20, 130	563, 200	185, 860
McKenzie	6, 930	3, 470	11, 670	250, 640	26, 760	337, 080	111, 240
Slope		1, 150	9, 830		4, 730	259, 220	85, 540
Total	42, 770	16, 390	67, 850	1, 650, 240	93, 290	1, 857, 150	612, 870
South Dakota, Harding	790	440	2, 020	24, 460	2, 430	55, 080	19, 280
Wyoming, Crook	1, 830	50	1, 110	54, 140	630	20, 870	11, 900
Grand total	48, 450	18, 380	84, 670	1, 837, 850	102, 040	2, 275, 670	829, 040

TABLE 8.—*Agricultural production—Potatoes*

State and county	Acres			Bushels			Value, 1925
	1910	1920	1925	1910	1920	1925	
Montana:							
Carter		80	130		1, 870	8, 340	$12, 090
Custer	240			21, 420			
Dawson	10			980			
Fallon		70	70		1, 320	6, 510	9, 440
Wibaux		200	80		3, 130	7, 560	10, 960
Total	250	350	280	22, 400	6, 320	22, 410	32, 490
North Dakota:							
Billings	400	210	100	53, 500	5, 350	7, 760	6, 830
Bowman	120	110	130	13, 330	1, 940	7, 960	7, 000
Dunn	160	180	110	16, 330	6, 570	11, 300	9, 940
Golden Valley		460	240		10, 420	16, 680	14, 680
McKenzie	170	310	260	18, 700	12, 090	24, 670	21, 710
Slope		210	110		4, 710	10, 370	9, 130
Total	850	1, 480	950	101, 860	41, 080	78, 740	69, 290
South Dakota, Harding	40	50	40	3, 800	1, 250	2, 920	2, 950
Wyoming, Crook	110	80	70	10, 580	2, 960	3, 870	5, 030
Grand total	1, 250	1, 960	1, 340	138, 640	51, 610	107, 940	109, 760

TABLE 9.—*Agricultural production—Rye*

State and county	Acres			Bushels			Value, 1925
	1910	1920	1925	1910	1920	1925	
Montana:							
Carter	----------	50	850	----------	90	8,830	$8,300
Custer	40	----------	----------	820	----------	----------	----------
Dawson	----------	----------	----------	----------	----------	----------	----------
Fallon	----------	280	1,140	----------	440	13,900	13,070
Wibaux	----------	650	130	----------	1,300	1,620	1,520
Total	40	980	2,120	820	1,830	24,350	22,890
North Dakota:							
Billings	30	310	270	530	600	3,100	2,820
Bowman	----------	3,080	5,940	----------	5,230	57,450	52,280
Dunn	10	4,160	1,030	230	17,040	11,860	10,790
Golden Valley	----------	3,210	260	----------	7,540	4,140	3,770
McKenzie	----------	7,910	3,790	----------	21,950	59,300	53,960
Slope	----------	5,770	8,470	----------	14,520	114,850	104,510
Total	40	24,440	19,760	760	66,880	250,700	228,130
South Dakota: Harding	----------	340	1,000	----------	790	10,180	9,060
Wyoming: Crook	50	70	120	610	310	1,180	990
Grand total	130	25,830	23,000	2,190	69,810	286,410	261,070

TABLE 10.—*Agricultural production—Wheat*

State ond county	Acres			Bushels			Value, 1925
	1910	1920	1925	1910	1920	1925	
Montana:							
Carter	----------	2,340	10,120	----------	4,070	117,920	$170,980
Custer	1,440	----------	----------	30,400	----------	----------	----------
Dawson	190	----------	----------	4,040	----------	----------	----------
Fallon	----------	12,770	26,600	----------	20,560	346,260	502,080
Wibaux	----------	17,790	20,480	----------	38,620	279,860	405,800
Total	1,630	32,900	57,200	34,440	63,250	744,040	1,078,800
North Dakota:							
Billings	28,290	12,400	31,390	554,160	27,460	391,590	556,060
Bowman	3,630	11,430	22,770	76,440	22,170	275,770	391,590
Dunn	8,830	28,680	42,820	154,410	115,170	558,370	792,890
Golden Valley	----------	71,850	67,140	----------	166,880	920,150	1,306,610
McKenzie	9,730	37,940	49,040	191,070	140,040	815,310	1,157,740
Slope	----------	24,520	37,760	----------	47,050	446,980	634,710
Total	50,480	186,820	250,920	976,080	518,770	3,408,170	4,839,600
South Dakota: Harding	280	1,670	2,430	4,600	4,430	35,630	49,530
Wyoming: Crook	670	670	1,870	12,220	2,650	23,710	30,590
Grand total	53,060	222,060	312,420	1,027,340	589,100	4,211,550	5,998,580

TABLE 11.—*Livestock statistics—Cattle*

State and county	Number			Value		
	1910	1920	1925	1910	1920	1925
Montana:						
Carter		12,820	24,270		$813,880	$703,030
Custer	28,280			$835,990		
Dawson	360			10,740		
Fallon		5,380	6,160		303,630	178,470
Wibaux		4,010	3,650		209,100	107,110
Total	28,640	22,210	34,080	846,730	1,326,530	988,610
North Dakota:						
Billings	23,170	10,680	10,170	707,450	623,780	266,720
Bowman	1,530	7,300	7,690	47,940	373,870	200,910
Dunn	5,670	9,770	10,490	149,890	575,160	261,550
Golden Valley		12,250	10,790		618,030	293,690
McKenzie	6,650	17,360	13,370	197,750	1,144,930	324,560
Slope		10,920	10,510		592,340	272,600
Total	37,020	68,280	63,020	1,103,030	3,928,110	1,620,030
South Dakota, Harding	4,980	6,670	8,500	154,990	387,290	228,550
Wyoming, Crook	11,360	8,450	9,740	339,730	542,090	276,220
Grand total	82,000	105,610	115,340	2,444,480	6,184,020	3,113,410

TABLE 12.—*Livestock statistics—Horses*

State and county	Number			Value		
	1910	1920	1925	1910	1920	1925
Montana:						
Carter		7,900	9,200		$402,240	$247,970
Custer	7,930			$576,470		
Dawson	280			26,080		
Fallon		4,060	3,710		234,060	102,560
Wibaux		3,070	2,760		193,390	93,900
Total	8,210	15,030	15,670	602,550	829,690	444,430
North Dakota:						
Billings	14,070	6,460	4,640	1,476,840	336,790	165,510
Bowman	1,960	3,230	2,890	242,710	212,640	104,800
Dunn	3,270	5,130	5,180	326,770	328,810	189,250
Golden Valley		8,500	7,350		494,020	261,960
McKenzie	3,850	10,230	7,430	420,190	698,010	269,540
Slope		5,740	4,260		392,070	153,570
Total	23,150	39,290	31,750	2,466,510	2,462,340	1,144,630
South Dakota, Harding	1,570	2,370	2,310	137,520	131,300	68,740
Wyoming, Crook	2,600	2,900	2,600	202,480	144,300	72,210
Grand total	35,530	59,590	52,330	3,409,060	3,567,630	1,730,010

TABLE 13.—*Livestock statistics—Mules*

State and county	Number			Value		
	1910	1920	1925	1910	1920	1925
Montana:						
Carter		60	190		$5, 440	$8, 240
Custer	50			$4, 760		
Dawson						
Fallon		20	40		1, 230	1, 580
Wibaux		30	40		3, 300	1, 920
Total	50	110	270	4, 760	9, 970	11, 740
North Dakota:						
Billings	50	20	40	7, 890	1, 630	1, 800
Bowman	30	20	30	4, 990	1, 150	1, 380
Dunn	10	20	20	900	1, 260	980
Golden Valley		60	70		5, 420	3, 120
McKenzie	20	30	70	3, 450	2, 870	3, 580
Slope		40	40		4, 580	1, 870
Total	110	190	270	17, 230	16, 910	12, 730
South Dakota, Harding	10	10	10	1, 360	820	560
Wyoming, Crook	20	50	70	1, 960	3, 760	3, 500
Grand total	190	360	620	25, 310	31, 460	28. 530

TABLE 14.—*Livestock statistics—Sheep*

State and county	Number			Value		
	1910	1920	1925	1910	1920	1925
Montana:						
Carter		30, 020	69, 230		$452, 380	$733, 510
Custer	125, 580			$654, 990		
Dawson	4, 550			24, 650		
Fallon		2, 670	4, 170		33, 820	43, 960
Wibaux		550	1, 150		6, 920	11, 100
Total	130, 130	33, 240	74, 550	679, 640	493, 120	788, 570
North Dakota:						
Billings	50, 510	590	1, 540	235, 520	7, 410	15, 580
Bowman	340	5, 170	8, 590	1, 810	65, 290	84, 850
Dunn	6, 660	610	810	28, 300	10, 740	7, 650
Golden Valley		11, 200	6, 400		128, 040	62, 430
McKenzie	9, 380	430	2, 800	35, 590	5, 410	24, 580
Slope		960	7, 720		10, 610	77, 560
Total	66, 890	18, 960	27, 860	301, 220	227, 500	272, 650
South Dakota, Harding	26, 670	16, 100	22, 130	145, 530	234, 560	223, 390
Wyoming, Crook	29, 770	13, 060	10, 940	169, 240	178, 050	117, 570
Grand total	253, 460	81, 360	135, 480	1, 295, 630	1, 133, 230	1, 402, 180

TABLE 15.—*Livestock statistics—Swine*

State and county	Number			Value		
	1910	1920	1925	1910	1920	1925
Montana:						
Carter	----------	730	5,470	----------	$13,870	$63,620
Custer	580	----------	----------	$6,340	----------	----------
Dawson	30	----------	----------	320	----------	----------
Fallon	----------	480	1,800	----------	8,420	21,860
Wibaux	----------	720	1,640	----------	10,400	19,120
Total	610	1,930	8,910	6,660	32,690	104,600
North Dakota:						
Billings	2,300	1,010	2,190	25,360	13,130	23,730
Bowman	280	1,010	2,560	3,870	18,070	28,710
Dunn	1,050	1,460	3,950	8,190	21,100	42,780
Golden Valley	----------	3,640	4,180	----------	63,720	47,790
McKenzie	1,140	1,760	3,680	10,420	31,510	41,210
Slope	----------	2,270	3,500	----------	34,760	39,790
Total	4,770	11,150	20,060	47,840	182,290	224,010
South Dakota, Harding	140	350	1,930	2,040	6,560	22,700
Wyoming, Crook	360	770	1,760	3,420	12,510	17,420
Grand total	5,880	14,200	32,660	59,960	234,050	368,730

TABLE 16.—*Livestock products*

State and county	Value of milk, cream, and butter	Value of eggs and chickens	Value of wool	Total value of livestock products
1910				
Montana:				
Custer	$6,870	$11,770	$147,640	$166,280
Dawson	380	650	4,650	5,680
Total	7,250	12,420	152,290	171,960
North Dakota:				
Billings	17,460	23,140	38,520	79,120
Bowman	5,940	9,040	250	15,230
Dunn	7,120	10,430	9,710	27,260
McKenzie	11,260	13,300	5,570	30,130
Total	41,780	55,910	54,050	151,740
South Dakota: Harding	2,450	3,460	34,650	40,560
Wyoming: Crook	5,150	7,430	48,950	61,530
Grand total	56,630	79,220	289,940	425,790
1920				
Montana:				
Carter	22,110	33,400	159,350	214,860
Fallon	35,520	26,580	5,750	67,850
Wibaux	30,160	23,310	310	53,780
Total	87,790	83,290	165,410	336,490
North Dakota:				
Billings	60,390	26,530	190	87,110
Bowman	89,210	27,730	10,240	127,180
Dunn	75,570	35,940	650	112,160
Golden Valley	111,720	86,150	26,210	224,080
McKenzie	120,550	60,170	17,850	198,570
Slope	109,920	49,550	2,030	161,500
Total	567,360	286,070	57,170	910,600
South Dakota: Harding	34,220	12,610	55,850	102,680
Wyoming: Crook	22,810	25,910	56,530	105,250
Grand total	712,180	407,880	334,960	1,455,020

TABLE 16.—*Livestock products*—Continued

State and county	Value of milk, cream, and butter	Value of eggs and chickens	Value of wool	Total value of livestock products
1925				
Montana:				
Carter	$64,770	$56,510	$238,660	$359,940
Fallon	45,390	26,870	10,020	82,280
Wibaux	31,370	22,510	3,420	57,300
Total	141,530	105,890	252,100	499,520
North Dakota:				
Billings	50,200	27,330	4,310	81,840
Bowman	62,630	27,610	18,810	109,050
Dunn	69,190	35,960	1,530	106,680
Golden Valley	111,030	43,780	11,230	166,040
McKenzie	82,190	42,160	1,580	125,930
Slope	64,740	33,320	18,040	116,100
Total	439,980	210,160	55,500	705,640
South Dakota: Harding	25,890	18,200	57,710	101,800
Wyoming: Crook	27,710	23,920	28,660	80,290
Grand total	635,110	358,170	393,970	1,387,250

TABLE 17.—*Manufacturing statistics, 1920*

State and county	Number of establishments	Wage earners: Average number	Wage earners: Wages	Cost of materials	Value of products	Value added by manufacturers
Montana:						
Carter	11	10	$10,600	$20,600	$52,500	$31,900
Wibaux	3	4	6,000	7,800	21,300	13,500
Total	14	14	16,600	28,400	73,800	45,400
North Dakota:						
Golden Valley	5	11	16,600	29,600	62,200	32,600
McKenzie	5	6	7,000	67,100	87,500	20,400
Slope	5	149	240,900	71,100	331,600	260,500
Total	15	166	264,500	167,800	481,300	313,500
Grand total	29	180	281,100	196,200	555,100	358,900

TABLE 18.—*General statistical data, summary*

	1900	1910	1920	1930
Population	4,570	17,410	25,600	24,770

Item	1910	1920	1925
Land and farm area:			
Area acres in basin	6, 080, 000	6, 080, 000	6, 080, 000
Acres improved in farms	349, 950	955, 650	----------
Cropland and plowable pasture	----------	----------	1, 363, 540
Acres woodland in farms	24, 270	75, 370	60, 800
Acres unimproved in farms	685, 990	2, 223, 290	----------
All other land in farms	----------	----------	1, 713, 330
Acres not in farms	5, 019, 790	2, 808, 410	2, 925, 050
Agricultural production:			
Corn:			
Acres	3, 850	1, 830	9, 390
Bushels	96, 840	12, 330	130, 790
Value	----------	----------	$121, 170
Wheat:			
Acres	53, 060	222, 060	312, 420
Bushels	1, 027, 340	589, 100	4, 211, 550
Value	----------	----------	$5, 998, 580
Oats:			
Acres	48, 450	18, 380	84, 670
Bushels	1, 837, 850	102, 040	2, 275, 670
Value	----------	----------	$829, 040
Rye:			
Acres	130	25, 830	23, 000
Bushels	2, 190	69, 810	286, 410
Value	----------	----------	$261, 070
Barley:			
Acres	4, 140	4, 710	19, 330
Bushels	113, 870	21, 130	424, 520
Value	----------	----------	$268, 030
Flaxseed:			
Acres	37, 270	9, 000	70, 690
Bushels	487, 940	18, 220	459, 160
Value	----------	----------	$1, 115, 310
Hay and forage:			
Acres	78, 890	216, 460	190, 350
Tons	70, 170	75, 560	167, 110
Value	----------	----------	$1, 492, 510
Potatoes:			
Acres	1, 250	1, 960	1, 340
Bushels	138, 640	51, 610	107, 940
Value	----------	----------	$109, 760
Livestock production:			
Cattle:			
Number	82, 000	105, 610	115, 340
Value	$2, 444, 480	$6, 184, 020	$3, 113, 410
Swine:			
Number	5, 880	14, 200	32, 660
Value	$59, 960	$234, 050	$368, 730
Sheep:			
Number	253, 460	81, 360	135, 480
Value	$1, 295, 630	$1, 133, 230	$1, 402, 180
Horses:			
Number	35, 530	59, 590	52, 330
Value	$3, 409, 060	$3, 567, 630	$1, 730, 010
Mules:			
Number	190	360	620
Value	$25, 310	$31, 460	$28, 530
Value of livestock products:			
Milk, cream, and butter	$56, 630	$712, 180	$635, 110
Chicken eggs and chickens	$79, 220	$407, 880	$358, 170
Wool	$289, 940	$334, 960	$393, 970
Coal production:			
Coal:			
Tons	----------	----------	15, 567
Value	----------	----------	$28, 000
Manufacturing:			
Number of establishments	----------	29	----------
Wage earners:			
Average number	----------	180	----------
Wages	----------	$281, 100	----------
Cost of materials	----------	$196, 200	----------
Value of products	----------	$555, 100	----------
Value added by manufacture	----------	$358, 900	----------

Changes in County Boundaries

MONTANA

Carter was organized from part of Fallon in 1917.
Fallon was organized from part of Custer in 1913.
Wibaux was organized from parts of Dawson, Fallon, and Richland in 1914.

NORTH DAKOTA

Bowman was formed from Billings in 1907.
Golden Valley was organized from part of Billings in 1912.
Slope was organized from part of Billings in 1915.
McKenzie was organized from parts of Billings and Stark in 1905.
Dunn was organized from parts of Mercer and Stark in 1908.

SOUTH DAKOTA

Harding was organized from part of Butte in 1909.

WYOMING

Campbell was formed from part of Crook.

TABLE 19.—*Climatic data, Amidon, N.Dak.*

TEMPERATURE

No record.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1921	May 17	Oct. 3	139	1924	May 25	Aug. 31	98
1922	Apr. 25	Sept. 15	143	1926	Apr. 27	Sept. 12	138
1923	May 16	Sept. 13	120	1927	May 10	Sept. 20	133

Average date of last spring frost, May 10; average date of first fall frost, Sept. 16; average length of growing season in days, 129.

WIND

No record.

TABLE 20.—*Climatic data, Amidon, N.Dak.*

PRECIPITATION

[Normal fall, in inches]

January	0.49	September	1.27
February	.59	October	1.11
March	.94	November	.38
April	1.49	December	.53
May	2.37		
June	2.66	Annual	15.75
July	2.69	Apr. 1-Sept. 30	11.71
August	1.23	Percent of normal annual, Apr. 1-Sept. 30	74

Year	Annual	Apr. 1-Sept. 30	Percent of annual, Apr. 1-Sept. 30	Year	Annual	Apr. 1-Sept. 30	Percent of annual, Apr. 1-Sept. 30
1913	13.87	10.17	73	1921	14.48	11.07	77
1914	16.14	12.82	79	1922	21.66	18.42	85
1915	21.84	17.99	83	1923	19.80	16.81	85
1916	18.45	13.65	74	1924	12.81	7.35	57
1917	12.55	7.76	62	1926	12.08	9.09	75
1918	15.64	11.58	74	1927	20.86	17.06	82
1919	12.57	8.03	64				

SNOWFALL

No record.

TABLE 21.—*Climatic data, Arnegard, N.Dak.*

TEMPERATURE

Mean:		Mean—Continued	
January	−10.7	August	67.1
February	13.2	September	56.8
March	23.5	October	42.1
April	40.6	November	28.8
May	53.1	December	12.5
June	62.0		
July	69.2	Annual	40.0

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1921	May 15	Oct. 3	171	1926	Apr. 27	Sept. 19	145
1922	May 3	Sept. 15	135	1927	May 11	Sept. 20	132
1923	May 16	Oct. 12	149	1928	May 11	Sept. 24	136
1924	May 25	Aug. 30	97	1930	May 23	Sept. 25	125
1925	May 17	Sept. 21	127				

Average date of last spring frost, May 10; average date of first fall frost, September 22; average length of growing season, in days, 135.

WIND

No record.

TABLE 22.—*Climatic data, Arnegard, N.Dak.*

PRECIPITATION

[Normal fall, in inches]

January	0.56	September	1.60
February	.42	October	1.04
March	.79	November	.36
April	1.45	December	.45
May	1.71		
June	3.29	Annual	14.70
July	1.60	Apr. 1–Sept. 30	11.08
August	1.43	Percent of normal annual, Apr. 1–Sept. 30	75

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1921	17.96	15.07	84	1926	14.78	11.26	76
1922	19.02	14.59	77	1927	20.95	15.73	75
1923	15.61	13.67	88	1928	15.06	14.06	93
1924	15.06	9.50	63	1929	15.52	9.83	63
1925	14.72	10.78	74	1930	11.86	9.12	77

SNOWFALL

No record.

TABLE 23.—*Climatic data, Beach, N.Dak.*

TEMPERATURE

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean	9.3	13.6	26.5	42.5	50.1	61.1	67.3	65.0	56.3	44.0	31.4	16.5	40.3
Mean maximum	22.2	25.3	38.0	54.7	64.1	76.0	83.6	81.6	71.2	57.3	44.3	28.5	53.9
Mean minimum	−2.4	2.8	14.4	28.4	37.0	47.8	51.8	49.6	40.7	29.5	18.9	5.9	27.0

Maximum ever recorded, 110; minimum ever recorded, −43.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1907	May 30	Sept. 14	107	1916	May 17	Sept. 15	121
1908	June 9	Aug. 13	65	1917	June 1	Sept. 19	110
1909	May 15	Oct. 9	147	1918	May 29	Sept. 3	106
1910	May 29	Sept. 9	103	1920	Apr. 30	Sept. 29	152
1911	May 27	Aug. 22	87	1922	Apr. 29	Sept. 15	139
1912	June 6	Sept. 16	102	1923	May 16	Sept. 12	119
1913	May 6	Sept. 11	128	1924	June 7	Sept. 26	111
1914	May 31	Sept. 22	83	1925	May 17	Sept. 21	127
1915	June 8	Sept. 13	97	1927	May 11	Sept. 20	132

Average date of last spring frost, May 26; average date of first fall frost, Sept. 15; average length of growing season, in days, 112.

WIND

Prevailing direction, northwest.

TABLE 24.—*Climatic data, Beach, N.Dak.*

PRECIPITATION

[Normal fall, in inches]

January	0.63	September	1.27
February	.51	October	.99
March	.78	November	.54
April	1.42	December	.51
May	2.81		
June	3.48	Annual	16.79
July	1.80	Apr. 1 to Sept. 30	12.83
August	2.05	Percent of normal annual, Apr. 1 to Sept. 30	76

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1906	22.94	19.59	85	1918	11.00	8.86	81
1907	13.45	10.14	75	1919	10.79	6.05	56
1908	23.29	15.84	68	1920	11.50	6.79	59
1909	22.02	19.36	88	1921	16.96	13.56	80
1910	16.06	10.35	64	1922	16.30	13.09	80
1911	17.91	13.57	76	1923	15.66	12.96	83
1912	20.48	15.76	77	1924	12.24	8.20	67
1913	13.67	10.51	77	1925	10.34	8.52	82
1914	15.91	13.57	85	1926	10.01	6.56	66
1915	21.39	17.41	81	1927	19.89	17.02	86
1916	14.32	11.09	77	1928	13.64	12.16	90
1917	6.02	4.72	78	1930	15.00	12.89	86

SNOWFALL

No record.

TABLE 25.—*Climatic data, Berthold Agency, N.Dak.*

[Station is 80 miles northeast of Medora, N.Dak., and lies a short distance beyond boundary of the Little Missouri River Basin]

TEMPERATURE

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean	7.5	9.4	24.7	43.7	53.7	62.6	68.9	67.7	57.0	44.7	28.8	15.7	40.4
Mean maximum	21.3	21.7	38.0	57.8	68.3	76.5	84.7	82.8	73.0	58.1	42.6	28.1	54.4
Mean minimum	−5.7	−5.2	12.3	29.2	38.9	48.3	53.6	50.4	41.0	30.7	17.1	2.9	26.1

Maximum ever recorded, 108; minimum ever recorded, −52.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1894	Apr. 20	Sept. 16	149	1915	June 16	Sept. 21	97
1895	May 19	Sept. 29	133	1916	May 19	Sept. 15	119
1896	Apr. 20	Sept. 13	146	1917	May 23	Aug. 28	97
1897	Apr. 29	Sept. 15	139	1918	May 22	Sept. 3	104
1898	Apr. 28	July 18	81	1919	June 2	Sept. 25	115
1899	Apr. 19	Sept. 18	152	1920	Apr. 27	Sept. 29	155
1901	June 7	Sept. 19	104	1921	Apr. 15	Oct. 1	169
1905	May 11	Oct. 11	153	1922	May 19	Sept. 10	114
1907	June 5	Sept. 24	111	1923	May 16	Sept. 12	119
1908	May 5	Aug. 22	109	1924	May 28	Sept. 1	96
1909	June 14	Oct. 9	117	1925	May 17	Sept. 21	127
1910	June 6	Sept. 9	95	1926	May 13	Sept. 25	135
1911	May 28	Aug. 23	87	1927	May 24	Sept. 20	119
1912	May 15	Sept. 17	125	1928	May 3	Sept. 18	138
1913	May 6	Sept. 11	128	1930	May 23	Sept. 20	120
1914	May 13	Oct. 5	145				

Average date of last spring frost, May 16; average date of first fall frost, Sept. 15; average length of growing season, in days, 122.

WIND

Prevailing direction, northwest.

TABLE 26.—*Climatic data, Berthold Agency, N.Dak.*

[Station is 80 miles northeast of Medora, N.Dak., and lies a short distance beyond boundary of the Little Missouri River Basin]

PRECIPITATION

[Normal fall, in inches]

January	0.40	September	1.46
February	.55	October	.84
March	.84	November	.40
April	1.16	December	.48
May	2.46		
June	3.88	Annual	16.21
July	1.97	Apr. 1–Sept. 30	12.68
August	1.77	Percent of normal annual, Apr. 1–Sept. 30	78

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1893	17.60	11.80	67	1912	19.21	17.48	91
1894	15.36	9.99	65	1913	11.45	9.37	82
1895	15.19	11.12	73	1914	19.06	17.22	90
1896	23.80	20.70	87	1915	16.96	14.47	85
1897	11.90	4.24	36	1916	13.87	13.43	96
1898	14.69	10.15	69	1917	9.81	7.32	75
1899	27.86	24.01	86	1918	11.18	9.30	58
1900	19.77	15.94	80	1919	12.28	9.20	75
1901	13.64	11.38	84	1920	15.00	12.11	81
1902	21.81	13.48	62	1921	17.42	15.80	91
1903	18.43	15.44	84	1922	18.85	14.20	75
1904	16.94	13.00	77	1923	11.03	9.12	83
1905	13.66	11.97	88	1924	12.09	8.37	69
1906	19.45	17.18	89	1925	15.14	13.95	93
1907	9.51	7.67	81	1926	12.34	12.24	99
1908	15.22	10.20	67	1927	17.75	16.03	90
1909	17.57	14.61	83	1928	22.92	22.09	97
1910	12.02	9.23	77	1929	10.95	7.10	65
1911	16.89	12.19	72	1930	14.08	11.95	85

SNOWFALL

[Normal fall, in inches]

January	4.3	October	1.1
February	6.0	November	3.8
March	5.5	December	4.3
April	2.1		
May	.2	Annual	27.8
September	.5		

TABLE 27.—*Climatic data, Bowman, N.Dak.*

[Station is 20 miles south of Amidon, N.Dak., and lies a short distance beyond boundary of the Little Missouri River Basin]

TEMPERATURE

No record.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1915	May 18	Sept. 13	118	1922	May 1	Oct. 7	159
1916	May 3	Sept. 17	137	1923	May 18	Sept. 13	118
1918	May 22	Sept. 3	104	1924	May 25	Sept. 5	103
1919	June 2	Oct. 4	124	1925	May 17	Sept. 21	127
1920	Apr. 25	Sept. 29	157	1930	do	Sept. 20	126
1921	May 15	Oct. 7	145				

Average date of last spring frost, May 15; average date of first fall frost, Sept. 21; average length of growing season, in days, 129.

WIND

No record.

TABLE 28.—*Climatic data, Bowman, N.Dak.*

[Station is 20 miles south of Amidon, N.Dak., and lies a short distance beyond boundary of the Little Missouri River Basin]

PRECIPITATION

[Normal fall, in inches]

January	0.50	September	0.92
February	.21	October	.64
March	.53	November	.28
April	1.54	December	.28
May	1.96		
June	3.08	Annual	13.95
July	3.00	Apr. 1–Sept. 30	11.51
August	1.01	Percent of normal annual, Apr. 1–Sept. 30	82

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1914	18.39	16.12	88	1922	17.04	13.71	81
1915	23.33	21.14	91	1923	17.96	14.32	79
1916	17.43	14.26	82	1924	14.81	10.22	69
1917	8.87	5.91	67	1925	11.70	10.78	92
1918	10.80	8.63	80	1928	16.09	13.49	84
1919	7.07	4.52	64	1929	15.52	10.81	70
1920	11.63	9.93	86	1930	17.21	12.68	74
1921	10.25	8.46	83				

SNOWFALL

No record.

TABLE 29.—*Climatic data, Camp Crook, S.Dak.*

TEMPERATURE

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean	17.2	19.1	28.4	43.2	53.3	63.2	70.2	68.3	58.5	45.6	31.8	21.4	43.3
Mean maximum	30.1	32.1	41.6	57.5	68.1	76.9	85.9	84.9	74.7	60.6	45.3	33.7	57.6
Mean minimum	3.9	6.0	15.1	29.7	39.0	48.7	54.3	52.0	42.0	30.0	18.0	9.5	29.0

Maximum ever recorded, 114; minimum ever recorded, −57.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1893	May 26	Sept. 15	112	1911	May 27	Aug. 28	93
1894	May 25	Sept. 9	107	1912	May 11	Sept. 18	130
1895	May 19	Sept. 7	111	1913	May 22	Sept. 11	112
1896	May 16	Sept. 18	125	1914	May 9	Oct. 5	149
1897	May 29	Sept. 15	109	1915	May 22	Sept. 14	115
1898	May 5	Sept. 9	127	1916	May 27	Sept. 12	108
1899	May 17	Sept. 7	113	1917	June 14	Sept. 26	104
1900	May 2	Sept. 19	140	1920	May 4	Sept. 29	148
1901	May 24	Sept. 16	115	1921	May 15	Oct. 1	139
1902	June 20	Sept. 11	83	1922	Apr. 29	Sept. 10	134
1903	June 10	Sept. 12	94	1923	May 16	Oct. 13	150
1904	May 18	Sept. 13	118	1924	May 28	Sept. 13	108
1905	May 30			1925	May 27	Oct. 1	127
1907	June 4	Sept. 14	102	1926	June 1	Sept. 23	114
1908	May 21	Sept. 27	129	1927	May 11	Sept. 20	132
1909	May 18	Sept. 19	124				

Average date of last spring frost, May 23; average date of first fall frost, Sept. 17; average length of growing season, in days, 117.

WIND

Prevailing direction, northwest.

TABLE 30.—*Climatic data, Camp Crook, S.Dak.*

PRECIPITATION

[Normal fall, in inches]

January	0.52	September	1.09
February	.40	October	.70
March	1.02	November	.39
April	1.03	December	.36
May	2.31		
June	2.77	Annual	13.72
July	1.80	Apr. 1 to Sept. 30	10.33
August	1.33	Percent of normal annual, Apr. 1–Sept. 30	75

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1893	13.64	9.19	67	1911	8.90	6.82	77
1894	15.12	10.77	71	1912	13.31	11.29	85
1895	13.17	9.74	74	1913	12.77	8.43	66
1896	19.66	14.86	76	1914	11.15	8.45	76
1897	10.30	6.05	59	1915	20.11	17.44	87
1898	15.24	10.06	66	1917	8.73	7.03	81
1899	14.41	9.65	67	1920	15.35	12.57	82
1900	12.92	11.00	85	1921	10.09	7.41	73
1901	11.39	9.56	84	1922	20.85	17.03	82
1902	16.00	12.36	77	1924	12.81	7.96	62
1903	13.21	10.25	78	1926	15.40	12.20	79
1904	10.42	6.54	63	1927	24.07	20.84	87
1905	13.78	10.11	73	1928	24.07	20.84	87
1906	18.90	15.16	80	1929	17.83	11.11	62
1907	15.45	14.20	92	1930	16.33	12.83	78
1908	15.56	9.47	61				

SNOWFALL

[Normal fall, in inches]

January	5.6	September	0.2
February	4.7	October	1.8
March	9.6	November	3.3
April	2.5	December	4.2
May	.6		
August	T.	Annual	32.5

TABLE 31.—*Climatic data, Dunn Center, N.Dak.*

[Station is 50 miles northeast of Medora, N.Dak., and lies a short distance beyond boundary of the Little Missouri River Basin]

TEMPERATURE

Mean:		Mean—Continued	
January	14.0	August	66.6
February	13.0	September	57.1
March	24.1	October	45.6
April	42.6	November	28.4
May	53.3	December	20.5
June	61.9		
July	68.0	Annual	41.2

Maximum ever recorded, 102; minimum ever recorded, −39.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1919	June 2	Oct. 4	124	1925	May 17	Sept. 21	127
1920	May 22	Sept. 30	131	1926	May 14	Sept. 19	128
1921	May 17	Oct. 1	137	1927	May 15	Sept. 20	128
1922	Apr. 29	Oct. 8	162	1928	May 11	Aug. 23	104
1923	May 16	Sept. 13	120	1930	May 24	Sept. 25	124
1924	May 30	Sept. 1	94				

Average date of last spring frost, May 18; average date of first fall frost, Sept. 20; average length of growing season, in days, 125.

WIND

No record.

TABLE 32.—*Climatic data, Dunn Center, N.Dak.*

[Station is 50 miles northeast of Medora, N.Dak., and lies a short distance beyond boundary of the Little Missouri River Basin]

PRECIPITATION

[Normal fall, in inches]

January	0.51	September	1.12
February	.56	October	.63
March	1.11	November	.62
April	1.32	December	.56
May	2.54		
June	4.30	Annual	16.89
July	2.05	Apr. 1–Sept. 30	12.90
August	1.57	Percent of normal annual Apr. 1–Sept. 30	76

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1893	14.77	9.28	63	1915	20.43	16.72	82
1894	16.36	12.03	87	1916	16.02	12.72	79
1895	15.70	13.31	85	1917	8.42	6.82	81
1896	22.64	16.80	74	1918	14.97	12.51	83
1897	14.91	9.07	61	1919	8.01	5.23	65
1898	18.49	13.71	74	1920	15.03	12.62	84
1899	12.54	10.18	90	1921	16.28	13.47	83
1900	12.85	8.40	66	1922	22.04	15.43	70
1901	17.15	13.56	79	1923	20.25	17.15	85
1902	19.84	10.88	55	1924	13.59	8.46	62
1903	26.02	21.17	82	1925	10.32	8.98	87
1904	13.38	8.85	66	1926	12.48	10.44	83
1905	22.00	18.43	84	1927	22.04	18.85	86
1906	25.06	21.50	86	1928	16.79	15.32	91
1907	13.89	10.12	73	1929	13.11	8.63	66
1914	22.24	19.70	89	1930	13.36	10.48	78

SNOWFALL

No record.

TABLE 33.—*Climatic data, Ekalaka, Mont.*

TEMPERATURE

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean	16.8	18.5	29.0	42.1	52.8	63.7	70.6	68.7	58.9	46.6	33.5	21.8	43.6
Mean maximum	30.0	30.0	42.0	56.8	66.4	77.4	80.3	83.9	74.1	59.4	44.9	32.5	56.5
Mean minimum	7.4	7.2	17.9	30.5	39.3	49.5	55.3	53.0	44.5	32.7	21.6	11.4	30.9

Maximum ever recorded, 108; minimum ever recorded, −42.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1899	May 19	Sept. 18	122	1915	June 8	Sept. 14	98
1900	May 2	Sept. 26	147	1916	May 12	do	125
1902	June 21	Sept. 3	74	1917	June 1	Sept. 19	110
1905	May 15	Oct. 9	147	1918	May 22	Oct. 16	147
1906	May 27	Sept. 26	122	1919	June 1	Sept. 29	120
1907	May 30	Sept. 14	107	1920	May 4	Oct. 14	163
1908	June 28	Sept. 27	91	1921	May 15	Sept. 10	118
1909	May 18	Oct. 8	143	1922	Apr. 24	Oct. 7	166
1910	June 4	Aug. 25	82	1923	May 8	Oct. 13	158
1911	May 28	Aug. 28	92	1924	May 27	Sept. 13	109
1912	May 13	Sept. 17	127	1925	May 16	Oct. 5	142
1913	May 22	Sept. 22	123	1926	Apr. 27	Sept. 23	149
1914	May 13	Oct. 6	146	1927	May 11	Sept. 20	132

Average date of last spring frost, May 25; average date of first fall frost, Sept. 22; average length of growing season, in days, 120.

WIND

Prevailing direction, west.

TABLE 34.—*Climatic data, Ekalaka, Mont.*

PRECIPITATION

[Normal fall, in inches]

January	0.50	September	1.34
February	.41	October	.82
March	.64	November	.29
April	1.06	December	.29
May	2.22		
June	2.82	Annual	13.66
July	1.71	Apr. 1–Sept. 30	10.71
August	1.56	Percent of normal annual, Apr. 1–Sept. 30	78

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1909	15.05	11.70	78	1921	11.05	8.26	75
1910	13.16	10.76	82	1925	14.57	12.93	89
1913	12.17	10.54	87	1926	11.96	8.22	69
1914	10.58	8.58	81	1927	18.60	16.24	87
1916	12.98	10.13	78	1928	15.09	11.60	77
1917	7.85	4.72	60	1929	17.61	12.88	73
1918	13.50	11.59	86	1930	12.13	10.10	83
1919	6.32	4.57	72				

SNOWFALL

[Normal fall, in inches]

January	6.2	October	2.0
February	3.6	November	1.3
March	5.4	December	3.6
April	1.6		
May	.3	Annual	24.1
September	.1		

TABLE 35.—*Climatic data, Fryburg, N.Dak.*

TEMPERATURE

No record.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1921	May 17	Oct. 1	137	1925	May 17	Sept. 21	127
1922	Apr. 25	Oct. 9	167	1927	May 10	Sept. 20	133
1923	May 16	Sept. 12	119	1930	May 23	Sept. 25	125

Average date of last spring frost, May 13; average date of first fal lfrost, Sept. 25; average length of growing season, in days, 135.

WIND

No record.

TABLE 36.—*Climatic data, Fryburg, N.Dak.*

PRECIPITATION

[Normal fall, in inches]

January	0.33	September	1.65
February	.48	October	1.20
March	.66	November	.64
April	1.44	December	.52
May	2.11		
June	3.38	Annual	16.23
July	2.28	Apr. 1–Sept. 30	12.40
August	1.54	Percent of normal annual, Apr. 1–Sept. 30	77

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1921	18.44	14.72	80	1926	12.74	9.17	72
1922	22.12	16.59	75	1927	24.38	19.69	81
1923	21.60	18.57	86	1928	14.94	13.81	93
1924	15.71	9.64	61	1929	18.05	10.30	57
1925	11.81	9.04	77	1930	14.43	10.77	75

SNOWFALL

No record.

TABLE 37.—*Climatic data, Gillette, Wyo.*

[Station is 46 miles southwest of Rockypoint, Wyo., and is 30 miles beyond boundary of the Little Missouri River Basin]

TEMPERATURE

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean	21.0	23.8	33.2	42.2	52.2	63.0	69.3	68.4	60.6	47.6	34.6	23.4	45.0
Mean maximum	31.3	34.6	45.2	54.9	65.0	77.4	84.4	83.1	75.4	60.8	45.4	33.1	57.6
Mean minimum	10.8	13.0	21.3	29.6	39.3	48.7	54.2	53.6	45.7	34.2	23.9	13.8	32.4

Maximum ever recorded, 110; minimum ever recorded, −31.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1905	May 12	Oct. 9	150	1924	June 9	Sept. 27	111
1908	May 21	Sept. 26	128	1925	May 16	Oct. 1	138
1909	May 18	Oct. 7	142	1926	Apr. 25	Sept. 23	151
1910	May 16	Aug. 24	100	1927	May 10	Sept. 20	133
1911	May 27	Oct. 4	130	1928	May 4	Oct. 11	160
1912	May 13	Sept. 15	125	1930	May 23	Oct. 15	145
1922	May 12	Oct. 12	153				

Average date of last spring frost, May 16; average date of first fall frost, Sept. 29; average length of growing season, in days, 136.

WIND

No record.

TABLE 38.—*Climatic data, Gillette, Wyo.*

[Station is 46 miles southwest of Rockypoint, Wyo., and is 30 miles beyond boundary of the Little Missouri River Basin]

PRECIPITATION

[Normal fall, in inches]

January	0.82	September	1.36
February	.46	October	1.16
March	.82	November	.54
April	1.53	December	.93
May	2.52		
June	1.85	Annual	15.50
July	1.96	Apr. 1-Sept. 30	10.77
August	1.55	Percent of normal annual, Apr. 1-Sept. 30	70

Year	Annual	Apr. 1-Sept. 30	Percent of annual, Apr. 1-Sept. 30	Year	Annual	Apr. 1-Sept. 30	Percent of annual, Apr. 1-Sept. 30
1905	21.43	15.72	73	1926	12.47	8.04	64
1909	20.81	16.11	77	1927	22.17	17.63	79
1910	10.70	8.06	75	1928	15.31	11.52	75
1911	12.82	5.61	44	1929	16.43	10.50	64
1912	19.55	14.07	72	1930	8.91	6.19	69
1925	13.72	8.86	65				

SNOWFALL

[Normal fall, in inches]

January	7.3	September	1.3
February	5.9	October	3.8
March	8.6	November	5.5
April	6.2	December	10.3
May	2.7		
June	.1	Annual	51.7
August	T		

TABLE 39.—*Climatic data, Knowles, Wyo.*

[Station is 40 miles east of Rockypoint, Wyo., and lies a short distance beyond boundary of the Little Missouri River Basin]

TEMPERATURE

No record.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1915	June 6	Sept. 11	97	1921	May 15	Sept. 11	119
1916	May 22	Sept. 14	115	1925	do	Sept. 30	138
1917	May 31	Oct. 8	130	1929	June 3	Sept. 4	93
1918	May 29	Sept. 20	114				

Average date of last spring frost, May 26; average date of first fall frost, Sept. 18; average length of growing season, in days, 115.

WIND

Prevailing direction, northwest.

TABLE 40.—*Climatic data, Knowles, Wyo.*

[Station is 40 miles east of Rockypoint, Wyo., and lies a short distance beyond boundary of the Little Missouri River Basin]

PRECIPITATION

[Normal fall, in inches]

January	0.59	September	2.46
February	.50	October	1.40
March	1.21	November	.60
April	1.96	December	.83
May	3.35		
June	3.12	Annual	20.00
July	2.31	Apr. 1–Sept. 30	14.87
August	1.67	Percent of normal annual, Apr. 1–Sept. 30	74

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1910	19.79	13.55	69	1921	14.43	9.30	65
1911	14.01	8.20	59	1922	32.07	24.30	76
1912	18.74	15.09	81	1923	36.47	28.46	78
1913	23.17	17.16	74	1924	18.51	9.46	51
1914	18.04	13.65	76	1925	16.48	10.67	65
1915	26.06	20.76	80	1926	22.73	15.78	70
1916	18.54	12.37	67	1927	30.02	25.31	84
1917	14.86	10.81	73	1928	21.44	16.11	75
1918	25.93	21.20	82	1929	26.99	18.06	67
1919	13.91	9.39	68	1930	19.18	14.43	75
1920	22.85	18.44	81				

SNOWFALL

[Normal fall, in inches]

January	8.8	September	1.8
February	8.8	October	8.9
March	18.1	November	8.2
April	16.3	December	13.7
May	6.5		
June	.5	Annual	91.8
August	.2		

TABLE 41.—*Climatic data, Medora, N.Dak.*

TEMPERATURE

Mean:		Mean—Continued	
January	14.8	August	67.7
February	15.3	September	57.5
March	27.3	October	46.0
April	42.0	November	29.7
May	53.9	December	19.7
June	67.3		
July	69.6	Annual	42.6

Maximum ever recorded, 124; minimum ever recorded, −52.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1896	May 2	Sept. 9	130	1905	May 14	Sept. 3	112
1897	May 23	Oct. 7	137	1906	May 27	Sept. 26	122
1898	May 3	Sept. 8	128	1907	June 5	Aug. 21	77
1900	May 1	Sept. 25	147	1908	May 22	Aug. 22	92
1901	May 24	Sept. 16	115	1909	May 29	Sept. 24	118
1902	Apr. 28	Sept. 11	106	1910	June 3	Aug. 16	74
1903	May 7	Sept. 13	129	1911	June 2	Aug. 28	87
1904	May 18	Sept. 10	115	1912	June 5	Sept. 22	109

Average date of last spring frost, May 21; average date of first fall frost, September 10; average length of growing season, in days, 112.

WIND

No record.

TABLE 42.—*Climatic data, Medora, N.Dak.*

PRECIPITATION

[Normal fall, in inches]

January	0.62	September	1.15
February	.48	October	.73
March	.90	November	.46
April	.93	December	.45
May	2.66		
June	3.06	Annual	15.31
July	2.16	Apr. 1–Sept. 30	11.67
August	1.71	Percent of normal annual, Apr. 1–Sept. 30	76

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1892	10.85	8.02	74	1905	17.35	13.94	80
1893	11.19	7.19	64	1906	21.38	17.12	80
1896	16.04	12.47	78	1907	12.04	9.77	81
1897	9.90	5.93	60	1908	18.42	13.92	76
1898	13.94	10.17	73	1909	25.89	22.69	68
1899	13.99	11.48	82	1910	13.56	9.67	71
1900	13.57	10.59	78	1911	17.64	10.99	63
1901	14.21	10.63	75	1912	18.49	16.09	87
1902	14.00	10.24	73	1913	13.73	9.45	69
1903	16.84	13.79	82	1914	15.97	13.10	82
1904	8.41	3.96	47	1915	19.39	15.89	82

SNOWFALL

[Normal fall, in inches]

January	5.9	October	0.3
February	5.6	November	3.9
March	6.7	December	5.0
April	1.4		
May	.3	Annual	29.1
September	T.		

TABLE 43.—*Climatic data, New England, N.Dak.*

[Station is 20 miles east of Amidon, N.Dak., and lies a short distance beyond boundary of the Little Missouri River Basin]

TEMPERATURE

Mean:		Mean—Continued	
January	13.3	August	66.7
February	12.1	September	55.8
March	24.4	October	43.7
April	43.1	November	30.2
May	51.6	December	17.4
June	62.0		
July	68.5	Annual	40.7

Maximum ever recorded, 109; minimum ever recorded, −44.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1889	May 29	Sept. 11	105	1913	May 22	Sept. 11	112
1890	May 26	Sept. 13	79	1915	May 18	Sept. 21	126
1895	May 21	Sept. 7	109	1916	May 11	Sept. 15	127
1896	May 2	Sept. 17	138	1917	May 23	Sept. 20	120
1898	May 4	Sept. 6	125	1918	May 22	Sept. 9	110
1900	May 16	Sept. 16	123	1919	June 2	Oct. 4	124
1901	May 25	Sept. 17	115	1921	May 15	Oct. 1	139
1902	June 8	Sept. 12	96	1922	May 3	Oct. 7	157
1903	May 9	Sept. 13	127	1923	May 16	Sept. 12	119
1904	May 17	Sept. 11	117	1924	May 25	Sept. 15	113
1905	May 12	Sept. 2	113	1925	May 16	Sept. 21	128
1908	May 22	Aug. 22	92	1926	Apr. 27	Sept. 18	144
1909	May 15	Sept. 24	132	1927	July 2	Sept. 24	84
1910	June 5	Sept. 6	93				

Average date of last spring frost, May 20; average date of first fall frost, Sept. 12; average length of growing season, in days, 115.

WIND

No record.

TABLE 44.—*Climatic data, New England, N.Dak.*

[Station is 20 miles east of Amidon, N.Dak., and lies a short distance beyond boundary of the Little Missouri River Basin]

PRECIPITATION

[Normal fall, in inches]

January	0.42	September	1.12
February	.54	October	.65
March	.87	November	.49
April	1.02	December	.41
May	2.15		
June	2.69	Annual	14.14
July	2.01	Apr. 1–Sept. 30	10.76
August	1.77	Percent of normal annual Apr. 1–Sept. 30	76

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1894	12.30	9.54	78	1912	18.55	15.51	84
1895	10.44	7.83	75	1913	12.45	8.87	71
1896	17.37	12.33	71	1914	19.24	15.30	80
1897	10.33	5.23	51	1915	21.22	19.27	91
1898	14.19	9.69	68	1916	17.04	12.54	74
1899	15.28	12.18	80	1917	8.76	5.46	62
1900	12.28	9.34	76	1918	11.82	9.51	80
1901	13.65	11.27	83	1919	9.39	6.63	71
1902	10.36	6.17	60	1920	13.41	11.25	84
1903	15.82	13.92	88	1921	12.15	9.43	78
1904	12.85	9.30	72	1922	18.52	12.10	65
1905	17.12	14.23	83	1923	19.55	16.13	83
1906	15.63	12.26	78	1924	10.87	7.13	66
1907	10.69	8.76	82	1925	9.80	8.32	85
1908	16.39	9.81	60	1926	11.67	10.27	88
1909	21.21	17.20	81	1927	13.87	11.29	81
1910	9.87	6.45	65	1930	15.71	12.40	79
1911	14.79	10.63	72				

SNOWFALL

[Normal fall, in inches]

January	4.7	October	1.1
February	6.0	November	4.1
March	7.6	December	4.4
April	2.6		
May	.2	Annual	31.0
September	.3		

TABLE 45.—*Climatic data, Pine Ridge, Wyo.*

[Station is 43 miles southeast of Rockypoint, Wyo., and is 20 miles beyond boundary of the Little Missouri River Basin]

TEMPERATURE

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean	17.4	19.8	30.1	43.8	50.3	62.2	69.8	68.8	57.8	46.6	34.5	21.8	43.6
Mean maximum	29.8	32.3	42.9	57.0	63.3	76.2	85.5	84.6	72.5	61.2	48.7	34.2	57.4
Mean minimum	5.1	7.3	17.3	30.5	37.3	48.2	54.2	53.0	43.0	32.1	20.3	9.3	29.8

Maximum ever recorded, 108; minimum ever recorded, —40.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1903	June 9	Sept. 9	92	1914	May 12	Sept. 13	124
1906	May 9	Sept. 22	136	1915	June 7	Sept. 14	99
1907	May 30	Sept. 10	103	1916	June 6	Sept. 11	97
1910	June 3	Aug. 25	83	1920	June 4	Sept. 29	117
1912	May 15	Oct. 5	143	1921	May 15	Sept. 11	119
1913	May 16	Sept. 20	127				

Average date of last spring frost, May 25; average date of first fall frost, Sept. 15; average length of growing season, in days, 113.

WIND

Prevailing direction, south.

TABLE 46.—*Climatic data, Pine Ridge, Wyo.*

[Station is 43 miles southeast of Rockypoint, Wyo., and is 20 miles beyond boundary of the Little Missouri River Basin]

PRECIPITATION

[Normal fall ,in inches]

January	0.61	September	1.52
February	.78	October	1.02
March	1.09	November	.49
April	1.58	December	.91
May	2.51		
June	2.25	Annual	15.78
July	1.64	Apr. 1–Sept. 30	10.88
August	1.38	Percent of normal annual, Apr. 1–Sept. 30	69

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1904	13.70	9.27	68	1914	14.15	9.93	70
1907	10.64	9.04	85	1915	23.66	19.14	81
1912	15.62	10.58	68	1916	16.49	9.08	55
1913	12.42	7.94	64	1921	16.19	11.74	72

SNOWFALL

[Normal fall, in inches]

January	6.7	September	0.8
February	8.3	October	3.2
March	9.8	November	4.6
April	5.4	December	9.5
May	2.0		
June	T.	Annual	50.4
August	0.1		

TABLE 47.—*Climatic data, Plevna, Mont.*

[Station is 45 miles north of Ekalaka, Mont., and lies a short distance beyond boundary of Little Missouri River Basin]

TEMPERATURE

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean	14.8	16.9	27.0	42.6	52.9	63.4	70.3	68.3	58.0	45.1	33.0	19.0	42.6
Mean maximum	26.0	26.8	37.8	55.8	65.4	76.7	85.3	83.7	71.5	57.6	45.2	30.4	55.2
Mean minimum	2.5	4.6	14.4	30.3	38.9	48.9	55.1	52.0	41.7	30.1	20.4	7.4	28.8

Maximum ever recorded, 109; minimum ever recorded, −52.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1912	May 13	Sept. 25	135	1920	May 4	Oct. 16	165
1913	May 21	do	127	1921	May 15	Oct. 1	139
1914	May 13	Oct. 5	145	1922	Apr. 24	Sept. 29	158
1915	June 16	Sept. 21	97	1923	May 16	Oct. 20	157
1916	May 17	Sept. 14	120	1924	May 27	Sept. 28	124
1917	June 1	Sept. 19	110	1925	May 17	Oct. 6	132
1918	May 26	Sept. 15	112	1926	May 13	Sept. 19	129
1919	June 2	Oct. 4	124	1927	May 11	Sept. 20	132

Average date of last spring frost, May 23; average date of first fall frost, Sept. 26; average length of growing season, in days, 126.

WIND

Prevailing direction, northwest.

TABLE 48.—*Climatic data, Plevna, Mont.*

[Station is 45 miles north of Ekalaka, Mont., and lies a short distance beyond boundary of Little Missouri River Basin]

PRECIPITATION

[Normal fall, in inches]

January	0.57	September	1.13
February	.48	October	.94
March	.66	November	.47
April	1.16	December	.42
May	2.05		
June	3.03	Annual	14.07
July	1.97	Apr. 1–Sept. 30	10.53
August	1.19	Percent of normal annual, Apr. 1–Sept. 30	75

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1913	12.24	9.93	81	1922	18.41	11.93	65
1914	14.55	12.14	83	1924	13.57	8.78	65
1915	21.20	17.73	84	1925	12.19	10.17	83
1916	13.02	9.31	72	1926	11.60	6.97	60
1917	8.10	5.66	70	1927	18.34	14.86	81
1918	11.89	7.92	67	1928	12.46	10.05	81
1919	7.26	4.40	61	1929	14.49	10.94	75
1920	17.14	12.45	73	1930	14.60	13.03	89
1921	14.00	10.13	72				

SNOWFALL

[Normal fall, in inches]

January	8.8	October	3.2
February	7.6	November	2.9
March	8.8	December	8.0
April	3.4		
May	1.9	Annual	44.9
September	0.3		

TABLE 49.—*Climatic data—Redig, S.Dak.*

[Station is 26 miles southeast of Camp Crook, S.Dak., and lies a short distance beyond boundary of the Little Missouri River Basin]

TEMPERATURE

Mean:		Mean—Continued	
January	14.9	August	67.4
February	20.4	September	57.4
March	29.2	October	40.8
April	41.4	November	32.1
May	51.5	December	18.1
June	62.5		
July	69.4	Annual	[1] 42.1

[1] 13 years.

No record for any maximum or minimum temperature.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1921	May 15	Sept. 30	138	1925	May 24		
1922	Apr. 21	Sept. 19	151	1926	May 14	Sept. 23	132
1923	May 16	Sept. 12	119	1927	May 11	Sept. 20	132
1924	May 27	Sept. 27	123				

Average date of last spring frost, May 12; average date of first fall frost, Sept. 22; average length of growing, season in days, 133.

WIND

No record.

TABLE 50.—*Climatic data, Redig, S.Dak.*

[Station is 26 miles southeast of Camp Crook, S.Dak., and lies a short distance beyond boundary of the Little Missouri River Basin]

PRECIPITATION

[Normal fall, in inches]

January	0.57	September	0.82
February	.49	October	.93
March	1.02	November	.56
April	1.35	December	.58
May	1.86		
June	2.76	Annual	14.39
July	2.16	Apr. 1-Sept. 30	10.24
August	1.29	Percent of normal annual, Apr. 1-Sept. 30	71

Year	Annual	Apr. 1-Sept. 30	Percent of annual, Apr. 1-Sept. 30	Year	Annual	Apr. 1-Sept. 30	Percent of annual, Apr. 1-Sept. 30
1915	17.85	15.56	87	1921	10.23	6.94	68
1916	15.15	9.34	62	1922	21.63	15.54	72
1917	8.62	5.00	58	1923	17.31	12.97	75
1918	12.37	9.53	77	1924	16.53	9.83	59
1919	9.27	5.58	60	1926	15.45	10.45	68
1920	15.59	12.06	77	1927	20.26	17.20	85

SNOWFALL

No record.

TABLE 51.—*Climatic data, Rockypoint, Wyo.*

TEMPERATURE

No record.
Maximum ever recorded, 105; minimum ever recorded, −37.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1913	June 6	Sept. 19	105	1923	May 16	Oct. 13	150
1914	May 29	Sept. 12	106	1924	May 24	Sept. 13	112
1915	June 13	Sept. 14	93	1925	May 16	Oct. 1	138
1916	May 24	do	113	1926	Apr. 25	Sept. 24	152
1917	June 1	Sept. 24	115	1927	May 11	Sept. 20	132
1918	May 27	Oct. 8	134	1928	May 5	Sept. 27	145
1919	June 3	Sept. 21	110	1929	June 20	Sept. 8	80
1921	May 15	Sept. 11	119	1930	May 23	Oct. 15	145
1922	May 11	Sept. 10	122				

Average date of last spring frost, May 23; average date of first fall frost, September 22; average length of growing season, in days, 122.

WIND

Prevailing direction, northwest.

TABLE 52.—*Climatic data, Rockypoint, Wyo.*

PRECIPITATION

[Normal fall, in inches]

January	0.68	September	1.74
February	.69	October	1.44
March	.83	November	.68
April	1.54	December	.66
May	2.16		
June	2.25	Annual	16.41
July	2.29	Apr. 1-Sept. 30	11.44
August	1.46	Percent of normal annual, Apr. 1-Sept. 30	70

Year	Annual	Apr. 1-Sept. 30	Percent of annual, Apr. 1-Sept. 30	Year	Annual	Apr. 1-Sept. 30	Percent of annual, Apr. 1-Sept. 30
1912	16.63	12.04	72	1922	22.69	16.07	71
1913	15.25	11.61	76	1923	24.81	17.65	71
1914	12.66	9.62	76	1924	16.99	6.78	40
1915	21.47	16.47	77	1925	16.59	10.64	64
1916	17.58	12.66	72	1926	21.45	12.77	60
1917	11.31	6.10	54	1927	26.96	20.66	77
1919	13.23	6.37	48	1928	19.39	14.37	74
1920	19.71	14.07	72	1929	21.37	12.05	56
1921	15.40	10.11	66	1930	13.55	10.29	76

SNOWFALL

[Normal fall, in inches]

January	8.2	September	1.4
February	8.0	October	5.6
March	8.1	November	7.1
April	5.9	December	6.7
May	3.2		
June	.3	Annual	54.5

TABLE 53.—*Climatic data, Wibaux, Mont.*

TEMPERATURE

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean	15.7	16.2	25.9	43.0	54.1	61.0	68.6	65.6	55.4	43.7	28.6	18.4	41.4
Mean maximum	27.6	28.9	39.2	56.7	68.7	75.1	84.1	82.2	70.6	58.7	41.2	29.7	55.2
Mean minimum	3.8	3.4	12.6	29.4	39.5	46.8	53.2	49.1	40.3	28.7	16.0	7.0	27.5

Maximum ever recorded, 110; minimum ever recorded, −55.

FROSTS

Year	Last spring frost	First fall frost	Length of growing season, in days	Year	Last spring frost	First fall frost	Length of growing season, in days
1895	May 21	Sept. 7	109	1917	June 1	Aug. 9	69
1896	May 17	Sept. 10	116	1918	May 22	Sept. 3	104
1897	June 6	Oct. 8	124	1919	May 2	Oct. 4	155
1898	May 14	July 20	67	1920	June 1	Oct. 10	128
1900	May 30	Sept. 26	119	1921	May 15	Oct. 1	139
1914	May 31	Sept. 3	95	1922	Apr. 25	Oct. 7	165
1915	June 8	Sept. 14	98	1923	May 16	Sept. 13	120
1916	May 19	Sept. 15	119	1924	May 31	Aug. 31	92

Average date of last spring frost, May 22; average date of first fall frost, Sept. 12; average length of growing season, in days, 113.

WIND

Prevailing direction, west.

TABLE 54.—*Climatic data, Wibaux, Mont.*

PRECIPITATION

[Normal fall, in inches]

January	0.51	September	1.01
February	.25	October	.80
March	.57	November	.69
April	1.34	December	.42
May	2.13		
June	4.04	Annual	14.98
July	1.65	Apr. 1–Sept. 30	11.74
August	1.57	Percent of normal annual, Apr. 1–Sept. 30	78

Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30	Year	Annual	Apr. 1–Sept. 30	Percent of annual, Apr. 1–Sept. 30
1894	14.39	10.29	72	1919	12.09	7.31	60
1895	13.85	11.49	83	1920	13.19	10.38	79
1915	20.71	17.90	86	1921	14.91	12.91	87
1916	21.31	17.44	82	1922	18.05	14.44	80
1917	13.55	10.43	76	1923	17.59	12.93	73
1918	14.34	11.47	80				

SNOWFALL

[Normal fall, in inches]

January	5.5	September	T.
February	2.4	October	4.4
March	3.3	November	4.3
April	2.4	December	4.0
May	1.4		
June	T.	Annual	27.7

TABLE 55.—*United States Geological Survey gaging stations, Little Missouri River Basin*

Station No.	Table No.	Miles above mouth of Little Missouri River	Drainage area, in square miles	Station and location	Period of record
				Little Missouri River:	
[1] 6	56	467.0	831	Near Alzada, Mont	1911–25; 1928–
7	57	472.5	640	At Alzada, Mont	1904–06.
8	58	409.0	1,931	At Camp Crook, S.Dak	1903–06.
[1] 9	59	187.9	6,323	At Medora, N.Dak	1903–08; 1922–26; 1928–

[1] Maintained at present by U.S. Geological Survey in cooperation with U.S. Engineer Department, Kansas City, Mo.

TABLE 56.—*Little Missouri River near Alzada, Mont., station no. 6, Little Missouri River Basin*

[Run-off in acre-feet]

Drainage area, 831 square miles. Miles above mouth of Little Missouri River, 467.

Year ending Sept. 30	October	November	December	January	February	March	April
1912	91	98	121	[1] 62	[1] 14,400	[1] 24,600	[2] 86,200
1913	3,340	175	234	[1] 153	[1] 5,500	[2] 39,800	35,500
1914	1,880	295	382	[1] 307	[1] 4,710	[1] 7,660	192
1915	2,520	292	[1] 245	[1] 123	[1] 2,770	[2] 7,660	14,800
1916	1,240	922	861	615	23,200	11,800	4,270
1917	612	455	347	[2] 31	[1] 28	[2] 6,150	54,400
1918	57	276	276	1,780	10,900	[2] 61,500	7,970
1919	488	368	448	286	303	1,030	4,040
1920	972	1,460	1,120	[2] 1,230	[1] 23,000	[1] 36,800	[2] 13,700
1921	63	286	111	[1] 62	[1] 1,390	[2] 1,410	87
1922	0	4	31	[3] 43	[1] 1,390	[2] 20,000	29,500
1923	984	5,750	1,300	[3] 1,480	[3] 1,060	[2] 13,800	9,880
1924	30,300	5,680	1,360	953	16,800	21,200	73,800
1925	6,330	756	1,380	[3] 1,100	36,800	43,200	2,530
1929	28	48	[2] 25	[1] 31	[1] 4,150	[2] 64,500	38,800
1930	3,460	199	[1] 184	[1] 184	[2] 31,100	3,800	631

Year ending Sept. 30	May	June	July	August	September	Annual total
1911	-------	[2] 169	6	4,140	898	-------
1912	21,600	3,340	4,670	8,060	5,250	168,000
1913	1,090	3,900	2,210	1,990	19,500	113,000
1914	3,040	1,490	7,870	11,700	292	39,800
1915	5,010	34,900	19,300	14,400	1,970	104,000
1916	4,220	2,360	2,260	3,750	10	55,500
1917	3,940	2,750	297	587	86	69,700
1918	9,960	3,110	10,100	7,130	6,600	120,000
1919	537	19	5,580	2,660	0	15,800
1920	[2] 21,500	19,400	5,950	98	92	125,000
1921	10	9,280	1,520	248	356	14,800
1922	31,300	52,100	9,960	4,790	803	150,000
1923	879	6,960	11,700	27,200	21,300	102,000
1924	2,310	4,460	6,820	2,250	637	167,000
1925	1,100	37,800	1,700	1,290	3,380	137,000
1928	-------	-------	-------	-------	2,500	-------
1929	36,500	21,400	2,670	775	1,260	170,000
1930	633	9,040	328	82	0	49,600

[1] Estimated. [2] Partially estimated. [3] Extended.

TABLE 57.—*Little Missouri River at Alzada, Mont., Station No. 7, Little Missouri River Basin*

[Run-off in acre-feet]

Drainage area, 640 square miles. Miles above mouth of Little Missouri River, 472.5.

Year ending Sept. 30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual total
1904	-----	-----	-----	-----	-----	-----	7,560	3,170	18,700	437	123	1,780	-------
1905	252	83	[1] 31	[2] 31	[2] 555	[3] 615	333	7,620	12,600	15,100	3,700	1,340	42,300
1906	2,180	60	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-------

[1] Extended. [2] Estimated. [3] Partially estimated.

Table 58.—*Little Missouri River at Camp Crook, S.Dak., Station No. 8, Little Missouri River Basin*

[Run-off in acre-feet]

Drainage area, 1,931 square miles. Miles above mouth of Little Missouri River, 409.

Year ending Sept 30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual total
1904	------	------	------	------	------	[1] 83, 000	27, 000	9, 650	[1] 35, 600	2, 200	------	6, 720	------
1905	18	356	92	92	1, 940	2, 150	[1] 891	10, 500	36, 200	59, 100	12, 800	14, 500	139, 000
1906	14, 100	1, 620	[2] 920	[2] 615	[2] 11, 700	[2] 20, 900	32, 500	37, 600	17, 100	1, 220	33, 000	7, 380	179, 000
1907	799	452	------	------	------	------	------	------	------	------	------	------	------

[1] Partially estimated. [2] Extended.

Table 59.—*Little Missouri River at Medora, N.Dak., Station No. 9, Little Missouri River Basin*

[Run-off in acre-feet]

Drainage area, 6,323 square miles. Miles above mouth of Little Missouri River, 187.9.

Year ending Sept. 30	October	November	December	January	February	March	April
1904	4, 200	[2] 4, 500	[2] 3, 100	[2] 2, 500	[2] 2, 300	[2] 46, 500	47, 400
1905	2, 040	[2] 840	[2] 100	[3] 62	[3] 2, 760	28, 700	483
1906	16, 700	[2] 13, 000	[3] 9, 200	[2] 4, 000	[2] 3, 300	[2] 76, 200	53, 200
1907	1, 620	[2] 3, 400	[2] 3, 100	[2] 2, 500	[2] 70, 000	41, 300	8, 450
1908	1, 810	476	[2] 140	[2] 200	[2] 3, 000	[2] 32, 000	22, 800
1909	18, 100	------	------	------	------	------	------
1922	[2] 690	[2] 670	[4] 675	[4] 982	[4] 1, 000	[1] 43, 000	70, 200
1923	[4] 6, 150	[1] 20, 300	5, 310	[4] 5, 530	[4] 13, 900	[4] 20, 900	[4] 26, 800
1924	126, 000	9, 700	7, 070	[2] 2, 360	[2] 25, 200	[2] 97, 400	333, 000
1925	[2] 32, 500	[2] 4, 120	[2] 1, 080	[2] 793	[2] 36, 800	[2] 293, 000	[2] 26, 500
1926	[2] 1, 690	[2] 890	[2] 1, 460	[2] 800	[2] 2, 730	[2] 112, 000	[2] 38, 900
1929	3, 920	2, 540	922	307	167	280, 000	191, 000
1930	11, 400	2, 680	1, 230	615	15, 200	57, 300	10, 500

Year ending Sept. 30	May	June	July	August	September	Annual total
1903	[1] 38, 600	14, 100	66, 600	141, 000	73, 900	------
1904	11, 100	71, 000	6, 330	621	4, 780	204, 000
1905	3, 720	120, 000	166, 000	48, 000	14, 000	387, 000
1906	62, 100	119, 000	11, 100	53, 300	26, 700	448, 000
1907	154, 000	248, 000	112, 000	17, 800	6, 840	669, 000
1908	78, 700	198, 000	29, 100	5, 810	3, 390	375, 000
1922	91, 600	[1] 125, 000	[4] 27, 000	[4] 12, 800	[4] 2, 080	376, 000
1923	4, 680	22, 700	21, 900	87, 900	39, 400	275, 000
1924	17, 700	37, 700	32, 600	14, 300	2, 820	706, 000
1925	[2] 5, 220	[2] 126, 000	[2] 24, 600	[2] 4, 290	[2] 7, 130	562, 000
1928	------	------	------	------	8, 330	------
1929	192, 000	279, 000	13, 000	5, 080	3, 300	971, 000
1930	9, 040	78, 000	9, 100	5, 720	17, 900	205, 000

[1] Partially estimated.
[2] North Dakota State Engineer's Report.
[3] Estimated.
[4] Extended.

Table 60.—*Summary of annual run-off in acre-feet*

Stream and location	Years of record	Maximum	Minimum	Mean	Mean annual run-off depth in inches
Little Missouri River at Medora, N.Dak	11	971, 000	204, 000	471, 000	1. 39
Little Missouri River at Camp Crook, S.Dak	2	179, 000	139, 000	159, 000	1. 54
Little Missouri River near Alzada, Mont	16	170, 000	14, 800	100, 000	2. 26
Little Missouri River at Alzada, Mont	1	42, 300	42, 300	42, 300	1. 24

TABLE 61.—*Summary of mean daily flow in second-feet*

Stream and location	Years of record	Maximum	Minimum	Mean	Maximum second-feet per square mile
Little Missouri River at Medora, N.Dak	11	33, 700	1. 9	651. 0	5. 33
Little Missouri River at Camp Crook, S.Dak	2	3, 480	0	220. 0	1. 80
Little Missouri River near Alzada, Mont	16	4, 550	0	138. 0	5. 48
Little Missouri River at Alzada, Mont	1	1, 744	0	58. 4	2. 73

TABLE 62.—*Operation of Cottonwood Creek Reservoir, Little Missouri Irrigation Project*

[Reservoir capacity=4,890 acre-feet; project area=3,000 acres; units in acre-feet]

Year and month	Run-off Little Missouri, near Alzada	Demand at river	Shortage in natural flow	Surplus for storage	Surplus diverted by feed canal	Irrigation draft on reservoir	Reservoir evaporation loss	Reservoir content	Irrigation shortage	Waste
1916:										
April	4, 280	0	0	4, 280	4, 280	0	77	4, 203	0	0
May	4, 240	375	0	3, 865	895	0	208	4, 890	0	2, 970
June	2, 380	1, 500	0	880	289	0	289	4, 890	0	591
July	2, 270	2, 625	355	0	0	266	329	4, 295	0	0
August	3, 750	2, 250	0	1, 500	1, 011	0	416	4, 890	0	489
September	0	750	750	0	0	564	150	4, 176	0	0
Total	16, 920	7, 500	1, 105	10, 525	6, 475	830	1, 469	--------	0	4, 050
1917:										
April	54, 400	0	0	54, 400	4, 760	0	84	4, 676	0	49, 640
May	3, 930	375	0	3, 555	434	0	220	4, 890	0	3, 121
June	2, 740	1, 500	0	1, 240	289	0	289	4, 890	0	951
July	308	2, 625	2, 317	0	0	1, 740	300	2, 850	0	0
August	615	2, 250	1, 635	0	0	1, 225	170	1, 455	0	0
September	60	750	690	0	0	518	50	887	0	0
Total	62, 053	7, 500	4, 642	59, 195	5, 483	3, 483	1, 113	--------	0	53, 712
1918:										
April	7, 980	0	0	7, 980	0	0	0	0	0	7, 980
May	9, 970	375	0	9, 595	0	0	0	0	0	9, 595
June	3, 090	1, 500	0	1, 590	0	0	0	0	0	1, 590
July	10, 100	2, 625	0	7, 475	0	0	0	0	0	7, 475
August	7, 140	2, 250	0	4, 890	0	0	0	0	0	4, 890
September	6, 600	750	0	5, 850	0	0	0	0	0	5, 850
Total	44, 800	7, 500	0	37, 380	0	0	0	--------	0	37, 380
1919:										
April	4, 050	0	0	4, 050	4, 050	0	74	3, 976	0	0
May	553	375	0	178	178	0	176	3, 978	0	0
June	0	1, 500	1, 500	0	0	1, 125	180	2, 673	0	0
July	5, 600	2, 625	0	2, 975	2, 460	0	290	4, 843	0	515
August	2, 640	2, 250	0	390	390	0	448	4, 785	0	0
September	0	750	750	0	0	564	165	4, 056	0	0
Total	12, 843	7, 500	2, 250	7, 593	7, 078	1, 689	1, 333	--------	0	515
1921:										
March	1, 420	0	0	1, 420	1, 420	0	33	1, 387	0	0
April	89	0	0	89	89	0	60	1, 416	0	0
May	0	375	375	0	0	282	70	1, 064	0	0
June	9, 280	1, 500	0	7, 780	3, 260	0	123	4, 201	0	4, 520
July	1, 540	2, 625	1, 085	0	0	814	287	3, 100	0	0
August	246	2, 250	2, 004	0	0	1, 500	216	1, 384	0	0
September	357	750	393	0	0	295	52	1, 037	0	0
Total	12, 932	7, 500	3, 857	9, 289	4, 769	2, 891	841	--------	0	4, 520
1930:										
March	3, 750	0	0	3, 750	3, 750	0	60	3, 690	0	0
April	654	0	0	654	654	0	132	4, 212	0	0
May	615	375	0	240	240	0	192	4, 260	0	0
June	9, 040	1, 500	0	7, 540	890	0	260	4, 890	0	6, 650
July	308	2, 625	2, 317	0	0	1, 968	287	2, 635	0	0
August	62	2, 250	2, 188	0	0	1, 686	176	773	0	0
September	0	750	750	0	0	564	26	183	0	0
Total	10, 679	7, 500	5, 255	12, 184	5, 534	4, 218	1, 133	--------	0	6, 650

NOTE.—The above data for the dry years of 1921 and 1930, also the dry period from 1916 to 1919, inclusive.

TABLE 63.—*Mechanical analysis of suspended sediment, Little Missouri River at Medora, N.Dak.*

LITTLE MISSOURI RIVER BASIN

	May 9, 1931	May 10, 1931	Sept. 19, 1929, to July 31, 1931
Gage height	1.86	1.86	Composite sample made up from daily mid-stream surface samples; represents average composition of sediment during the period of sampling.
Depth	0.9	0.9	
Station	0+43	0+43	

Classification and size limits in millimeters	Percent of total sediment in each classification		
(a) Clay (0 to 1/256)	60.5	60.9	46.6
(b) Silt:			
Very fine and fine (1/256 to 1/64)	27.5	23.9	35.0
Medium and coarse (1/64 to 1/16)	01.1	01.4	15.2
(c) Very fine sand (1/16 to 1/8)	04.6	04.4	01.8
(d) Fine sand (1/8 to 1/4)	03.3	05.5	00.9
(e) Medium sand (1/4 to 1/2)	01.9	03.0	00.3
(f) Coarse sand (1/2 to 1)	01.1	00.9	00.2
(g) Very coarse sand (1 to 2)	00.0	00.0	00.0
Total	100.0	100.0	100.0

APPENDIX III

Description of potential irrigation projects

CONTENTS

SUMMARY OF PRINCIPAL DATA

State: Montana.
County: Carter.
Latitude: 45° 15′ north.
Longitude: 104° 10′ west.
Location: T. 6 S., R. 61 and 62 E.; T. 7 S., R. 60 and 61 E.; T. 8 S., R. 60 E., Montana principal meridian.
Railroad connections: None; 45 miles to Belle Fourche, S.Dak., the nearest railroad station.
Principal markets: Alzada, Mont; Belle Fourche, S.Dak.; and other local points.
Elevation of land: 3,380 feet to 3,460 feet above sea level.
Character of soil: Heavy clay and clay loams, containing varying quantities of gypsum and alkali and characterized by poor drainage.
Range of temperature: −35° to 108°.
Mean temperature: Annual, 44.6°; growing season, 64.6°.
Average date of last spring frost: May 16.
Average date of first fall frost: September 26.
Average length of growing season: 133 days.
Average precipitation: Annual, 18.04 inches; growing season, 13.57 inches.
Principal crops: Small grains and forage crops.
Duty of water: 1.5 acre-feet per acre per annum on land, 2.5 acre-feet per acre per annum at source.
Net irrigable area: 3,000 acres.
Construction cost per irrigable acre: $189.33.
See maps 15, 16, and 17, and charts 25 and 26, appendix I[1]; also, see table 62, appendix II.

[1] Only charts 25 and 26 printed.

1. *History.*—A reconnaissance of the Little Missouri project was made by the Bureau of Reclamation in 1904. (See Third Annual Report of the Bureau.)

2. The Little Missouri Land & Irrigation Co. was organized in 1912 for the purpose of developing this project under the Carey Act. On March 24, 1913, the General Land Office approved the segregation (Montana, no. 22). The plan of reclamation included a storage reservoir on lower Cottonwood Creek, claimed to have a capacity of 20,000 acre-feet; a feeder canal of 500 second-feet capacity diverting from the Little Missouri River; and a main canal and distribution system supplied directly from the reservoir. Construction work was started in 1914 and the storage dam partially built. Excavation was also completed for the first 9 miles of the main canal below the reservoir. In 1915, a freshet in Cottonwood Creek damaged the dam and washed out about 600 feet of the main canal. Work was abandoned at this time and has not been resumed, although the project was kept alive by extensions of time for completion. However, the General Land Office has refused further extensions and as it is understood that the segregation was canceled as of January 1, 1931, the project can be considered as abandoned as a Carey Act enterprise.

3. Preliminary topographic surveys, covering the project storage site and the irrigable lands, were made by this office early in the Summer of 1931. The lands included in the survey were later classified as to their desirability for irrigation.

4. *Lands in project.*—The lands lie in a long narrow strip along the west side of the Little Missouri River, between the proposed reservoir on Cottonwood Creek and a point a few miles above Capitol, Mont. The gross area under the project is approximately 25,700 acres, the major portion of which is public land.

5. The soil classification indicates that a large portion of the gross area under the proposed main canal is of inferior character and unsuited for irrigation. The soils vary from sandy-clay loams to heavy clays and much of the heavier soils contain considerable amounts of deleterious salts.

6. None of the land within the project is at present under irrigation. The bench, on which the lands are situated, has a gentle slope toward the river but is cut by numerous small ravines.

7. After eliminating the land determined to be undesirable for irrigation, and allowing for rights of way, roads, buildings, etc., a net irrigable area of only 3,000 acres remains.

8. *Soil classification.*—The soil classification of this project is based upon the soil type, as determined by the proportion and relative size of the soil particles, and upon the topography where the various types occur. The Little Missouri River in this section follows a meandering course through its valley, with a 20- to 25-foot entrenchment below the general level of the plain. At each of the sharp bends is found a steep cut bank on the convex side and a low point on the concave side. The low area on the concave side is generally subject to overflow during periods of high water. The area subject to overflow is usually grown up in low trees and scrub growth. Back from the river rises the gentle slope of the terrace, which steepens slightly with increased distance from the stream as it approaches the buttes bordering the valley. Except for the low land on the river bank, the courses of the few creeks and draws entering the river, and a few

natural depressions, all the land under the proposed canal is terrace soil.

9. Two soil types predominate on the terrace, a clay loam and a clay, which are very similar in all characteristics except in the texture and structure of their surface layers. These surface types are underlain by calcareous, granular clay subsoils. While the slope of the terrace is very gentle even in the higher areas, it is quite uniform, and this condition, combined with the heavy texture of the soil, results in an immediate run-off of all surface water after a rain. The terrace soils are alluvial in origin, of materials washed down from the shale and sandstone formations of the adjoining high land, but are derived principally from the clay-forming shales.

10. There is a fairly even distribution of alkali over the area of clay soil on the terrace, which, when tested in the field by the electric-bridge method, showed an average concentration of 0.17 percent of soluble salts in the surface soil and 0.60 percent in the subsoil. However, the alkali content of the surface soil in low or depressed areas is much higher than the average, approaching 1 percent in poorly drained spots. Analyses of solutions of this soil showed the alkali to be mainly sulphates and carbonates.

11. The native vegetation supported by this soil is a very patchy growth of low scrub sage, prickly pear, and a few scattered clumps of wheat grass. The presence of the sage bears out the results obtained by the alkali tests with the electric-bridge, which indicate that the soil, while containing a harmful quantity of soluble salts, will produce yields if planted with alkali resisting crops.

12. In this report each soil type is designated by a number, and is further classified as to the terrain where it occurs by letters as follows:

A, lands with slopes from 0 to 6 percent.

B, lands with slopes from 6 to 12 percent.

C, lands with slopes in excess of 12 percent or lands so rough and broken as to be unsuited for irrigation.

D, lands so low, flat, or poorly drained as to be impractical of drainage after irrigating desirable land.

13. The following table presents the areas classed as desirable and undesirable for irrigation listed by type numbers and terrain letters. The symbol (+) behind the terrain letter indicates the presence of alkali to a degree harmful to crops. A detailed description of each soil type follows the table.

Soil types and acreages

	Acreage
Soils desirable for irrigation:	
Type no.:	
13A	3, 440
13B	20
Total	3, 460
Percent of total gross area	13. 5

Soil types and acreages—Continued

Soils undesirable for irrigation:	
Type no.:	Acreage
5A	10
12A+	19, 580
12B+	150
12C	520
12D	720
13C	20
13D	1, 070
U.I	200
Total	22, 270
Percent of total gross area	86. 5

NOTE.—The above acreage desirable for irrigation has not had excluded from it an allowance for rights of way, roads, buildings, etc. If 13 percent is deducted for these uses, the net irrigable area is 3,000 acres.

14. Soil type no. 12 is the most extensive type found in the project, making up 82 percent of the total acreage. It is a gray to grayish-yellow, compact clay, which continues through the 3-foot section, with finely divided lime particles below a depth of 18 inches. A more compact hardpan layer is usually found between depths of 2 and 6 inches, and the structure of the clay normally becomes slightly granular in the zone of lime concentration. This soil occurs on the flat terrace of the river and is characterized by a sparse, patchy vegetation of scrubby valley sage, prickly pear, and grass, with frequent almost white, bare, blown-out areas. Being almost impervious and having a smooth gentle slope, the soil is not penetrated more than a few inches by even the hardest rains and shows a tendency to erode into deep gullies at the natural drainage outlets and on the banks of the river due to the excessive run-off. This soil is alluvial in origin, being composed of materials washed down from the adjoining shale and sandstone highlands, which are high in alkali content. A detailed study of the alkalinity of this type, made with the electric salt bridge, showed an average of 0.17 and 0.60 percent of soluble salts in the surface and subsoils respectively. None of the soil is under cultivation but is used as sheep range, supporting not more than 15 animals to the square mile, and is not a desirable type for irrigation.

15. Soil type no. 13 is a brown to grayish-brown, clay loam of heavy columnar structure, underlain at a depth of 8 inches by a 4-inch compact clay loam, hardpan layer. From this depth clay loam continues, gradually becoming lighter in color and heavier in texture with increased depth to below the second foot, where it grades to the heavy, calcareous clay of soil type no. 12. This soil occurs on the flat terraces in small isolated areas surrounded by type no. 12, and was formed by alluvial action but under conditions not favorable to the accumulation of alkali. It is the best agricultural land in the valley, with good surface drainage, and is cultivated mainly in hay and forage crops, and supports a fair stand of native grasses in its natural state. Where cultivated the hardpan layer is usually absent, having been broken up by root action and deep cultivation, making a manageable soil greatly retentive of moisture and a desirable type for irrigation.

16. The lands classed as irrigable in the project form a relatively small percentage of the total area. Soil type no. 13, the lightest and best agricultural land in the area, is at present practically free from alkali. However, the parent material of the terrace soils is a blue-black shale, containing thin layers and pockets of gypsum and other soluble salts, which is a practically inexhaustible source of alkali. This shale is found in the higher land above the terrace and in the low buttes and usually has but a shallow soil cover. As the proposed ditch at several points passes through this shale formation, it is certain that the irrigation water in the canal would become impregnated with alkali before distribution over the land unless preventive measures were taken. Such measures to prevent contamination of the water and further accumulation of salts on the land would prove costly; and it is extremely doubtful whether the expenditure would be justified.

17. *Water supply.*—The main source of water supply for this project is the Little Missouri River. A gaging station was established on the river near Alzada, Mont., in 1911, and records are practically continuous since that date with the exceptions of the years 1926, 1927, and 1928. (See table 56, appendix II, and charts 22, 25, and 26, appendix I.) The minimum flow during the 16 years of record frequently was zero. At Alzada, the Little Missouri has been dry during almost every month of the year. The maximum observed daily mean flow was 4,550 second-feet, on April 6, 1912. The average annual run-off for the years of record is 100,000 acre-feet, or 2.26 inches on the drainage area (831 square miles). About 39 percent of the average run-off occurs during the May-September irrigation season, but the flow is so erratic that it is not a dependable source for irrigation unless controlled by storage works. In 11 of the 16 years of available stream-flow records there were shortages in the May–September natural flow for irrigating 3,000 acres of land, varying from 1,100 acre-feet to over 5,000 acre-feet. A reservoir of 4,890 acre-feet usable capacity would regulate the run-off from April 1 to September 30 and make it available for the full irrigation of 3,000 acres of irrigable land below the reservoir. (See table 62, appendix II.)

18. Existing water appropriations on the Little Missouri River which might conflict with the supply for this project are practically negligible.

19. *Quality of water supply.*—Only one sample of water from the Little Missouri River in the vicinity of the project has been analyzed. It was taken during low summer flow and indicates the presence of alkali, mainly in the form of sulphates and bicarbonates, in a concentration of about 1,200 parts per million. It is probable that analyses of samples taken from the stream under higher flow conditions will show considerably less concentration. However, it is evident that the water contains a dangerous amount of injurious salts for the heavy soils of the project and must be used in irrigation with considerable care to prevent ruining the land.

20. *Plan of reclamation.*—The proposed system for irrigating the 3,000 acres of land classed as desirable for irrigation in this project, consists of a 4,890 acre-foot reservoir on Cottonwood Creek, fed by an 80 second-foot canal from the Little Missouri River; and a main canal, of 35 second-feet maximum capacity, leading from the reservoir to

the project lands. (See maps 15, 16, and 17, appendix I.) [2] Following are brief data concerning the several construction units of the project:

COTTONWOOD CREEK RESERVOIR

Status: Dam partly built but washed out in 1915. Entirely new dam required. Preliminary surveys made in 1931.
Location: Secs. 5, 6, 7, 8, and 9, T. 8 S., R. 60 E., Montana principal meridian.
Source of water supply: Little Missouri River.
Type of dam: Earth fill with concrete spillway.
Height of dam: 43 feet above stream bed.
Length of dam: 1,530 feet on crest.
Size of spillway: 150 feet wide, 5 feet deep.
Capacity of spillway: 1,500 second-feet.
Area of reservoir: 577 acres.
Capacity of reservoir: 4,890 acre-feet.
Estimated total cost: $374,000.

DIVERSION DAM

Status: Potential, preliminary surveys made.
Location: Sec. 6, T. 9 S., R. 60 E.
Type of dam: Concrete weir with concrete and earth abutments.
Length: 108 feet.
Height: 12 feet.
Estimated total cost: $46,000.

FEED CANAL

Status: Potential, preliminary surveys made.
Capacity: 80 second-feet.
Length: About 6 miles.
Estimated total cost: $50,000.

MAIN CANAL

Status: Excavated for 9 miles, no structures (now of little practical value).
Capacity: 35 second-feet required.
Length: 24 miles (total requirement, disregarding previous construction).
Lateral and drainage systems: For 3,000 acres.
Estimated total cost for main canal and lateral system: $98,000.

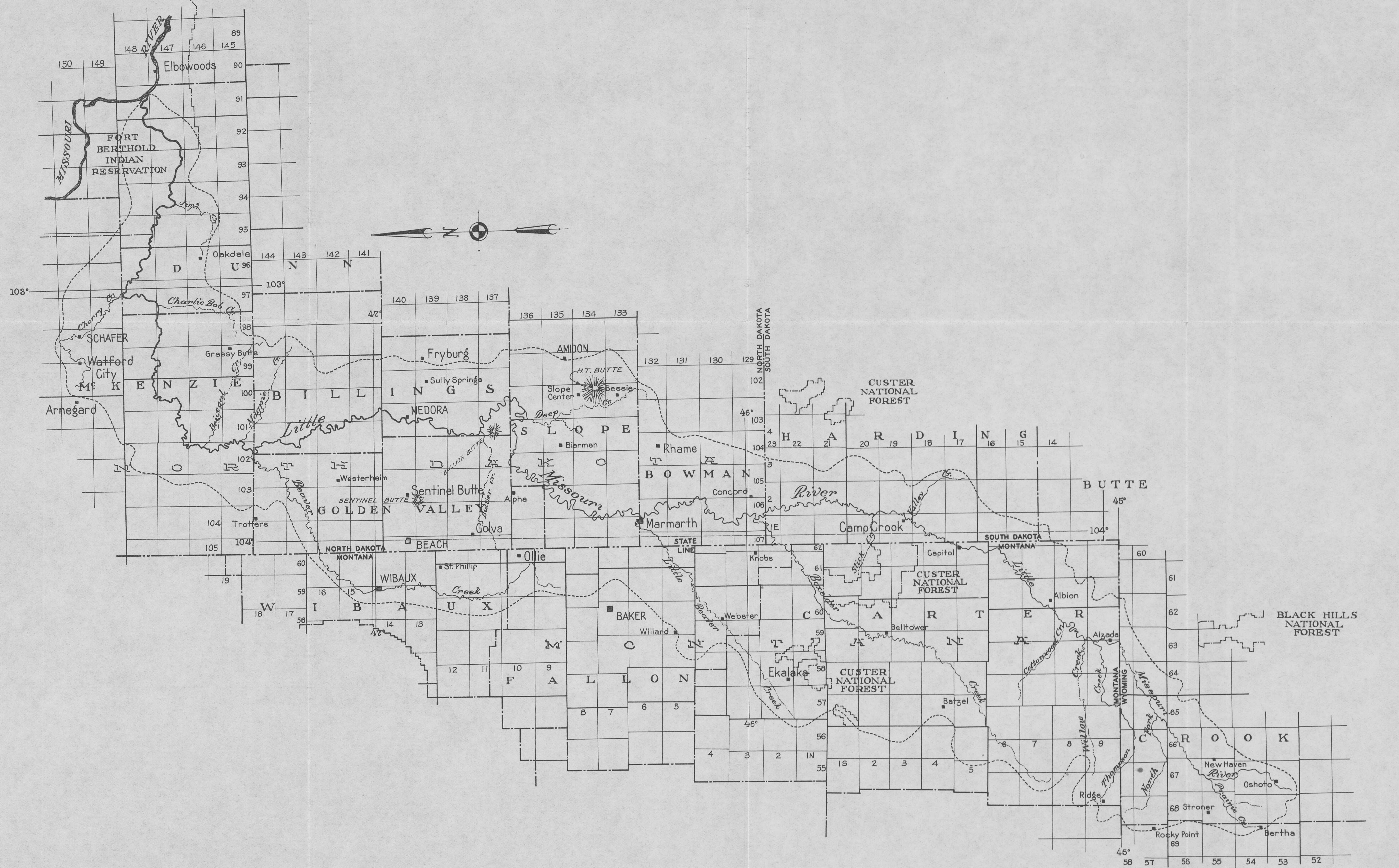
The construction work involved in the development would not be especially difficult. The dam foundations, consisting of clay and shale, are considered suitable for supporting a low earth dam of the type proposed. Material for the main part of the dam can be obtained from the hillside adjacent to the north abutment. The canals are to be unlined, with concrete structures.

COSTS

21. Preliminary cost estimates, including the reservoir and feed canal, main canal, and lateral systems, were prepared for this project. The total estimated construction cost for a system to serve 3,000 acres of irrigable land is $568,000, or $189.33 per acre.

[2] Not printed.

○



MISSOURI RIVER AND TRIBUTARIES

FLOOD CONTROL - IRRIGATION - NAVIGATION - POWER

LITTLE MISSOURI RIVER

TRIBUTARIES, TOWNS AND PUBLIC LAND LINES

In 1 Sheet — Sheet No. 1 — Scale: (see graphic)

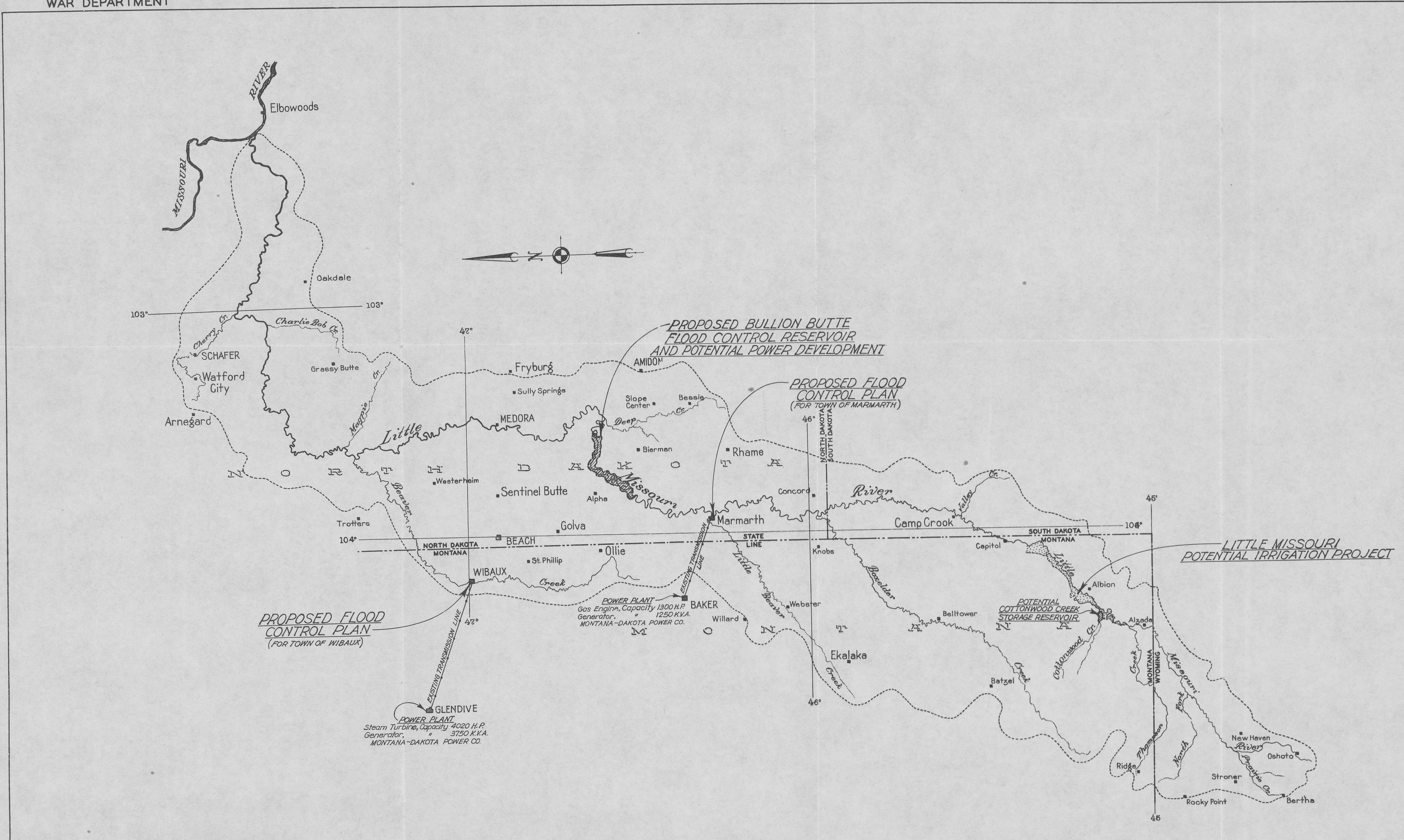
MILES 10 0 10 20 30 40

U. S. ENGINEER OFFICE, KANSAS CITY, MO. NOV. 1931.

Submitted: Captain, Corps of Engineers.

Approved: Captain, Corps of Engineers.

Compiled by	Traced by	Checked by	Transmitted with report dated:	File No.
G.H.J.	G.H.J.	F.B.S.	DECEMBER 1931	M-224-2



MISSOURI RIVER AND TRIBUTARIES

FLOOD CONTROL-IRRIGATION-NAVIGATION-POWER

LITTLE MISSOURI RIVER

EXISTING AND POTENTIAL FLOOD CONTROL, IRRIGATION AND POWER PROJECTS

In 1 Sheet — Sheet No. 1 — Scale: (see graphic)

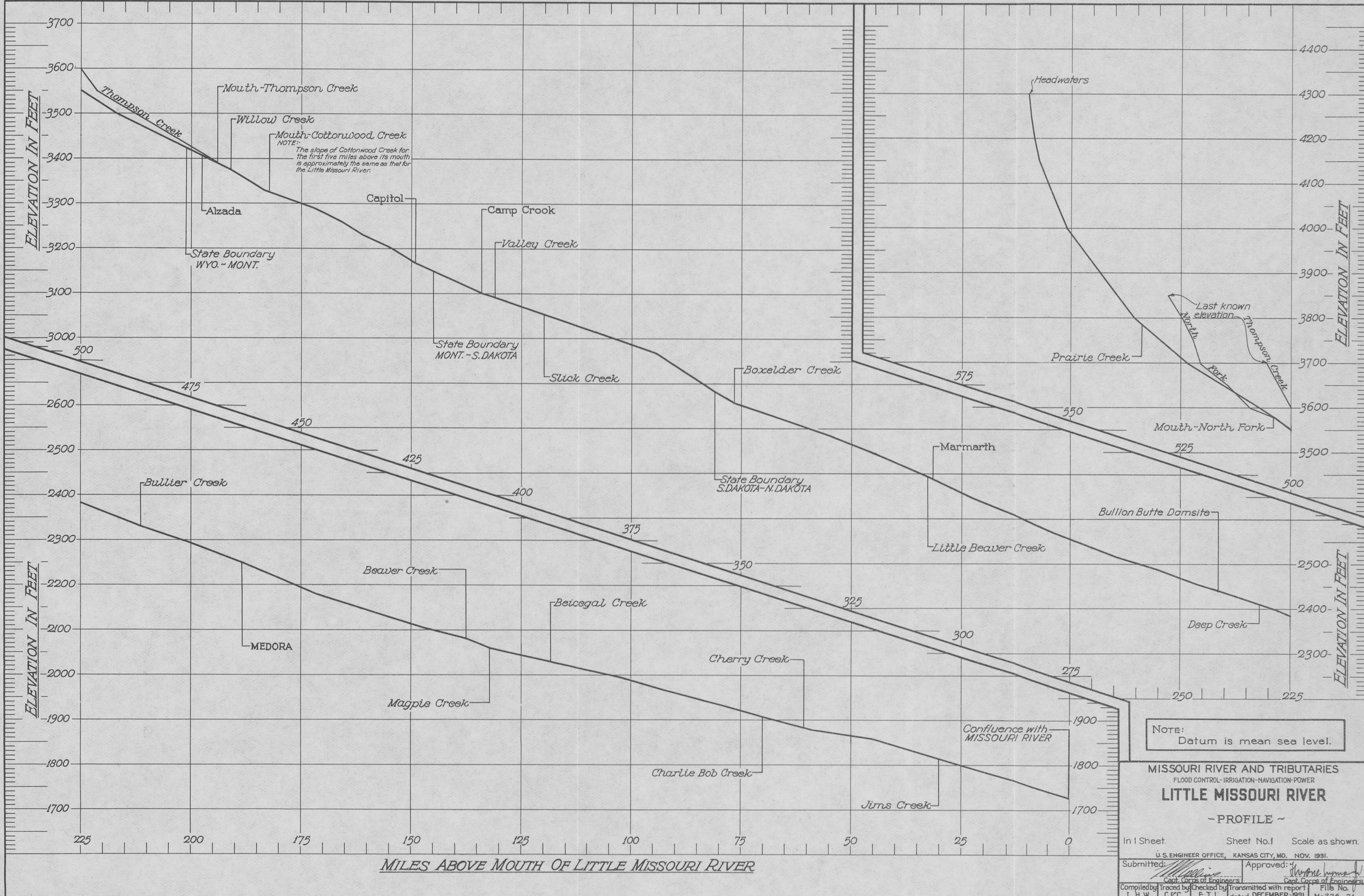
10 5 0 10 20 30 40
MILES

U. S. ENGINEER OFFICE, KANSAS CITY, MO. NOV. 1931.

Submitted:	Approved:
Captain, Corps of Engineers.	Captain, Corps of Engineers.

Compiled by	Traced by	Checked by	Transmitted with report	File No.
C.P.C.	C.P.C.	F.B.S.	dated: DECEMBER-1931	M-224-18

HOUSE DOC. NO. 64, 73D CONG., 1ST SESSION



HOUSE DOC. NO. 64, 73D CONG., 1ST SESSION

CHART 21

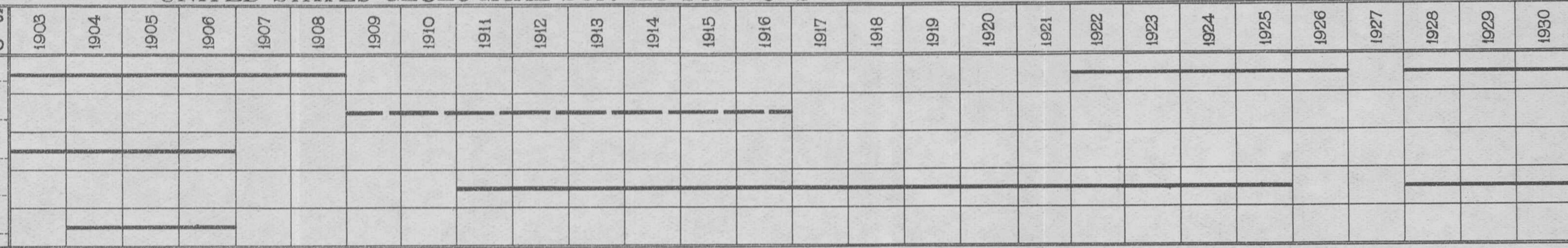
U.S. GOVERNMENT PRINTING OFFICE: 1934

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

- UNITED STATES GEOLOGICAL SURVEY STATIONS -

STREAM	STATION	STATE	STATION NO.	YEARS OF RECORD
LITTLE MISSOURI RIVER	at MEDORA	N. DAK.	*9	14
" " "	" "	" "		8
" " "	at CAMP CROOK	S. DAK.	8	4
" " "	near ALZADA	MONT.	*6	18
" " "	at ALZADA	"	7	3



* = Maintained at present by U.S. Geological Survey in cooperation with U.S. Engineer Office, Kansas City, Mo.

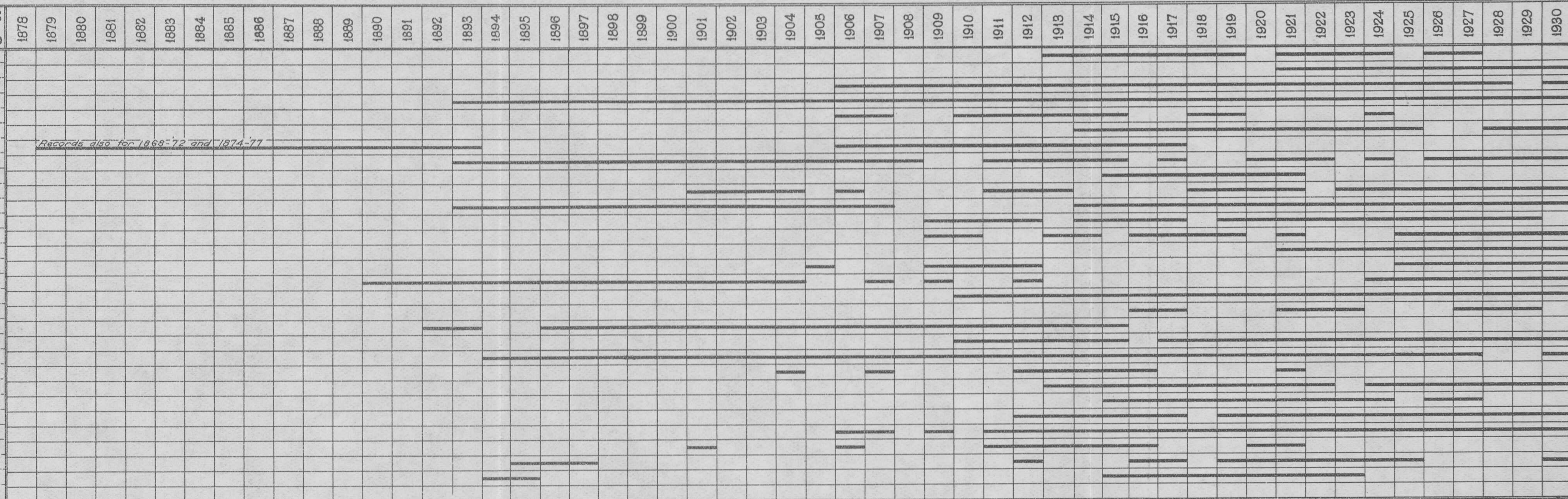
-LEGEND-

U.S. GEOLOGICAL SURVEY GAGING STATION ————

U.S. WEATHER BUREAU GAGING STATION — — —

- UNITED STATES WEATHER BUREAU PRECIPITATION STATIONS -

STATION	STATE	YEARS OF RECORD
AMIDON	N. DAK.	13
ARNEGARD	" "	10
BEACH	" "	24
*BERTHOLD AGENCY	" "	38
*BIDDLE	MONT.	11
*BOWMAN	N. DAK.	15
*BUFORD	" "	36
CAMP CROOK	S. DAK.	31
*COLONY	WYO.	7
*CULBERTSON	MONT.	20
*DUNN CENTER	N. DAK.	32
*CHETA	WYO.	19
KALAKA	MONT.	15
FRYBURG	N. DAK.	10
*GILLETTE	WYO.	11
*GLENDIVE	MONT.	25
*KNOWLES	WYO.	21
*KNOWLTON	MONT.	8
MEDORA	N. DAK.	22
*MILDRED	MONT.	20
*NEW ENGLAND	N. DAK.	35
*PINE RIDGE	WYO.	8
*PLEVNA	MONT.	17
*REDIG	S. DAK.	12
ROCKY POINT	WYO.	18
*SAVAGE	MONT.	23
*SIDNEY	"	10
*SUNDANCE	WYO.	14
WIBAUX	MONT.	11



* = Adjacent to basin.

NOTE:
Only complete years used in period of record.

NOTE:
For location of gaging stations see map No. 10
For location of precipitation stations see map No. 4

MISSOURI RIVER AND TRIBUTARIES
FLOOD CONTROL-IRRIGATION-NAVIGATION-POWER

LITTLE MISSOURI RIVER

DURATION OF RECORDS~DISCHARGE, RIVER STAGE AND PRECIPITATION STATIONS

In 1 Sheet. Sheet No. 1 Scale: as shown.

U.S. ENGINEER OFFICE, KANSAS CITY, MO. NOV. 1931.

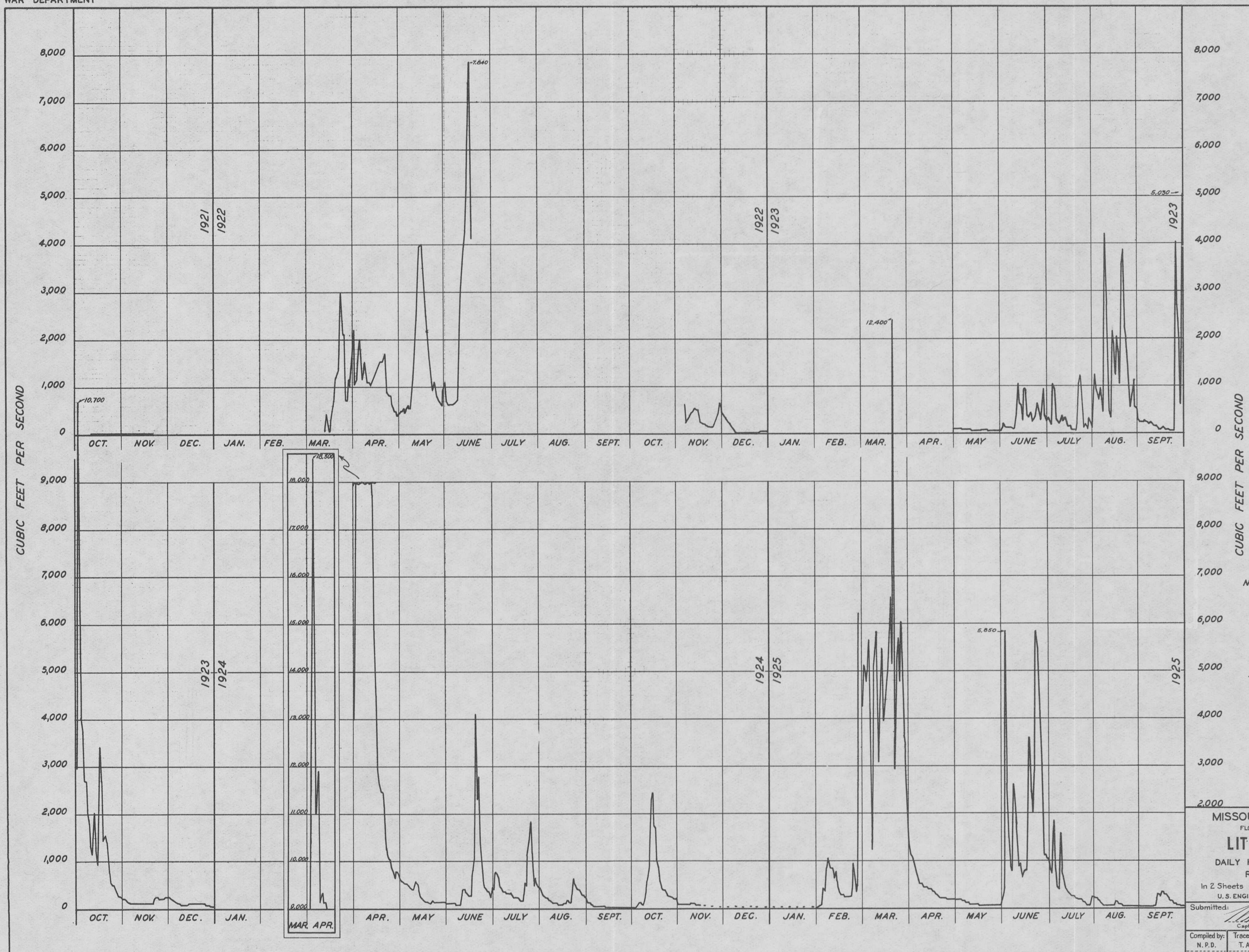
Submitted: [signature] Capt., Corps of Engineers. Approved: [signature] Capt., Corps of Engineers.

Compiled by: H.K.S. & D.D.F. | Traced by: C.E.C. | Checked by: H.K.S. & D.D.F. | Transmitted with report dated DECEMBER 1931. | File No. M-224-22

O U.S. GOVERNMENT PRINTING OFFICE: 1934

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



NOTE:-
THIS HYDROGRAPH WAS COMPILED FROM DAILY DISCHARGE RECORDS OF U. S. GEOLOGICAL SURVEY.
GAGE READINGS ON WHICH THESE RECORDS ARE BASED WERE OBTAINED FROM THE GAGE DESIGNATED AS NO. 9 ON MAP NO. 10.

MISSOURI RIVER AND TRIBUTARIES

FLOOD CONTROL-IRRIGATION-NAVIGATION-POWER

LITTLE MISSOURI RIVER

DAILY HYDROGRAPH OF LITTLE MISSOURI RIVER AT MEDORA, N. DAK.

In 2 Sheets — Sheet No. 1 — Scale: See Graphic

U. S. ENGINEER OFFICE, KANSAS CITY, MO. — NOV. 1931.

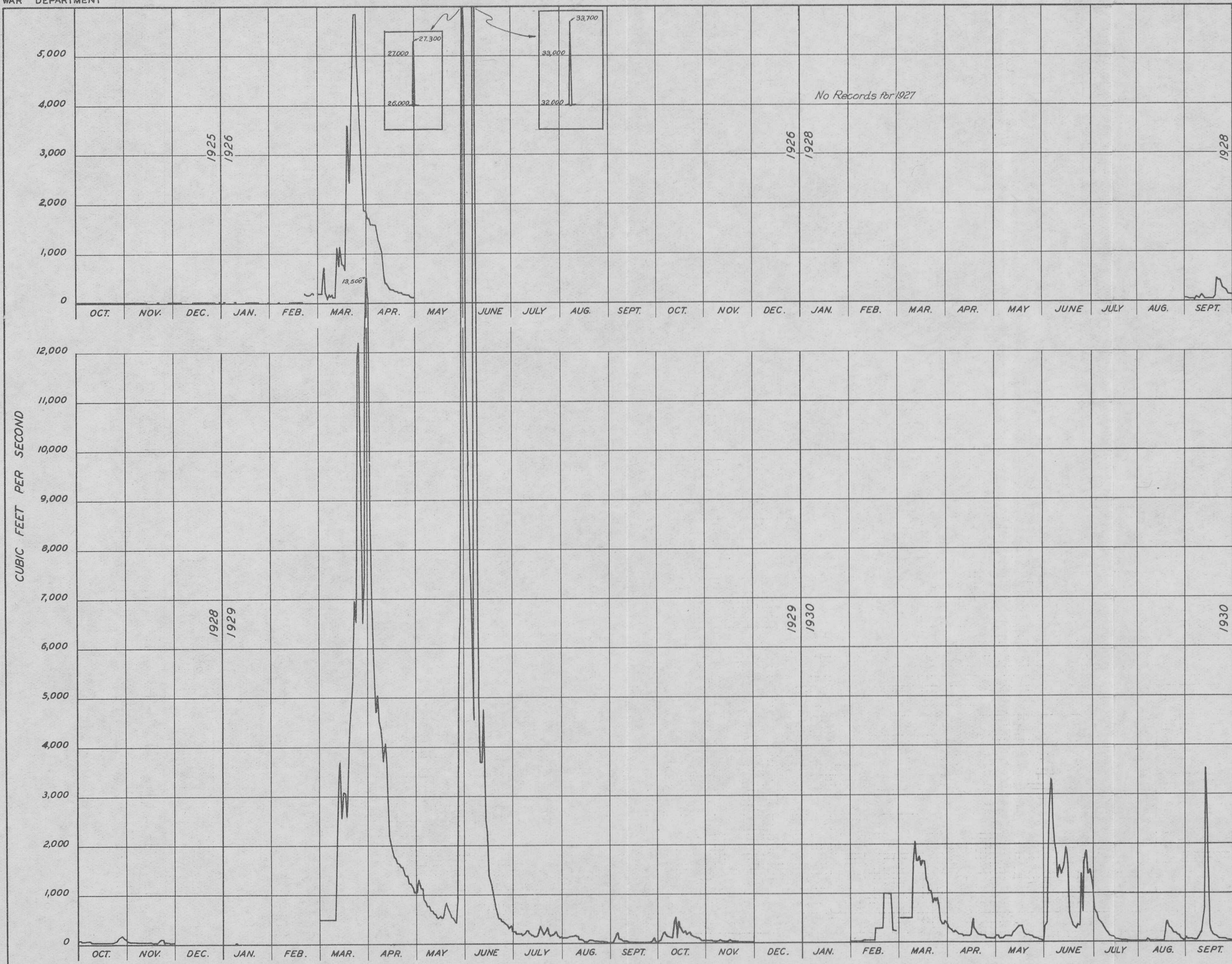
Submitted: Capt. Corps of Engineers — Approved: Capt. Corps of Engineers

Compiled by:	Traced by:	Checked by:	Transmitted with report dated:	File No.
N. P. D.	T. A. N.	T. A. N.	DECEMBER-1931	M-224-23

O U. S. GOVERNMENT PRINTING OFFICE : 1934

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



NOTE:-
THIS HYDROGRAPH WAS COMPILED FROM DAILY DISCHARGE RECORDS OF U. S. GEOLOGICAL SURVEY.
GAGE READINGS ON WHICH THESE RECORDS ARE BASED WERE OBTAINED FROM THE GAGE DESIGNATED AS NO. 9 ON MAP NO. 10.

MISSOURI RIVER AND TRIBUTARIES

FLOOD CONTROL—IRRIGATION—NAVIGATION—POWER

LITTLE MISSOURI RIVER

DAILY HYDROGRAPH OF LITTLE MISSOURI RIVER AT MEDORA, N. DAK.

In 2 Sheets Sheet No. 2 Scale: See Graphic

U. S. ENGINEER OFFICE, KANSAS CITY, MO. NOV. 1931.

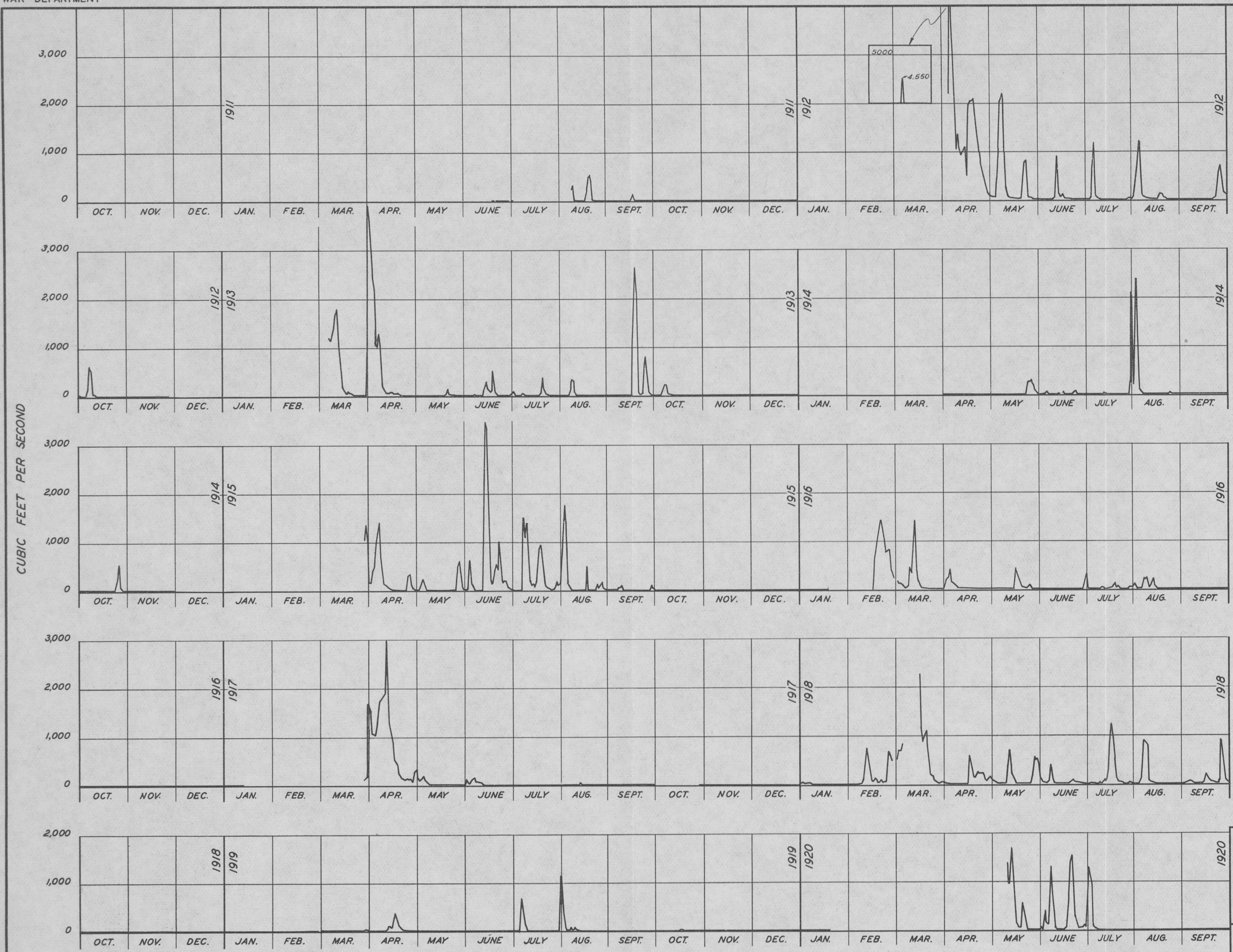
Submitted: [signature] Capt. Corps of Engineers

Approved: [signature] Capt. Corps of Engineers

Compiled by:	Traced by:	Checked by:	Transmitted with report dated:	File No.
N.P.D.	T.A.N.	T.A.N.	DECEMBER-1931	M-22.4-24

CHART 24

O U.S. GOVERNMENT PRINTING OFFICE : 1934



NOTE:- THIS HYDROGRAPH WAS COMPILED FROM DAILY DISCHARGE RECORDS OF U. S. GEOLOGICAL SURVEY.
GAGE READINGS ON WHICH THESE RECORDS ARE BASED WERE OBTAINED FROM THE GAGE DESIGNATED AS NO. 6 ON MAP NO. 10.

MISSOURI RIVER AND TRIBUTARIES
FLOOD CONTROL-IRRIGATION-NAVIGATION-POWER

LITTLE MISSOURI RIVER

DAILY HYDROGRAPH OF LITTLE MISSOURI RIVER NEAR ALZADA, MONT.

In 2 Sheets | Sheet No. 1 | Scale: See Graphic

U.S. ENGINEER OFFICE, KANSAS CITY, MO. NOVEMBER 1931.

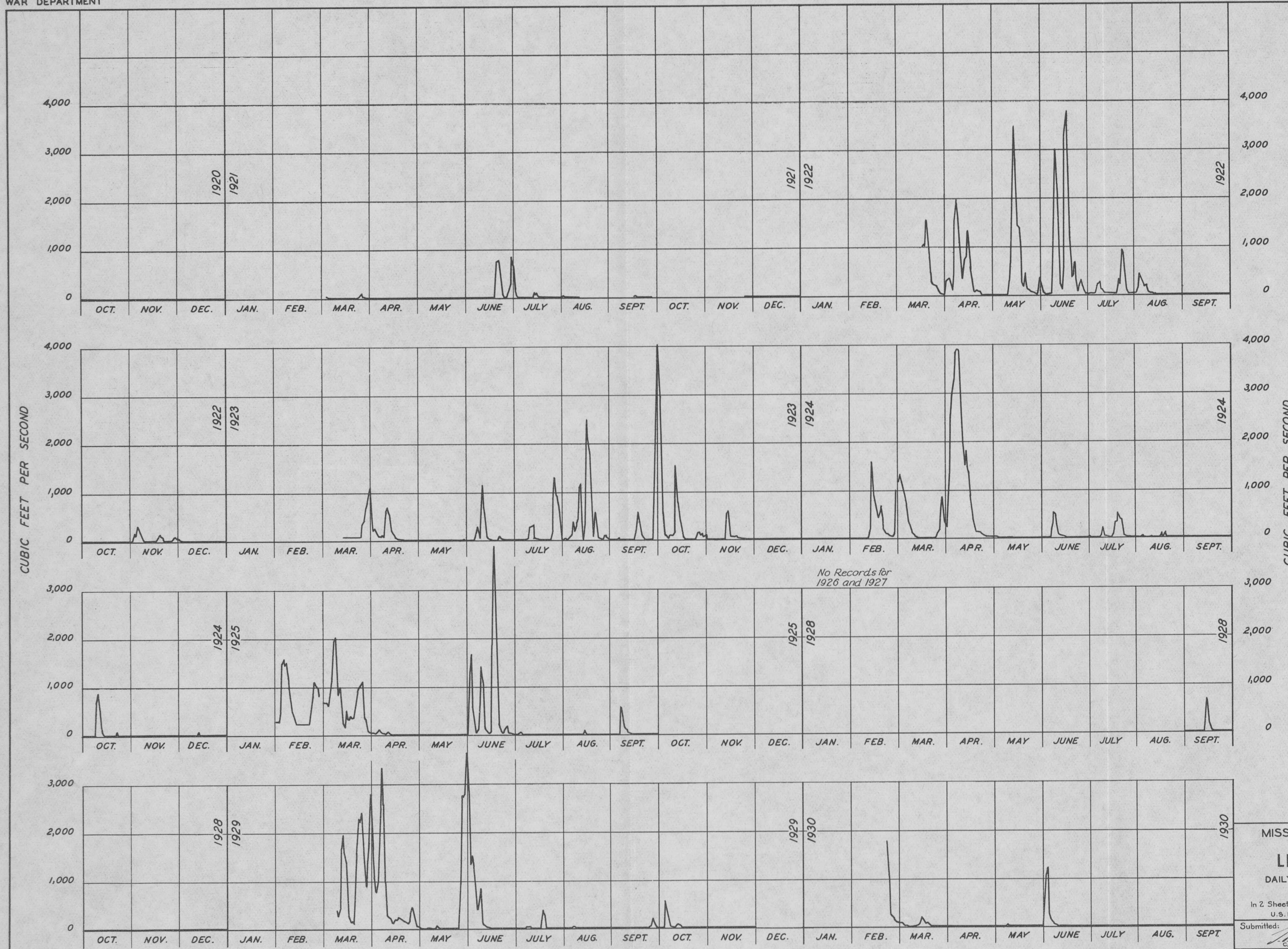
Submitted: Capt. Corps of Engineers. | Approved: Capt. Corps of Engineers.

Compiled by:	Traced by:	Checked by:	Transmitted with report dated:	File No.
N. P. D.	T. A. N.	T. A. N.	DECEMBER-1931.	M-224-25

O U.S. GOVERNMENT PRINTING OFFICE : 1934

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



NOTE:-

THIS HYDROGRAPH WAS COMPILED FROM DAILY DISCHARGE RECORDS OF U. S. GEOLOGICAL SURVEY.

GAGE READINGS ON WHICH THESE RECORDS ARE BASED WERE OBTAINED FROM THE GAGE DESIGNATED AS NO. 6 ON MAP NO. 10.

MISSOURI RIVER AND TRIBUTARIES

FLOOD CONTROL-IRRIGATION-NAVIGATION-POWER

LITTLE MISSOURI RIVER

DAILY HYDROGRAPH OF LITTLE MISSOURI RIVER NEAR ALZADA, MONT.

In 2 Sheets — Sheet No. 2 — Scale: See Graphic

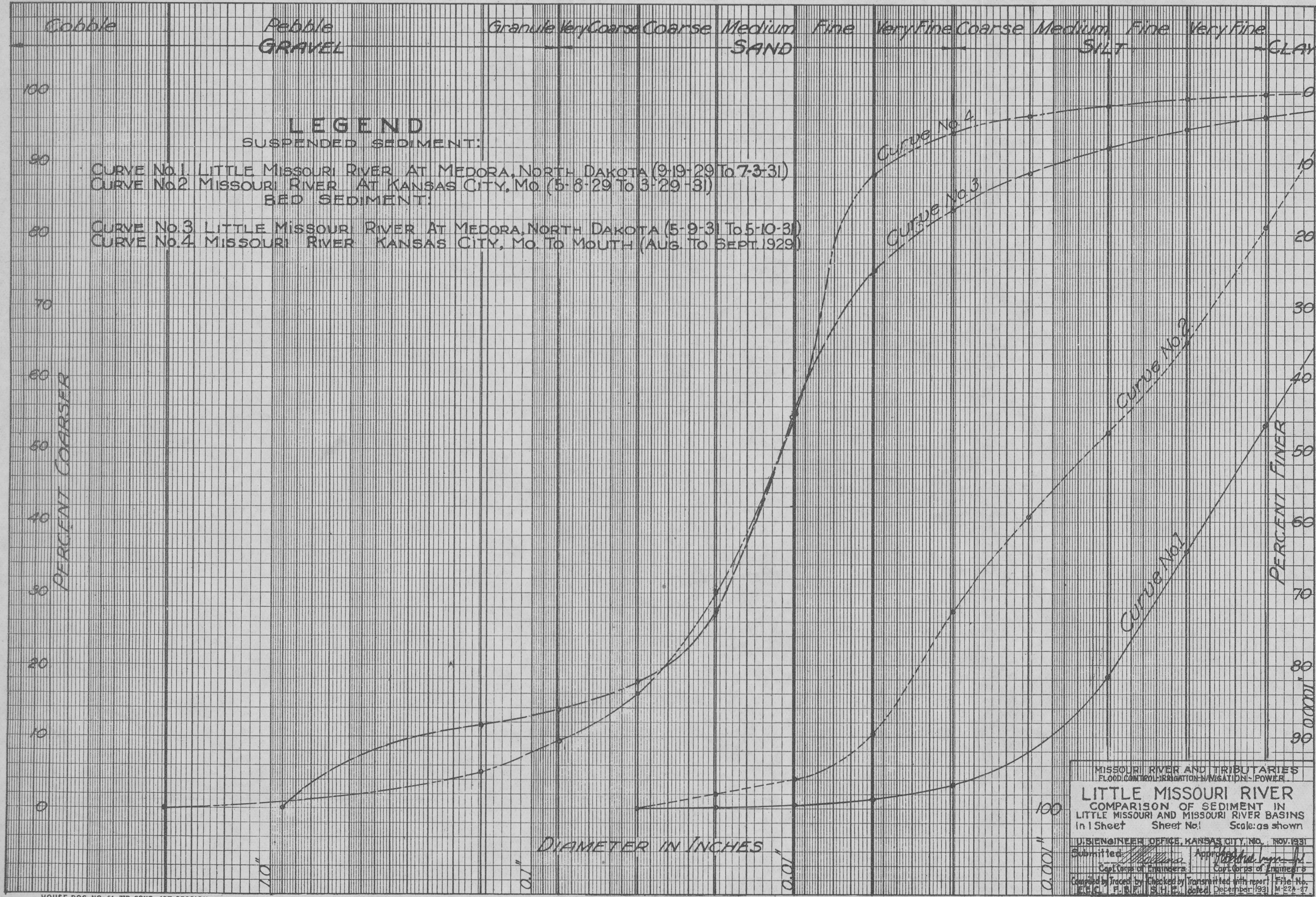
U.S. ENGINEER OFFICE, KANSAS CITY, MO. NOV. 1931.

Submitted: [signature] Capt. Corps of Engineers — Approved: [signature] Capt. Corps of Engineers

Compiled by:	Traced by:	Checked by:	Transmitted with report	File No.
N. P. D.	T. A. N.	T. A. N.	dated: DECEMBER-1931	M-224-26

CHART 26

O U.S. GOVERNMENT PRINTING OFFICE: 1934



HOUSE DOC. NO. 64, 73D CONG., 1ST SESSION

CHART 27

O U.S. GOVERNMENT PRINTING OFFICE : 1934