# REPORT UPON THE PHYSICS AND HYDRAULICS OF THE MISSISSIPPI RIVER; UPON THE PROTECTION OF THE ALLUVIAL REGION AGAINST OVERFLOW; AND UPON THE DEEPENING OF THE MOUTHS, PP. 1-214

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A. A. HUMPHREYS & H. L. ABBOT

# REPORT UPON THE PHYSICS AND HYDRAULICS OF THE MISSISSIPPI RIVER; UPON THE PROTECTION OF THE ALLUVIAL REGION AGAINST OVERFLOW; AND UPON THE DEEPENING OF THE MOUTHS, PP. 1-214

Trieste

# REPORT

UPON

# THE PHYSICS AND HYDRAULICS

OF

# THE MISSISSIPPI RIVER;

UPON THE

## PROTECTION OF THE ALLUVIAL REGION AGAINST OVERFLOW;

AND UPON THE

## DEEPENING OF THE MOUTHS:

BASED UPON SURVEYS AND INVESTIGATIONS MADE UNDER THE ACTS OF CONGRESS DIRECTING THE TOPOGRAPHICAL AND HYDROGRAPHICAL SURVEY OF THE DELTA OF THE MISSISSIPPI RIVER, WITH SUCH INVESTIGATIONS AS MIGHT LEAD TO DETERMINE THE MOST PRACTICABLE PLAN FOR SECURING IT FROM INUNDATION, AND THE BEST MODE OF DEEPENING THE CHANNELS AT THE MOUTHS OF THE RIVER.

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PREPARED BY

CAPTAIN A. A. HUMPHREYS

AND

LIEUT. H. L. ABBOT,

CORPS OF TOPOGRAPHICAL ENGINEERS UNITED STATES ARMY.

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Submitted to the Bureau of Topographical Engineers, War Department, 1861.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1867.

10956

IN THE HOUSE OF REPRESENTATIVES, *July* 20, 1867.

*Resolved*, That there be printed for the use of the members of this House thirty-five hundred copies of the introductory letter, chapters 2, 6, and 7, and plate No. 2, of the Report upon the Physics and Hydraulics of the Mississippi river, and upon the protection of the alluvial regions against overflow, made under acts of Congress by Captain (now major general) A. A. Humphreys, of the engineer department of the United States.

# LETTER OF CAPTAIN A. A. HUMPHREYS,

*Corps of Topographical Engineers,*

TRANSMITTING THE

REPORT TO THE BUREAU OF TOPOGRAPHICAL ENGINEERS.

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OFFICE OF THE MISSISSIPPI DELTA SURVEY,
*Washington, August* 5, 1861.

*Preliminary board.*—SIR: Under the act of Congress directing the topographical and hydrographical survey of the delta of the Mississippi river, with such investigations as might lead to determine the most practicable plan for securing it from inundation, a board, consisting of Lieutenant Colonel S. H. Long, topographical engineers, and myself, was organized in November, 1850, and directed to examine the river with a view to decide upon the character and extent of the surveys required. It was further ordered that, the duty of the board being completed and a report thereon being made, I should take the direction of the work.

In accordance with those instructions, the report of the board was made from Napoleon, Arkansas, December 18, 1850. That report was communicated to Congress and printed in Senate Ex. Doc. No. 13, 31st Congress, 2d session. The field of survey and investigation by measurement, as enlarged by authority of the Bureau of Topographical Engineers in the following spring, extended from the head of the alluvial region at Cape Girardeau to the gulf of Mexico. At a still later date, the investigations were authorized to include within their scope the best mode of deepening the channels at the mouths of the river, an object which had been likewise contemplated in the original appropriation act.

*Three parties organized.*—That act required a topographical and hydrographical survey of the delta of the Mississippi to be made in connection with the investigations; and in execution of the plan of operations laid down in the report of the board of December 18, 1850, three parties were at once organized to determine the topography, hydrography, and hydrometry of the alluvial region. Fortunately for the objects of the survey, the succeeding high water proved to be a flood of a peculiar character.

*The topographical party.*—The topographical party, in charge of Mr. James K. Ford, assisted by Mr. Joseph Bennett, Mr. W. Thornton Thompson, Mr. George F. Fuller, and Mr. Samuel Hill, made a minute topographical survey of the Mississippi river, extending from one mile above Routh's Point to one mile below the Barataria canal locks, just above New Orleans, collecting at the same time information concerning the crevasses of former years, old flood-marks, the history of levee construction, the dimensions of levees, well-authenticated changes in the banks of the river, &c., &c. Owing to the high stage of the river, and the consequent inaccessibility of the east bank between the foot of the Raccourci cut-off and a point one mile above Baton Rouge, that portion was omitted. The survey included the mouth of Red river, the heads of bayous Atchafalaya, Plaquemine, and La Fourche, and numerous off-set lines—among them one from Carrollton to the mouth of the new canal, Lake Pontchartrain. It comprised

carefully determined lines of level throughout. The maps of Captain Campbell Graham and of Captain G. W. Hughes, topographical engineers, accompanying their reports upon the military reconnoissance of the approaches to New Orleans, and those of Captain A. Talcott of the mouths and passes of the river, afford sufficient data for any general purposes connected with the river for the remainder of its course from Carrollton to the Gulf.

*The hydrographical party.*—The hydrographical party was placed in charge of Mr. G. Castor Smith, aided by Mr. James O'Rourke* and Mr. Otto Sackersdorff, and subsequently by Mr. Joseph Gorlinski. Its operations included the measurement of sets of cross-sections of the Mississippi at Routh's Point, at Red River landing, in the Raccourci cut-off, at Raccourci bend, at Baton Rouge, at site of Bonnet-Carré crevasse, at Carrollton and above and below that locality, and of sets of cross-sections of the mouth of Red river, of Old Red River bend, and of the heads of bayous Atchafalaya, Plaquemine, and La Fourche. In each set of cross-sections, the velocity of the current was measured—in some instances with great elaboration. The nature of the material pushed along at the bottom of the river was examined from time to time. The operations of this party were greatly impeded and interrupted by the high water. It was intended that it should make an accurate, detailed hydrographic survey of the river from the mouth of Red river to New Orleans; but this—from the difficulties encountered in the strength of the current, the great depth of the river, and the climate—was found to be impracticable without a greater expenditure of money than a proper regard for the other branches of the survey would allow. A similar, though much less elaborate, survey of the bayous Atchafalaya and Plaquemine was likewise contemplated, but for a like reason was not executed.

Previous to commencing the hydrography, this party made a survey from McMaster's plantation on the Mississippi, eleven miles below New Orleans, to Lake Borgne.

The topographical survey of the site of the Bonnet-Carré crevasse and vicinity, and of Carrollton and vicinity, and of the line to the mouth of the new canal, Lake Pontchartrain, were made by this party when temporarily under the charge of Lieutenant G. K. Warren, topographical engineers.

*The hydrometrical party.*—The hydrometrical party was placed in charge of Professor C. G. Forshey, assisted by Mr. William Sidney Smith and Mr. William Forshey, and—upon the cessation of the field duties of the topographical and hydrographical parties—by Mr. Thompson and Mr. O'Rourke† for brief periods. Subsequently, Mr. William H. Williams took the place of Mr. W. Forshey.

In connection with the operations of this party, gauge-rods were established in Lakes Pontchartrain and Borgne, in the gulf bayou at Fort St. Philip, and (in the river) at Fort St. Philip, Carrollton, Donaldsonville, Baton Rouge, Red River landing, Natchez, New Carthage, and Lake Providence. Most of these observations were continued for two years, and some of them longer. The gauge-observations made under the Navy Department at the Memphis navy yard were relied upon for that position, and private gauge-observations at Napoleon and Cairo for those localities. Temporary gauge rods were likewise observed at Berwick's bay, at Field's Mills on bayou La Fourche, and at Indian village on bayou Plaquemine.

The chief labor of the hydrometrical party, however, was directed to the constant measurement of the velocity of the current of the Mississippi in all parts of the width and depth of the Carrollton section, in order to obtain the

* Mr. O'Rourke was, during the progress of the survey, detached from this party, and, in connection with the topographical party, made the triangulations connecting the two banks of the river.

† Zeal for the public service led Mr. O'Rourke to volunteer for this duty. The exposure necessarily attendant upon its performance brought on sickness, which proved fatal to him very soon after he rejoined the topographical party, at Louisville, Kentucky.

volume of discharge in every condition of the river throughout the period of a river year, and with a view to determine the law of change of velocity from the surface to the bottom and from side to side, including the effect of wind, and thus to furnish the hydrometrical data for completing the determination of the laws governing the flow of water in natural channels. During a portion of the periods of high and low water, similar measurements were made upon a section of the river at Baton Rouge, in which vicinity the course of the river is nearly straight for several miles.

In connection with these operations, the amount of sedimentary matter held in suspension by the river was measured daily for two years, together with the temperature of the river water, and the air, &c. The character of the material pushed along the bottom was likewise examined from time to time.

Detachments from this party measured the discharge of the crevasses in the vicinity of Carrollton, the cross-sections of Berwick's bay, and of the La Fourche, at Pain Court, Thibodeaux, and Field's Mills, and ran a line of levels from the high-water mark of the Mississippi, at McMaster's plantation, to the gauge-rod at Proctorsville on Lake Borgne. Mr. Smith's lines of cross-section, at Carrollton, were likewise re-sounded by this party in low water, 1851.

It also made experiments upon the velocities of the current from the surface to the bottom at the mouths of the Mississippi, both in the high and low stages of the river, sounded the bars, and determined by measurement the advance of that of the Southwest Pass.

*Results of the operations of these parties.*—The results of the labors of all these parties enter into the most important deductions of the report; they will be found embodied in the chapters devoted to the subjects for which they were designed to furnish the data.

The original large scale topographical and hydrographical maps, profile sections, and diagrams, and hydrometric plats and drawings, are, however, valuable for the information they convey in other connections than those they have with the problem of protection against overflow. They are therefore transmitted to the bureau. A list of them will be found in a subsequent part of this letter.

*Acknowledgments.*—Professor Forshey is entitled to great credit for the zealous and intelligent manner in which he devoted himself, for many years previous to the organization of the delta survey, to observing and collecting facts relative to river phenomena, without aid from any source whatever; he thus accumulated a mass of valuable material, which has been available for the purposes of the delta survey. When it is considered how difficult and costly perfect observations are, of the character of some of those made by him as an amateur, it is a matter of surprise that so much should have been done by the unassisted enterprise of a private individual. His knowledge of the alluvial region afforded me valuable aid, and I esteemed myself fortunate in securing his services. The duties intrusted to him comprehended a great variety of subjects, some requiring the most delicately conducted experiments, and all exacting severe labor; the important results that have been deduced from these observations are evidences of the care with which they were made.

Lieutenant G. K. Warren, topographical engineers, established the river gauge-rods, made portions of the topographical and hydrographical surveys, prepared several of the topographical sheets, and aided in the general supervision and direction of the work, a duty which he performed in a highly intelligent manner, and which, acceptable to me at all times, was particularly so when I was almost entirely disabled by sickness.

To all the gentlemen composing the parties enumerated, acknowledgments are due for the faithful performance of difficult and arduous duties.

*Interruption of the work.*—While engaged in the field, in the summer of 1851, I was suddenly prostrated by sickness, which obliged me early in the following winter to relinquish the charge of the work to Lieutenant Colonel Long, topo-

graphical engineers. The operations in the field were soon after entirely suspended, with the exception already stated in connection with the Carrollton work, and continued so until the fall of 1857, when, the charge of the work having been previously resumed by me, the surveys and investigations were again vigorously prosecuted.

*Examination of European rivers.*—During the interval, while they were in abeyance, the state of my health still rendering me unfit for duty, I sought and obtained authority to visit Europe, with instructions to examine its delta rivers, and ascertain what the experience of many centuries had really proved as to the ultimate as well as immediate effects of the different methods of protection against inundation. Such of the results of that visit as have immediate application to the Mississippi river are briefly embodied in the text of the report.

Upon returning from Europe, in the summer of 1854, I was assigned to special service under the immediate orders of the War Department, and placed in charge of the office organized in connection with the explorations and surveys, then in progress, for the determination of the most practicable and economical route for a railroad from the Mississippi river to the Pacific ocean. The duties thus devolved upon me prevented my giving sufficient attention to the survey of the delta of the Mississippi to admit of its active resumption until the autumn of 1857.

*The investigations resumed.*—At my request, Lieutenant Henry L. Abbot, topographical engineers, was then directed to report to me for duty on the delta survey. This request was made in order that Lieutenant Abbot might take the immediate charge of the parties of the delta survey under my direction, the office being established at this place. An arrangement of this kind was rendered absolutely necessary by the nature of the duties then imposed upon me. Having the general charge, under the direction of the Secretary of War, of the explorations and surveys for a Pacific railroad route, of geographical explorations, and of other operations in the field more or less directly connected with those, and being also a member of the Light-house Board, I could not, with any effort, give that constant, daily, undivided attention to the delta survey required for its steady progress; and to remain long in the field was impossible. During the further progress of that work—in the field and office—I was, besides, appointed a member of several temporary commissions, the last of which was the commission instituted by the 8th section of the act of Congress of June 21, 1860, to examine into the organization, system of discipline, and course of instruction of the Military Academy.

*Partial reduction of the results of the former field work.*—Previous to the resumption of the field work of the survey, Lieutenant Abbot recomputed the volumes of discharge at Carrollton from the original notes; Mr. James S. Williams, a civil engineer of high standing, carefully revised the level notes of the survey, and deduced the results used in the report; and Mr. George F. Fuller completed the drawing of the topographical sheets of the survey.

*Field work resumed.*—As other important duties required my presence in Washington at that time, Lieutenant Abbot was directed by me in November, 1857, to proceed to the Mississippi river, organize the necessary parties, and prosecute the surveys and investigations. The completion of the topographical and hydrographical survey of the delta in the manner in which it was commenced in 1851 was not attempted; because the investigations, the more important of the two classes of work called for by the appropriation acts, required the expenditure of the balance of the appropriation. It was extremely fortunate that they were resumed just at that time, for the flood of 1858 was one of a remarkable character, and furnished data which could not have been collected if the appropriation had been exhausted by the resumption of the survey in a previous year, inasmuch as no Mississippi flood occurred between 1851 and 1858.

*Gauge-rods.*—In compliance with these instructions, gauge-rods were established at Columbus, Kentucky; Memphis, Tennessee; Napoleon, Arkansas; Vicksburg and Natchez, Mississippi; and Red River landing and Carrollton, Louisiana. Donaldsonville, Louisiana, and Cairo, Illinois, were subsequently added to the list. A daily record of the height of the water upon the rod, the state of the weather, the direction and force of the wind, &c., was kept at these stations until January, 1859. The observations at Columbus, Memphis, and Vicksburg, were continued until September, 1859, and those at Carrollton until April 30, 1861. From May 11, 1859, to June 5, 1860, a self-registering tide-gauge was maintained at the mouth of the Southwest Pass, a portion of the corresponding Carrollton observations also being made with one of these instruments.

*Discharge measurements at Columbus.*—A party in charge of Mr. Henry C. Fillebrown, assisted at first by Mr. W. E. Webster and subsequently by Mr. C. L. Jones, was established at Columbus, Kentucky, 20 miles below the mouth of the Ohio, which measured daily the velocity of the current from bank to bank, and occasionally from surface to bottom. To this duty were added the determination of the quantity of earthy matter held in suspension by the river-water, and a careful survey of the river above and below the base of current observations, with lines of level to determine the slope of the river at high and low water. A survey across the low grounds between Cape Girardeau and the Commerce bluffs was likewise made by this party.

*At Natchez and Vicksburg.*—A party with similar duties, in charge of Lieutenant H. S. Putnam, topographical engineers, assisted by Mr. J. T. Champneys, was stationed at Natchez, Mississippi; but was subsequently moved to Vicksburg, Mississippi, and placed in charge of Mr. Holmes A. Pattison, upon Lieutenant Putnam's being assigned to duty with the troops in Utah. In addition to its regular duty of current-measurements, this party made a careful survey of the river for about eight miles at Vicksburg, including the site of the velocity sections, with exceedingly accurate lines of level to determine the slope of the water surface at various stages between high and low water, entirely around the abrupt bend above Vicksburg. The discharge of the Yazoo river was also measured by this party, whenever it could be done without interfering with the regular progress of the work of the Vicksburg station. Subsequent to November 5, the gauging of the Mississippi at Vicksburg was conducted by Mr. J. J. Conway, assisted by Mr. J. M. Couper, Mr. Pattison's party having been detached to make an important survey through the Yazoo bottom, which could be best done in that month.

The observations at Columbus were continued until November 16, 1858, and those at Vicksburg until December 15, 1858. The summer of 1858 was remarkable for its intense heat and sickly character, notwithstanding which, the gentlemen composing these parties never relaxed their exertions.

*Discharge measurements upon the Arkansas.*—Similar but much less elaborate observations were made by Mr. A. A. Edington, to ascertain the daily discharge of the Arkansas river at Napoleon. These commenced on January 1, and continued until November 30, 1858.

*Upon other tributaries; with soundings in the Mississippi and bayous.*—Aided by Mr. Pattison, and, at times, by others of the assistants already named, Lieutenant Abbot, besides establishing the parties at Columbus and Natchez, measured accurate cross-sections with corresponding velocities, of the following streams, to determine approximately their discharge during the flood: the Ohio, the Hatchee, the St. Francis, the White, the Arkansas, the cut-off between the Arkansas and White rivers, the Yazoo, the Red, the Black, the Atchafalaya bayou, Old river above Red River landing, and Grand river at Berwick's bay, Louisiana. In addition, accurate measurements of the high-water cross-sections of the Mississippi were made by him at Columbus, Kentucky; New Madrid,