

232 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

July 1, 1883, amount available,	\$2,346 07
July 1, 1884, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1883.....	1,713 25
July 1, 1884, amount available.....	632 82
Amount appropriated by act approved July 5, 1884.....	5,000 00
Amount available for fiscal year ending June 30, 1885.....	5,632 82
Amount (estimated) required for completion of existing project.....	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1886.	5,000 00

(See Appendix T 9.)

10. *Continuation of the survey of the Arkansas River from Wichita, Kansas, to Fort Gibson, Indian Territory.*—A survey party commenced work in the field at Wichita, Kans., the latter part of March, where the necessary outfit had been provided, and to date have worked over all that portion of the river between there and a point somewhere in the vicinity of Tulsa, Ind. T.

It is expected that the party will have reached Tulsa by the 10th of July, and that the entire work assigned them will be completed by the early part of August.

(See Appendix T 10.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENTS, TO COMPLY WITH REQUIREMENTS OF THE RIVER AND HARBOR ACT OF AUGUST 2, 1882.

The following localities were, after preliminary examination, reported by the local engineer as not worthy of improvement and the work not a public necessity:

1. *Little River and Saline Creek, Arkansas.* (See Appendix T 11.)
2. *Big Bayou Metre from its mouth up.* (See Appendix T 12.)

Upon a favorable report from the preliminary examination made by him, Captain Handbury was charged with and completed the following, the results of which were transmitted to Congress and printed as Senate Ex. Doc. No. 104, Forty-eighth Congress, first session:

1. *White River, Arkansas, at the Memphis and Little Rock Railroad Bridge, near Duvall's Bluff, with the view of removing obstructions from the channel.* (See Appendix T 13.)

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS—IMPROVING HARBOR AND MISSISSIPPI RIVER AT ALTON—MISSISSIPPI RIVER OPPOSITE THE CITY OF SAINT LOUIS, AND AT OR NEAR CAPE GIRARDEAU AND MINTON POINT—IMPROVEMENT OF OSAGE RIVER IN KANSAS AND MISSOURI.

Officer in charge, Maj. O. H. Ernst, Corps of Engineers, having under his immediate orders First Lieut. F. V. Abbot, Corps of Engineers.

1. *Mississippi River, between the Illinois and Ohio rivers.*—Work was carried on at Horsetail, Twin Hollows, Pulltight, Chesley Island, Jim Smith's, and Foster's Island. All of these works constitute parts of one connected whole, carried on under the general scheme of making the improvement continuous, beginning at Saint Louis and working down-stream, reducing the river to an approximately uniform width of about 2,500 feet, and protecting its banks from erosion.

Horsetail.—The present project for the improvement of this locality was adopted in 1873 and modified in 1879, the object being to afford a

channel not less than 8 feet deep. The natural channel was often not more than 4 feet deep, and was tortuous. The amount expended during the year was \$103,817.88. The total amount expended to June 30, 1884, is \$765,374.49, of which, however, but \$540,308.18 has been employed upon the system adopted in 1879. It has resulted in securing a direct navigable channel with a depth of about 8 feet. Further work will be required to preserve these results, the amount of which is a matter of future contingency.

Twin Hollows, west bank.—The present project for the improvement of this locality was adopted in 1881, the object being to afford a channel not less than 8 feet deep. The natural channel was often not more than 4 feet deep in the shoalest parts. The amount expended during the year was \$29,743.71. The total amount expended to June 30, 1884, is \$226,380.87, and has resulted in securing a navigable channel in which the depth during the year has not been less than 9½ feet, but which is still tortuous. It is intended during the coming year to keep the work already constructed in repair.

Twin Hollows, east bank.—The present project for the improvement of this locality was adopted in 1881, the object being to stop the caving, which extended over a length of 8,400 feet of the bank, and the consequent deterioration of the navigation. Before the work was begun the caving was progressing at the rate of several feet per day. The amount expended during the year was \$4,719.84. The total amount expended to June 30, 1884, is \$100,648.78, and has resulted in the protection of 8,725 feet of bank, of which about half is completed and the remainder well advanced. It is proposed during the coming year to complete the unfinished portion and to extend the entire work down stream in case the point of attack of the river be so altered as to make that necessary, as now seems probable.

Pulltight.—The present project for the improvement of this locality was adopted in 1881, the object being to afford a channel not less than 8 feet deep. The natural channel was often not more than 4 feet deep in the shoalest parts. The amount expended during the year was \$39,639.94. The total amount expended to June 30, 1884, is \$86,105.41, and has resulted, in connection with the works at Twin Hollows, west bank, in securing a navigable channel in which the depth during the year was not less than 9½ feet. Much further work will be required before the result can be considered permanent. It is proposed during the coming year to extend the works down stream to connect with Beard's Island.

Chesley Island.—The present project for the improvement of this locality was adopted in 1881, the object being to stop the erosion of the east side of the island and the consequent deterioration of the navigation, and also to close the chute west of the island in order to afford, in connection with the works at Jim Smith's, a channel not less than 8 feet deep. The bank was caving at the rate of several feet per day, and the natural channel was often not more than 4 feet deep in the shoalest parts. The amount expended during the year was \$16,100.47. The total amount expended to June 30, 1884, is \$63,501.86, and has resulted in the protection of the east side of the island for a length of 4,305 feet and in partially closing the chute, affording, in connection with the works at Jim Smith's and external causes, a navigable channel in which the depth during the year was not less than 8 feet. It is proposed during the coming year to complete the closure of the chute.

Jim Smith's.—The present project for the improvement of this locality was adopted in 1881, the object being to afford a channel not less than

8 feet deep. The natural channel was often not more than 4 feet deep in the shoalest parts. The amount expended during the year was \$24,901.69. The total amount expended to June 30, 1884, is \$130,388.43, and has resulted in securing a navigable channel in which the depth during the year was not less than 8 feet. External causes contributed to this depth, which is not regarded as permanent without much further work.

It is proposed during the coming year to reconstruct the works, which have suffered greatly from the failure of the appropriation last year, and to extend them down-stream.

Foster's Island.—The present project for the improvement of this locality was adopted in 1881, its object being to stop the caving of the west side of the island and the consequent deterioration of the navigation. Before the work was begun the caving was progressing at the rate of several feet per day. The amount expended during the year was \$38,516.84. The total amount expended to June 20, 1884, is \$44,296.02, and has resulted in the partial protection of 5,864 feet of the bank. It is proposed during the coming year to complete the work by extending it up the face of the bank.

The river and harbor act of July 5, 1884, provides that the sums therein appropriated for the Mississippi River from the Des Moines Rapids to the mouth of the Ohio shall be expended under the direction of the Secretary of War, in accordance with the plans, specifications, estimates, and recommendations of the Mississippi River Commission.

July 1, 1883, amount available.....	\$195, 245 58
July 1, 1884, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1883.....	\$185, 276 43
July 1, 1884, outstanding liabilities.....	4, 614 64
	<hr/> 189, 891 07

July 1, 1884, amount available.....	5, 354 51
Amount appropriated by act approved July 5, 1884.....	520, 000 00
	<hr/> 525, 354 51

(See Appendix U 1.)

2. *Harbor and Mississippi River at Alton.*—The present project for the improvement of this harbor was adopted in 1881, the object being to remove a shoal in front of the down-stream portion of the landing. There were no expenditures during the year. The total amount expended to June 30, 1884, is \$67,324.70, and has resulted in entirely removing the shoal. To preserve these results some repairs are required in the dike, which it is proposed to make during the coming year from funds made available by Congress from the appropriation for the general improvement of the Mississippi between the Illinois and Ohio rivers. No further appropriation for this work is at present required.

(See Appendix U 2.)

3. *Mississippi River opposite the city of Saint Louis, Missouri.*—The present project for the improvement of this locality was adopted in 1882, the object being to increase the available length of river front opposite Saint Louis by reclaiming the land occupied by Cahokia Chute; also to stop the erosion at high water of the Illinois shore in Cahokia Chute, and, furthermore, to perpetuate the good results previously obtained under a different project in the channel depth. Before the work was begun a considerable body of water passed through Cahokia Chute at the higher stages and a small body at low stage, preventing access to

the navigable water west of Arsenal Island; a slight erosion of the Illinois shore occurred at the higher stages, destroying land of considerable value, and a portion of the west side of Arsenal Island was in need of protection in order to perpetuate the good channel already existing there. The amount expended during the year was \$17,581.06. The total amount expended to June 30, 1884, is \$58,455.54, and has resulted in very largely decreasing the flow through Cahokia Chute, and in partially protecting the west side of Arsenal Island. It is proposed during the coming year to simply keep in repair the works already existing, for which funds are available from the appropriation for the general improvement of the Mississippi between the Illinois and Ohio. No special appropriation for this work is at present required.

July 1, 1883, amount available.....	\$26,096 06
July 1, 1884, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1883.....	26,096 06
(See Appendix U 3.)	

4. *Mississippi River at or near Cape Girardeau, Missouri, and Minton Point, Illinois.*—The present project for the improvement of this locality was adopted in 1881, the object being to remove a large and growing bar in front of the Cape Girardeau Landing, and to provide an 8-foot channel between that place and Minton Point. The bar was dry at a stage 16 feet above low water, and the channel depth was liable to be as little as 4 feet.

There were no expenditures during the year. The total amount expended to June 30, 1884, is \$65,366.55, of which \$35,366.55 was added to the special appropriation from the funds provided for improving the Mississippi between the Illinois and Ohio, and has resulted in wholly removing the bar and securing a channel as high up as Minton Point, in which the depth during the year was not less than 8 feet. Further work will be required to perpetuate these results, for which an appropriation is recommended.

Amount (estimated) required for completion of existing project	\$41,820 04
(See Appendix U 4.)	

5. *Osage River, Kansas and Missouri.*—Since the discontinuation of the system of open-channel improvement, begun in 1871, there is no definite project for the improvement of this stream, except to remove overhanging trees from the banks and snags from the channel. Fresh supplies of these obstructions are found annually in uncertain quantities. It is thought that \$5,000 will be sufficient to accomplish such of this work as may be required during the fiscal year ending June 30, 1886.

July 1, 1883, amount available.....	\$1,660 65
Miscellaneous receipts	31 66
	<hr/>
	1,692 31
July 1, 1884, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1883.....	\$1,493 45
July 1, 1884, outstanding liabilities	55 12
	<hr/>
	1,548 57
	<hr/>
July 1, 1884, amount available.....	143 74
	<hr/>

Amount that can be profitably expended in fiscal year ending June 30, 1886. 5,000 00
(See Appendix U 5.)

APPENDIX U.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS—IMPROVING HARBOR AND MISSISSIPPI RIVER AT ALTON—MISSISSIPPI RIVER OPPOSITE THE CITY OF SAINT LOUIS, AND AT OR NEAR CAPE GIRARDEAU AND MINTON POINT—IMPROVEMENT OF OSAGE RIVER IN KANSAS AND MISSOURI.

REPORT OF MAJOR O. H. ERNST, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1884, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

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| 1. Mississippi River, between the Illinois and Ohio rivers. | 4. Mississippi River at or near Cape Girardeau, Missouri, and Minton Point, Illinois. |
| 2. Harbor and Mississippi River at Alton. | |
| 3. Mississippi River opposite the city of Saint Louis, Missouri. | 5. Osage River, Kansas and Missouri. |

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., July 29, 1884.

GENERAL: I have the honor to transmit herewith the annual reports for the fiscal year ending June 30, 1884, upon the works under my charge.

Very respectfully, your obedient servant,

O. H. ERNST,
Major of Engineers.

Brig. Gen. JOHN NEWTON,
Chief of Engineers, U. S. A.

U I.

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE ILLINOIS AND OHIO RIVERS.

The funds available during the year were not sufficient in amount to justify the undertaking of any new work, or even to prosecute successfully all of those which had already been inaugurated. They were applied as far as possible to such works as were in urgent need of repair and extension to prevent loss of a part of the results previously obtained. The plan of all these works having been fully described in

former reports, but little further explanation will be required here. Examinations made late in July, after the subsidence of the previous high water, showed that many of the hurdles were in worse condition than had been indicated by the surveys made in June for my last annual report. A survey of the entire field seemed to show that it would be possible to complete the protection of Foster's Island, and to place all of the works in as good condition as before, with the exception of those at "Jim Smith's." Work has accordingly been carried on during the year at Horsetail, Twin Hollows, Pulltight, Chesley Island, "Jim Smith's," and Foster's Island. A tabular statement is given in Appendix 1, which shows the amount of work accomplished at each locality, with the cost of each subdivision of each work.

ORGANIZATION.

The organization of the engineering staff was similar to that inaugurated in 1882 and described in former reports. It was composed of the persons named in my last report, with the exception of Assistant Engineer J. W. Irwin and S. B. Cady, who resigned during the year. The reports of the assistant engineers and of the supply clerk and subsistence clerk are herewith transmitted, constituting Appendixes 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, and 13, and are intended to form part of this report.

HORSETAIL.

The works at this locality are shown upon Plate I. The hurdles constructed several years ago at the up-stream end of the reach upon the Illinois side seemed to be exerting their influence over the entire area below to Carroll's Island. Their construction was suspended upon the completion of No. 30, to await the results of their action below. They caused heavy deposits below, but these did not reach a height sufficient to shut off all the water even at low stages.

No great additions to these deposits have since been secured, and it would seem that the limit of usefulness over this area for the hurdles above has been reached. In addition to repairing hurdles Nos. 27 and 30, and the hurdle built last year to connect Carroll's Island with the Illinois shore, the construction of two new hurdles, 27½ and 29½, was begun this year. The first was completed to a distance of 1,325 feet from shore, except wattling, and the second to a distance 1,450 feet, except wattling. The object of these hurdles was to reinforce those formerly constructed. It was not possible to undertake the construction of others to cover the area below. At the up-stream portion of the reach, within the area actually covered by the hurdles, the process of building up the new bank has continued in a satisfactory manner, the height formerly reached having been considerably increased, and the area upon which willows are growing being much enlarged.

Upon the Missouri side the new bank had at the beginning of the year reached a height about 25 feet above standard low water, and was covered with a vigorous growth of willows. The channel had begun to undermine it, however, and considerable caving was progressing. It had become necessary to protect the face of this bank, as in the case of any other caving bank. The approach of the channel being nearly parallel to the general direction of the bank, the width of the mattress to be placed below low-water mark was not so great as is considered necessary in some cases. The width fixed upon was 100 feet. A single

mattress 3,880 feet long was placed, extending from the river Des Peres to the old dike No. 1. Riprap was placed upon the bank extending to a height of 6 feet above standard low water for a length of 2,930 feet. For a length of 150 feet just above the dike the riprapping was carried 7 feet higher.

For details attention is invited to the report of Mr. E. D. Libby (Appendix 3), who was the resident engineer on the Illinois side, and to that of Mr. J. E. Savage (Appendix 4), who was resident engineer on the Missouri side; also to Appendixes 1 and 2 for detailed statements of labor and material employed and cost.

The good results of the work upon the channel previously secured were not fully maintained throughout the year. A depth of but 7 feet was found upon the lower reef for a few days in September. The upper two reefs had from 15 to 20 feet depth upon them at that time. The shoal spot soon cut out, and as there was less depth in the unimproved portion of the river it did not constitute an obstruction to navigation. The channel was direct and wide throughout the year.

The expenditures here were \$103,817.89.

TWIN HOLLOWS, WEST BANK.

Repairs were made in the primary hurdle and in secondary hurdles 1, 3, 4, and 5 (see Plate II). The deposits secured by these hurdles were considerable, but they were not as large and did not increase as rapidly as was to have been expected upon this side of the river. It will be remembered that these hurdles were placed 2,000 feet apart, the distance between them being much greater than that previously given in other works. The object of this increase of distance was to ascertain practically the greatest distance at which they could advantageously be placed apart. The results seem to indicate that 2,000 feet is too great, at least at the up-stream end of the work. An additional hurdle, numbered 0, was accordingly constructed last autumn midway between the upper extremity of the work and secondary hurdle No. 1. Since that time the depositing action has been more rapid, large quantities of material having been added to the new bank during the high water of the last spring.

For details of the work done here attention is invited to the report of the resident engineer, Mr. W. S. Mitchell, Appendix 5; and for detailed statements of labor and material employed, and the cost, to Appendixes 1 and 2.

The effect upon the channel has been beneficial, the least depth found during the year being 9½ feet. The crossing at the lower end of the works retains about the same position that it had last year, and as the channel below seems to have assumed a well-defined direct course near the Missouri bluffs, it is not improbable that it will be found advisable to stop the works where they are, rather than to push them farther downstream in accordance with the original plan.

The expenditures were \$29,743.71.

TWIN HOLLOWS, EAST BANK.

The revetment at this place was extended up the face of the bank wherever it had been left incomplete, and where the grading action of the river had cut back sufficiently to produce a proper slope. It was also extended down-stream about 100 feet to stop the action of an eddy which had begun at its lower end. The total length of the protection is 8,650

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feet. Of this 2,900 linear feet was extended to higher levels. Its height now varies from 8 to 16 feet above standard low water, except at one point, where for a length of 25 feet the bank is still vertical, and the protection has not been carried above low-water mark. The indications now are that it will be necessary to extend the protection several hundred feet down-stream, as the river has shown some tendency to attack that portion of the bank.

As far as completed the revetment has entirely stopped all caving. (For details of the work attention is invited to the report of the resident engineer, Mr. B. E. Johnson, Appendix 6; also to Appendixes 1 and 2.)

The expenditures were \$4,719.84.

PULLTIGHT.

At this locality the primary hurdle was repaired, secondary hurdle No. 1 was reconstructed, and Nos. 2 and 5 were built. They are shown on Plate II. No. 5 was placed in the chute in rear of Beard's Island to check a tendency to the enlargement of that chute. In connection with No. 2 and the others it has accomplished that object, but the positive results in the way of deposits secured have not as yet been great. In preventing the channel from splitting up, however, the works have contributed to the good results above reported for Twin Hollows, West Bank. (For details attention is invited to the report of the resident engineer, Mr. C. D. Lamb, Appendix 7; also to Appendixes 1 and 2.)

The expenditures were \$39,639.94.

CHESLEY ISLAND.

The hurdle to close the chute west of the island was completed, but just before the close of the working season it was breached. There being no funds available for its repair it was left in that condition, some riprap being thrown upon the bottom to prevent its enlargement. No results of importance have as yet been accomplished by this hurdle, except to stop the navigation of the chute at high water with the excavation of the bottom usually attendant upon the disturbance of the water by boats.

The bank protection upon the east side and about the head of the island continued perfectly effective and in good order. The bank above the protection having been graded by the flood to the full height to which the revetment was to be carried, it was completed by extending the layer of riprap to a higher level. (For details attention is invited to the report of the resident engineer, Mr. C. V. Mersereau, Appendix 8; also to Appendixes 1 and 2.)

The expenditures were \$16,100.47.

JIM SMITH'S.

The hurdles constructed at this locality in 1882 covered a large area of ground. They aggregated over 13,000 feet in length. They suffered serious damage from ice in the winter of 1882-'83, and from the subsequent flood, to repair which there were no means available. The longer they were neglected the more serious they became, until at the opening of the last year's operations the amount of work which would have been required to place them all in repair was far beyond what the means at disposal would allow. Although the hurdles themselves were much broken up, most of the deposits which they had caused were still

present, and it was thought possible to preserve these by reconstructing one or two lines near the head of the works. This was done with satisfactory results. (See Plate II.) (For details of the work attention is invited to the report of the resident engineer, Mr. J. O. Holman, Appendix 9; also to Appendixes 1 and 2.)

The beneficial effects upon the channel previously attained were maintained throughout the year, the least depth found during the low water of last autumn being 8 feet.

The expenditures were \$24,901.69.

FOSTER'S ISLAND.

In the protection of the west side of Foster's Island a small amount of work was done in the autumn of 1882. For want of means it was not possible to resume the work until late in the summer of 1883. At that time a bar had formed in front of the island near its head, covering up and shutting off access to the point where the protection had been placed. Some distance below, however, the channel was undermining and eroding the bank with great rapidity, the maximum excavation since 1881 being 580 feet. The river at this point was in excellent shape for preservation, and it was concluded that no better application could be made of some of the limited means available than in protecting this bank. The work was begun in August under the local supervision of Lieutenant Abbot, but about the end of September was transferred to Mr. J. E. Savage, Lieutenant Abbot having been called for special duty to Washington. A mattress 120 feet wide and 5,284 feet long was placed below low-water mark, covering the slope from a point just below the bar above referred to (see Plate III) to the foot of the island. The slope above low water was covered with a layer of riprap to a height of 9 feet above standard low water for a length of 5,030 feet, and to a height of 13 feet for the remaining 254 feet. It is intended to carry the protection to higher levels as the bank becomes graded to a proper slope by the action of the river. All undermining and caving have been completely stopped. (For details of the work attention is invited to Appendix 10; also to Appendixes 1 and 2.)

The expenditures were \$38,516.84.

SUPPLY DEPOT AND EQUIPMENT.

All of the materials and supplies used upon the works, except brush, stone, piles, and fuel, and all subsistence supplies were stored at the depot and issued as required. Many miscellaneous constructions and repairs were made, for details of which see Appendix 11.

The floating property deteriorated greatly during the year. The most important changes was among the barges, of which 12 barge-flats and 1 model barge had become worn out and were condemned and sunk. It is proposed to replace them by an equal number of well-built model barges. The employment of second-hand coal-flats is not an economical measure. The hull of the steam launch *Hornet* having become worn out, the machinery was removed and stored, and the hull destroyed.

As stated in former reports, a special record is kept in which the equipment is treated as so much unexpended appropriation. Each work is charged for the use and repair of such as may be employed upon it. The amounts given in this report as expended at each locality include the wear and tear of equipment.

The present valuation of the property remaining to be distributed in

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the future is given in the last column of the following table, in which are given, in separate columns, its valuation at the beginning of the year, the sums which have been expended upon it, and its estimated deterioration during the year.

Class of property.	Balance July 1, 1883.	Debits.	Credits.	Balance June 30, 1884.
Steamer A. A. Humphreys.....	\$20,701 50	\$371 89		\$21,163 45
Steamer General Gillmore.....	21,800 25	784 11	\$2,784 11	19,800 25
Launch Hornet.....	106 50	157 00	39 20	224 90
Launch Florence.....	900 00	226 68	326 68	800 00
Barges.....	62,107 37	7,757 53	24,391 83	45,473 07
Pile-drivers.....	40,817 15	1,200 52	9,400 52	41,617 15
Quarter-boats, quarters, shops, &c.....	44,705 07	4,805 55	13,357 19	30,154 03
Skiffs, flats, &c.....	12,030 58	1,428 17	5,106 01	8,858 74
Tools and appliances.....	15,448 10	2,279 31	9,783 59	7,943 01
Hydraulic excavator.....	7,204 87	180 70		7,385 63
Ways for mattresses.....	5,331 60	133 16	1,133 16	4,331 09
Office furniture.....	1,177 21	2 50	226 17	953 54
Surveying instruments.....	1,431 66	45 75	317 76	1,159 05
Boarding outfit.....	15,065 07	487 22	2,142 86	13,409 43
Total.....	257,983 83	19,800 75	69,009 08	208,835 50

SUBSISTENCE.

Further experience in furnishing subsistence has resulted in reducing the cost to 42 cents per man per day, while improving the ration. The report of the subsistence clerk (Appendix 12) gives some interesting figures upon this subject.

PILE DRIVING.

The operations of the numerous pile-drivers employed upon the works have been watched during the year, and a record kept of the amount of work accomplished by each and its cost. The records have been worked up and discussed by Lieutenant Abbot, in continuation of the study of this subject begun by him last year. His report is given as Appendix 13. The object of these studies is to detect any defects which may exist in the machines, or in the organization of the men, with a view to their removal.

GAUGES.

The gauges at Grafton and Gray's Point were read daily throughout the year. Their records are appended, marked 14 and 15 respectively.

NAVIGABLE DEPTH BETWEEN SAINT LOUIS AND CAIRO.

The association of Saint Louis and New Orleans pilots have transferred to me, as in former years, the reports made to it by its members, and from them has been made a record of the depths found upon the bars between Saint Louis and Cairo throughout the year. So much of it as covers the low-water season is herewith transmitted, constituting Appendix 16. As explained in former reports, strict accuracy is not claimed for any one measurement. The record, to be of value, should be taken as a whole, several days' measurements and the gauge record being considered together. The low-water season extended from about the middle of August to the close of navigation by ice in December. The lowest stage reached was 3 feet above standard low water. The least depth reported and not contradicted was $4\frac{1}{2}$ feet, and was found at

Devil's Island. A depth of but 5 feet was found at Sulphur Springs and Jacket Pattern. A depth of but $5\frac{1}{2}$ feet was found at Salem, Liberty Island, and Crawford's. The least depth found in the $21\frac{1}{2}$ miles of river between Saint Louis and Kimmswick, over which the works of improvement have extended, was 7 feet, and was found at the lower Horsetail reef at Beard's Island.

ESTIMATE.

The amount which can be profitably expended during the year ending June 30, 1886, is \$1,000,000. It is proposed to expend it in carrying out the programme heretofore adopted. This is to first improve the part of the river below Saint Louis, to make the improvement continuous, beginning at Saint Louis and working down-stream, reclaiming land and building up new banks, thus reducing the river to the approximately uniform width of about 2,500 feet. Alluvial banks are to be protected from erosion. It is proposed by this means to secure a channel depth of at least 8 feet at the lowest stage. The depth is now liable to become as little as 4 feet or even less in some places, and less than 8 feet in every place where the width is greater than 2,500 feet. This general statement of the proposed application of the appropriation is as specific as the nature of the case will admit of. The changeable character of the river renders it impracticable to give in advance the exact localities where works will be required:

The original estimated cost of the work as revised in 1883, was..... \$16,997,100 00
 The aggregate amount appropriated to July 5, 1884, is..... 3,364,600 00
 The amount actually expended is..... 3,354,630 85

The work is located in the collection district of New Orleans.

Amount of revenue collected at the port of Saint Louis for the fiscal year ending June 30, 1884, was \$1,549,400.58.

Money statement.

July 1, 1883, amount available	\$195,245 58
July 1, 1884, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1883	\$125,276 43
July, 1, 1884, outstanding liabilities	4,614 64
	<hr/> 189,891 07
July 1, 1884, amount available	5,354 51
Amount appropriated by act approved July 5, 1884.....	520,000 00
	<hr/> 525,354 51
Amount available for fiscal year ending June 30, 1885	525,354 51
Amount (estimated) required for completion of existing project.....	13,632,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1886	1,000,000 00

Construction account.

Name of work.	Expended prior to July 1, 1883.	Expended during fiscal year ending June 30, 1884.	Total cost to June 30, 1884.
Piasa Island Dam.....	\$32,333 30		\$32,333 30
Piasa Island Dam, removing.....	2,750 11		2,750 11
Alton Dam.....	33,623 92		33,623 92
Alton Dike.....	67,324 70		67,324 70
Sawyer Bend protection	96,803 63		96,803 63
Venice Dikes	36,341 85		36,341 85
Arsenal Island protection	30,732 65		30,732 65
Closing Cahokia Chute.....	110,088 00		110,088 00
Channel opposite Saint Louis	40,873 88	\$17,581 66	58,455 54

1418 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Construction account—Continued.

Name of work.	Expended prior to July 1, 1883.	Expended during fiscal year ending June 30, 1884.	Total cost to June 30, 1884.
Horsetail Bar:			
Dike 1	\$10,540 53		\$40,540 53
Dike 2	23,600 26		23,600 26
Dike 3	82,692 54		82,692 54
Dike 4	41,290 11		41,290 11
Dike 5	30,933 87		30,933 87
Training-wall	80,627 03		80,627 03
Primary hurdles			
Secondary hurdles	355,863 20	\$73,118 58	428,981 84
Protection works		30,099 31	30,099 31
Twin Hollows, west bank:			
Primary hurdles	100,637 10	29,743 71	220,380 87
Secondary hurdles			
Twin Hollows, east bank, bank protection.....	95,928 04	4,719 84	100,648 78
Beard's Island:			
Primary hurdles	7,166 24		7,166 24
Bank protection	84,258 76		84,258 76
Jim Smith's:			
Primary hurdle			
Secondary hurdle	114,480 74	24,901 09	139,388 43
Pulltight:			
Primary hurdle			
Secondary hurdle	46,465 47	39,639 94	86,105 41
Chealey Island:			
Bank protection			
Hurdle	47,401 30	10,100 47	63,501 86
Foster's Island bank protection.....	5,779 18	38,516 84	44,296 02
Fort Chartres Dam.....	36,812 80		36,812 80
Turkey Island	24,463 85		24,463 85
Kaskaskia protection	66,465 62		66,465 62
Liberty Island:			
Dam	5,053 91		5,053 91
Protection	45,129 40		45,129 40
Devil's Island:			
Dike 1	65,871 17		65,871 17
Devil's Island:			
Dam 1	40,848 58		40,848 58
Dam 2	16,678 30		16,678 30
Minton Point:			
Primary hurdle	33,436 37		33,436 37
Secondary hurdle			
Cape Girardeau, primary hurdle	31,030 18		31,030 18
Calro protection.....	119,868 66		119,868 66
	2,212,112 02	275,022 04	2,487,134 06

Property and material account.

Class of property.	Balance, June 30, 1883.	Debits.	Credits.	Balance, June 30, 1884.
Steamer Humphreys and expenses.....	\$20,791 56	\$371 89		\$21,163 45
Steamer Gillmore and expenses	21,860 25	21,104 70	\$23,104 70	19,860 25
Launch Hornet and expenses	106 50	800 32	*690 02	224 06
Launch Florence and expenses	800 00	801 26	991 26	800 00
Barges				
Barge-flats	62,107 37	11,510 47	28,144 77	45,473 07
Pile-drivers	49,817 15	2,290 09	10,490 09	41,617 15
Quarters, shops, &c.....	38,429 09	4,589 65	11,891 29	31,128 05
Quarter-boats	6,275 98	508 88	1,758 88	5,025 98
Skiffs, &c.....	12,036 58	1,919 37	5,597 21	8,358 74
Tools and appliances	15,448 19	3,254 71	10,758 99	7,943 91
Hydraulic excavator.....	7,204 87	180 76		7,385 63
Ways for mattresses.....	5,331 09	268 01	1,268 01	4,331 09
Photographic apparatus	339 51			339 51
Office furniture	1,177 21	39 04	262 71	953 64
Surveying instruments	1,431 06	48 75	320 76	1,159 65
Boarding outfit	15,065 07	1,213 51	2,869 15	13,409 43
Subsistence, &c.....	4,120 45	28,468 93	30,545 85	2,043 53
Material:				
Stone, Little Rock	1,581 99			1,581 99
Stone, Saint Louis	1,544 17	28,650 30	28,094 47	
Brush, Saint Louis	3,030 23	38,221 21	41,251 44	
Piles, Saint Louis	9,425 71	20,673 59	30,089 30	
Miscellaneous	13,590 72	5,454 74	10,954 29	8,091 17
Miscellaneous		1,212 26	877 29	834 97
	291,616 61	175,581 44	245,971 38	221,226 67

1.

Tabular statement showing expenditures of labor and material and amount of work accomplished during the fiscal year.

HURDLE No. 1.

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Cahokia Chute:				
Preparing piles	Labor		\$147 25	
Driving piles	Labor	\$510 35		
	Gillmore, 4 hours	27 04		
	Pile-drivers, 379 hours	314 34		
	Pile-timber, 395 (14,277 feet)	1,229 84		
	Coal, 511 bushels	34 55		
	Miscellaneous	7 50		
			2,153 62	
Bracing (595 linear feet) ...	Labor	210 05		
	Gillmore, 4 hours	27 04		
	Pile-drivers, 78 hours	65 52		
	Pile-timber, 82 (2,964 feet)	256 25		
	Bolts, &c., 232	126 45		
	Coal, 136 bushels	9 01		
	Miscellaneous	2 00		
			706 22	
Stringers (850 linear feet) ..	Labor	114 00		
	Gillmore, 1 hour	6 68		
	Pile-drivers, 58 hours	49 59		
	Piles, 31 (1,279 feet)	110 56		
	Bolts, 242	36 39		
	Coal, 143 bushels	9 38		
	Miscellaneous	1 50		
			328 97	
Foundation mattress, 825 linear feet by 55½ feet by 1 foot thick (46,000 square feet.)	Labor	726 16		
	Gillmore, 8 hours	53 76		
	Stone, 344 cubic yards	367 71		
	Sisal rope, 704 pounds	73 31		
	Wire rope, 728 pounds	33 13		
	Barge flats, 190 hours	79 07		
	Nails, 310 pounds	7 97		
	Spikes, 1,000 pounds	39 46		
	Miscellaneous	6 00		
	Brush, 286 cords	843 26		
	Hornet, 9 hours	8 41		
			2,238 24	
Wattling, 650 linear feet by 11½ feet (7,250 square feet).	Labor	202 72		
	Gillmore, 2 hours	13 68		
	Hornet, 10 hours	9 35		
	Brush, 41 cords	108 90		
	Wire, 80 pounds	3 65		
	Nails, 40 pounds	1 04		
			339 34	
Subsistence	Labor	102 06		
	Rations, 1,238	452 48		
			614 54	
Equipment	Barge flats, 552 hours	73 37		
	Quarters, 1,800 hours	56 34		
	Quarter-boats, 1,200 hours	55 50		
	Skills, &c., 2,335 hours	184 27		
	Tools, &c., 11,917 hours	216 41		
			585 89	
				\$7,114 07

1420 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Tabular statement showing expenditures of labor and material, &c.—Continued.

HURDLE No. 2.

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Cahokia Chute:				
Pulling drift	Labor		\$101 75	
Preparing piles	Labor		231 50	
Driving piles	Labor	\$500 48		
	Gillmore, 6 hours	40 72		
	Pile-drivers, 307 hours	201 44		
	Pile-timber, 226 by 9, 131 feet	777 95		
	Iron, 90 pounds	2 37		
	Coal, 641 bushels	42 16		
	Miscellaneous	9 50		
			1, 004 62	
Bracing (690 linear feet) ..	Labor	372 71		
	Gillmore, 6 hours	40 50		
	Pile drivers, 155 hours	130 23		
	Pile-timber, 129 (4,458 feet)	376 23		
	Bolts, &c., 256	115 70		
	Coal, 324 bushels	21 06		
	Miscellaneous	3 50		
			1, 000 65	
Wattling 600 linear feet by 14 feet (8,400 square feet).	Labor	100 19		
	Gillmore, 2 hours	13 68		
	Hornet, 5 hours	4 67		
	Brush, 20 cords	77 02		
	Wire, 140 pounds	6 39		
	Nails, 10 pounds	26		
			202 21	
Foundation mattress 580 linear feet by 79½ feet by 1 foot thick (46,000 square feet).	Labor	1, 008 33		
	Gillmore, 10 hours	66 80		
	Barge-flats, 581 hours	241 81		
	Brush, 240 cords	778 89		
	Stone, 426.5 yards	517 55		
	Rope, sisal, 442 pounds	47 06		
	Wire, 112 pounds	5 07		
	Nails, 730 pounds	18 70		
	Spikes, 340 pounds	12 58		
	Miscellaneous	9 46		
			2, 796 31	
Stringers (490 linear feet) ..	Labor	255 45		
	Gillmore, 1 hour	6 68		
	Pile-drivers, 143 hours	122 27		
	Pile-timber, 39 (1,492 feet)	121 69		
	Bolts, &c., 100	15 00		
	Coal, 74 bushels	4 85		
	Miscellaneous	1 75		
			527 69	
Incidental work	Pile-drivers, 35 hours	29 02		
	Labor	163 99		
	Gillmore, 2 hours	13 36		
			207 27	
Removing obstructions	Pile-drivers, 46 hours		30 83	
Subsistence	Labor	64 00		
	Rations, 493	180 19		
			244 19	
Equipment	Quarters, 648 hours	20 28		
	Quarter-boats, 570 hours	20 64		
	Skiffs, &c., 4, 158 hours	272 15		
	Tools, &c., 13,215 hours	213 48		
	Barge flats, 264 hours	35 06		
			567 64	
Engineering, &c.	Assistants, &c., office work	738 00		
	Assistants, &c., surveys	115 38		
	Survey instruments, surveys	32 41		
	Surveys, &c.	23 69		
	Assistants, &c., inspections	282 63		
	Skiffs, &c., 360 hours	22 32		
	Tools, &c., 391 hours	6 14		
	Subsistence, 108 rations	36 47		
			1, 260 24	
General expense	Assistants	713 02		
	Manila rope, 2,000 pounds	305 00		
	Telephone	351 26		
	Office furniture	10 02		
	Hornet	4 67		
			1, 380 97	
Contingencies	Labor		144 22	2, 794 43
Total				17, 581 66

APPENDIX U—REPORT OF MAJOR ERNST.

1421

Tabular statement showing expenditures of labor and material, &c.—Continued.

CARROLL'S ISLAND HURDLE (2,016 linear feet).

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Horseshall Bar, east side:				
Pulling drift.....	Labor.....		\$107 25	
Removing obstructions ...	Pile-drivers, 113 hours.....	\$92 40		
	Coal, 100 bushels.....	12 46		
			104 95	
Pulling piles.....	Labor.....		57 58	
Preparing piles.....	Labor.....		515 51	
Driving piles.....	Labor.....	841 64		
	Gillmore, 16 hours.....	107 52		
	Florence, 55 hours.....	44 31		
	Pile-drivers, 740 hours.....	620 03		
	Piles, 660 (20,223 feet).....	2, 249 01		
	Sisal rope, 223 pounds.....	34 26		
	Iron, 197 pounds.....	5 18		
	Manila rope, 1,117 pounds.....	155 23		
	Spikes, 60 pounds.....	2 22		
	Coal, 891 bushels.....	59 05		
	Miscellaneous.....	3 91		
			4, 132 40	
Bracing (2,738 linear feet).	Labor.....	034 39		
	Gillmore, 10 hours.....	07 12		
	Florence, 25 hours.....	20 11		
	Pile-drivers, 420 hours.....	351 85		
	Piles, 458 (17,120 feet).....	1, 518 32		
	Manila rope, 74 pounds.....	11 29		
	Sisal rope, 244 pounds.....	24 04		
	Bolts, &c., 944.....	411 38		
	Wire, 160 pounds.....	7 20		
	Spikes, 68 pounds.....	2 52		
	Coal, 521 bushels.....	34 89		
	Miscellaneous.....	1 21		
			3, 084 92	
Stringers (5,018 linear feet).	Labor.....	1, 036 23		
	Gillmore, 10 hours.....	07 44		
	Pile-drivers, 410 hours.....	345 51		
	Piles, 382 (14,772 feet).....	1, 332 59		
	Manila rope 50 pounds.....	7 03		
	Sisal rope, 374 pounds.....	37 77		
	Bolts, &c., 1,569.....	346 50		
	Coal, 479 bushels.....	31 90		
	Florence, 20 hours.....	16 09		
	Miscellaneous.....	2 08		
			3, 223 80	
Wattling, 970 linear feet by 16 feet 10 inches (16,420 square feet).	Labor.....	362 41		
	Gillmore, 4 hours.....	27 36		
	Brush, 98 cords.....	260 29		
	Sisal hide rope, 261 pounds.....	17 62		
	Nails, 100 pounds.....	2 59		
			670 27	
Foundation mattress, 1,900 linear feet by 81½ by 1 foot thick (155,050 square feet).	Labor.....	916 42		
	Gillmore, 8 hours.....	53 76		
	Brush, 552.9 cords.....	1, 728 22		
	Stone, 887 yards.....	1, 032 42		
	Sisal rope, 300 pounds.....	30 30		
	Wire, 870 pounds.....	30 43		
	Spikes, 575 pounds.....	20 93		
	Florence, 52 hours.....	41 84		
	Sisal hide rope, 125 pounds.....	8 42		
	Nails, 129 pounds.....	3 31		
	Miscellaneous.....	1 62		
			3, 876 67	
Miscellaneous.....	Pile-drivers, 27 hours.....		23 09	
Subsistence.....	Labor.....	734 75		
	Rations, 4,904.....	2, 071 85		
	Coal, 118 bushels.....	7 74		
	Miscellaneous.....	40 30		
			2, 854 04	
Equipments, &c.	Quarters, 15,993 hours.....	732 72		
	Quarter-boats, 1,038 hours.....	151 03		
	Barge-flats, 2,496 hours.....	331 76		
	Skiffs, &c., 8,835 hours.....	682 42		
	Tools, &c., 32,747 hours.....	578 90		
			2, 476 83	
				21, 127 97

1422 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Tabular statement showing expenditures of labor and material, &c.—Continued.

SECONDARY HURDLE No. 27 (1,700 linear feet).

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Horseshall Bar, east side:				
Pulling drift.....	Labor.....		\$6 75	
Removing obstructions.....	Pile-drivers.....		39 85	
Pulling piles.....	Labor.....		60 08	
Preparing piles.....	Labor.....		173 80	
Driving piles.....	Labor.....	\$457 31		
	Gillmore, 7 hours.....	47 88		
	Pile-drivers, 510 hours.....	414 80		
	Piles, 430 + 10, 130 feet.....	1,492 58		
	Manila rope, 304 pounds.....	46 30		
	Sisal rope, 45 pounds.....	4 55		
	Iron, 147 pounds.....	3 79		
	Coal, 500 bushels.....	35 00		
			2,502 27	
Bracing (1,728 linear feet)	Labor.....	207 15		
	Gillmore, 2 hours.....	13 68		
	Pile-drivers, 93 hours.....	75 04		
	Piles, 100 (3,544 feet).....	327 82		
	Manila rope, 49 pounds.....	7 47		
	Spikes, 105 pounds.....	3 96		
	Bolts, &c., 137.....	106 61		
	Coal, 109 bushels.....	7 63		
			740 90	
Stringers (1,273 linear feet)	Labor.....	138 72		
	Pile-drivers, 18 hours.....	14 04		
	Piles, 63 (2,306 feet).....	221 03		
	Manila rope, 12 pounds.....	1 83		
	Bolts, &c., 207.....	51 13		
	Coal, 27 bushels.....	1 89		
			429 84	
Foundation mattress, 795 linear feet by 33½ feet (26,500 square feet).	Labor.....	251 44		
	Gillmore, 3 hours.....	20 54		
	Brush, 193 cords.....	525 89		
	Stone, 309.8 yards.....	201 86		
	Sisal rope, 200 pounds.....	20 20		
	Wire, 400 pounds.....	18 28		
	Spikes, 400 pounds.....	15 12		
			1,143 33	
Wattling, 1,780 linear feet by 17 feet (30,110 square feet).	Labor.....	411 09		
	Gillmore, 5 hours.....	34 20		
	Brush, 148 cords.....	393 09		
	Sisal hide rope, 377 pounds.....	25 44		
	Nails, 140 pounds.....	3 03		
			867 45	
Curtains, 866 linear feet by 11½ feet (9,842 square feet).	Labor.....	191 35		
	Gillmore, 2 hours.....	13 08		
	Brush, 70 cords.....	185 92		
	Nails, 139 pounds.....	3 00		
			394 55	
Subsistence.....	Labor.....	272 30		
	Rations, 2,093.....	764 90		
			1,037 38	
Equipment, &c.....	Barge-flats, 2,304 hours.....	300 24		
	Quarters, 12,668 hours.....	403 42		
	Skills, &c., 1,025 hours.....	150 00		
	Tools, &c., 15,104 hours.....	305 10		
			1,170 76	
				8,576 08

Tabular statement showing expenditures of labor and material, &c.—Continued.

SECONDARY HURDLE No. 27½ (1,325 linear feet).

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grandtotal.
Horsetail Bar, east side:				
Pulling drift.....	Labor.....		\$141 15	
Removing obstructions.....	Pile-drivers, 121 hours.....	\$103 45		
	Coal, 235 bushels.....	15 42		
	Miscellaneous.....	2 29		
			121 16	
Preparing piles.....	Labor.....	510 70	202 50	
Driving piles.....	Gillmore, 7 hours.....	46 70		
	Florence, 50 hours.....	40 23		
	Pile-drivers, 397 hours.....	339 44		
	Manila-rope, 895 pounds.....	119 20		
	Piles, 510 (21,086 feet).....	1,863 14		
	Sisal rope, 457 pounds.....	48 90		
	Iron, 125 pounds.....	3 28		
	Spikes, 230 pounds.....	8 51		
	Coal, 625 bushels.....	41 00		
	Miscellaneous.....	14 50		
			3,026 84	
Bracing (1,320 linear feet).....	Labor.....	312 33		
	Gillmore, 6 hours.....	40 08		
	Florence, 20 hours.....	16 09		
	Pile-drivers, 187 hours.....	159 88		
	Piles, 107 (6,194 feet).....	509 38		
	Wire, 200 pounds.....	9 00		
	Spikes, 190 pounds.....	7 03		
	Bolts, &c., 415.....	210 30		
	Coal, 200 bushels.....	13 12		
	Miscellaneous.....	7 86		
			1,285 16	
Stringers (1,320 linear feet).....	Labor.....	289 32		
	Gillmore, 5 hours.....	33 40		
	Florence, 20 hours.....	16 09		
	Pile-drivers, 141 hours.....	120 55		
	Piles, 72 (3,268 feet).....	287 22		
	Sisal rope, 85 pounds.....	9 09		
	Bolts, &c., 454.....	68 10		
	Coal, 316 bushels.....	20 73		
	Miscellaneous.....	7 35		
			851 85	
Foundation mattress, 1,435 linear feet by 80 feet by 1 foot thick (114,225 square feet).....	Labor.....	941 39		
	Gillmore, 5 hours.....	33 40		
	Florence, 55 hours.....	44 28		
	Brush, 575½ cords.....	1,881 15		
	Stone, 580½ yards.....	715 04		
	Wire, 950 pounds.....	42 75		
	Nails, 450 pounds.....	11 50		
	Spikes, 225 pounds.....	8 33		
	Miscellaneous.....	22 68		
			3,700 56	
Miscellaneous.....	Pile-drivers, 25 hours.....		21 38	
Subsistence.....	Labor.....	362 33		
	Rations, 2,008.....	1,325 17		
	Coal, 120 bushels.....	7 87		
	Miscellaneous.....	35 09		
			1,730 40	
Equipment, &c.....	Quarters, 4,550 hours.....	705 28		
	Quarter-boats, 813 hours.....	74 96		
	Skiffs, &c., 6,915 hours.....	428 67		
	Tools, &c., 16,083 hours.....	252 51		
			1,461 42	
				\$12,542 57

1424 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Tabular statement showing expenditures of labor and material, &c.—Continued.

SECONDARY HURDLE, No. 29½ (1,450 linear feet).

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Horsetail Bar, east side:				
Pulling drift.....	Labor.....		\$189 25	
Pulling piles.....	Labor.....		11 10	
Removing obstructions.....	Pile-drivers, 143 hours.....	\$122 26		
	Coal, 10 bushels.....	60		
	Miscellaneous.....	2 45		
			125 37	
Preparing piles.....	Labor.....		226 57	
Driving piles.....	Labor.....	548 70		
	Gillmore, 6 hours.....	40 08		
	Florence, 50 hours.....	40 24		
	Pile-drivers, 535 hours.....	457 42		
	Manilla rope, 784 pounds.....	107 41		
	Piles, 510 (20,841 feet).....	1,727 17		
	Staal rope, 220 pounds.....	23 54		
	Iron, 125 pounds.....	3 28		
	Spikes, 225 pounds.....	8 32		
	Coal, 700 bushels.....	45 02		
	Miscellaneous.....	18 18		
			3,020 35	
Bracing (1,325 linear feet).....	Labor.....	294 83		
	Gillmore, 6 hours.....	40 08		
	Florence, 20 hours.....	10 09		
	Pile-drivers, 226 hours.....	103 23		
	Piles, 231 (8,577 feet).....	693 91		
	Spikes, 110 pounds.....	4 07		
	Bolts, &c., 467.....	257 02		
	Coal, 132 bushels.....	8 06		
	Miscellaneous.....	1 39		
			1,509 28	
Stringers (1,450 linear feet).....	Labor.....	224 93		
	Gillmore, 5 hours.....	33 40		
	Florence, 20 hours.....	16 09		
	Pile-drivers, 154 hours.....	131 07		
	Piles, 84 (3,514 feet).....	302 14		
	Staal rope, 92 pounds.....	9 84		
	Bolts, &c., 642.....	96 30		
	Coal, 314 bushels.....	20 80		
	Miscellaneous.....	3 53		
			838 50	
Foundation mattress, (1,478 linear feet by 80 feet by 1 foot thick) (118,240 square feet).....	Labor.....	1,013 36		
	Gillmore, 4 hours.....	20 72		
	Florence, 55 hours.....	44 25		
	Brush, 645.1 cords.....	2,109 12		
	Stone, 719.4 yards.....	877 66		
	Wire, 988 pounds.....	44 46		
	Nails, 275 pounds.....	7 07		
	Spikes, 305 pounds.....	11 28		
	Miscellaneous.....	20 35		
			4,154 27	
Miscellaneous.....	Pile-drivers, 51 hours.....		43 60	
Subsistence.....	Labor.....	391 09		
	Rations, 3,014.....	1,373 48		
	Coal, 125 bushels.....	8 20		
	Miscellaneous.....	33 45		
			1,806 22	
Equipment, &c.....	Quarters, 4,966 hours.....	768 24		
	Quarter-boats, 720 hours.....	66 39		
	Skiffs, &c., 7,320 hours.....	449 81		
	Tools, &c., 17,017 hours.....	267 17		
			1,551 61	
				\$13,476 12

SECONDARY HURDLE No. 30 (1,292 linear feet).

Horsetail Bar, east side:				
Removing obstructions.....	Labor.....	\$0 63		
	Pile-drivers, 10 hours.....	8 13		
			\$8 76	
Pulling piles.....	Labor.....		45	
Preparing piles.....	Labor.....		138 52	
Driving piles.....	Labor.....	282 37		
	Gillmore, 4 hours.....	27 36		

APPENDIX U—REPORT OF MAJOR ERNST.

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Tabular statement showing expenditures of labor and material, &c.—Continued.

SECONDARY HURDLE No. 30 (1,292 linear feet)—Continued.

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Horsetail Bar, east side—Cont'd	Pile-drivers, 838 hours.....	\$274 91	\$1,671 59	
	Piles, 323 (11,072 feet)	1,024 16		
	Manila rope, 183 pounds.....	27 91		
	Sisal rope, 74 pounds.....	7 47		
	Iron, 175 pounds.....	4 52		
	Coal, 327 bushels.....	22 89		
Bracing (1,392 linear feet)...	Labor	161 25	605 68	
	Gillmore, 2 hours	13 68		
	Pile-drivers, 27 hours.....	21 96		
	Piles, 100 (3,420 feet)	316 35		
	Manila rope, 25 pounds	3 81		
	Sisal rope, 60 pounds	6 06		
	Bolts, &c., 90	78 72	400 90	
	Coal, 55 bushels.....	3 85		
Stringers (1,465 linear feet).	Labor	145 07		
	Pile-drivers, 7 hours	5 69		
	Piles, 48 (1,788 feet)	165 39		
	Manila rope, 12 pounds	1 83		
	Sisal rope, 60 pounds.....	6 06	1,375 49	
	Spikes, 130 pounds.....	4 91		
	Bolts, &c., 280	96 16		
	Coal, 27 bushels.....	1 89		
Foundation mattresses, 1,100 linear feet by 31½ feet by 1 foot thick (34,900 square feet).	Labor	340 84		
	Gillmore, 2 hours	13 68	680 82	
	Brush, 239.1 cords.....	635 05		
	Stone, 335.5 yards.....	315 96		
	Sisal rope, 271 pounds.....	27 38		
	Wire, 600 pounds	27 42		
	Spikes, 401 pounds.....	15 16		
Wattling, 1,465 linear feet (23,215 square feet).	Labor	312 26	195 25	
	Gillmore, 4 hours	27 36		
	Brush, 122.7 cords.....	325 89		
	Sisal hide rope, 200 pounds.....	13 50		
	Nails, 70 pounds	1 81		
Curtains, 950 linear feet by 85 feet (8,170 square feet).	Labor	55 61	1,173 93	
	Gillmore, 1 hour	6 84		
	Brush, 50 cords	132 80		
Subsistence.....	Labor	298 50		
	Rations, 2,395.....	875 37		
Equipment, &c	Barge-flats, 1,324 hours.....	242 44	982 88	
	Quarters, 10,200 hours	319 28		
	Skiffs, &c., 961 hours.....	146 25		
	Tools, &c., 13,610 hours.....	274 92		
				\$7,234 28

ENGINEERING, CONTINGENCIES, ETC.

Horsetail Bar, east side—Cont'd	Labor	\$504 75	\$1,012 30	
Incidental work	Gillmore, 34 hours	227 12		
	Tools, &c., 3,471 hours	54 49		
	Subsistence, 324 rations.....	147 64		
	Subsistence service	35 34		
	Coal, 20 bushels.....	1 31		
	Miscellaneous	4 25		
	Quarters, 156 hours.....	24 13		
	Quarter-boats, 144 hours.....	13 27		
Engineering	Assistants, &c., surveys.....	589 90	5,696 55	
	Assistants, &c., inspection	452 73		
	Assistants, &c., office work	2,752 19		
	Coal, 20 bushels	1 31		
	Subsistence, 876 rations	348 58		
	Subsistence service	110 02		
	Miscellaneous	8 79		
	Skiffs, &c., 502 hours	31 12		
	Tools, &c., 434 hours.....	6 82	1,395 09	
	Quarters, 9,018 hours.....			

1426 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Tabular statement showing expenditures of labor and material, &c.—Continued.

ENGINEERING, CONTINGENCIES, ETC.—Continued.

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Horsetail Bar, east side—cont'd.				
General expense, &c.....	Assistants, &c.....	\$1,650 83		
	Telephone.....	783 58		
	Cinchona and whisky, 75 gallons.	139 85		
	Office furniture.....	29 19		
	Survey instruments.....	64 88		
	Surveys, &c., stationery.....	35 95		
			\$2,704 28	
Contingencies.....	Ice, &c.....	108 31		
	Labor.....	640 12		
			748 43	\$10,161 56

LOW-WATER PROTECTION.

Horsetail Bar, west side:				
Removing obstructions....	Pile-drivers, 19 hours.....		\$16 25	
Preparing piles.....	Labor.....		53 44	
Driving piles.....	Labor.....	\$268 87		
	Gillmore, 13 hours.....	86 64		
	Pile-drivers, 221 hours.....	188 95		
	Piles, 287 (12,498 feet).....	1,085 03		
	Iron, 59 pounds.....	1 55		
	Bolts, &c., 12.....	2 76		
	Coal, 450 bushels.....	29 52		
	Miscellaneous.....	14 10		
			1,677 62	
Foundation mattress, 3,880 linear feet by 100 feet (388,000 square feet).	Labor.....	3,332 91		
	Gillmore, 8 hours.....	53 44		
	Barges, 949 hours.....	207 36		
	Barge-flats, 1,104 hours.....	459 48		
	Ways, 1,122 hours.....	580 18		
	Manila rope, 601 pounds.....	82 34		
	Brush, 2,608.8 cords.....	8,528 39		
	Stone, 1,107.4 yards.....	1,351 02		
	Sisal rope, 564 pounds.....	60 34		
	Wire, 8,053 pounds.....	362 39		
	Nails, 680 pounds.....	17 48		
	Spikes, 2,702 pounds.....	101 28		
	Miscellaneous.....	45 30		
			15,181 91	
Subsistence.....	Labor.....	513 48		
	Rations, 4,076.....	1,857 90		
	Coal, 402 bushels.....	13 25		
	Miscellaneous.....	70 50		
			2,455 13	
Equipment, &c.....	Quarters, 13,056 hours.....	2,019 76		
	Skiffs, &c., 8,490 hours.....	523 65		
	Tools, &c., 29,253 hours.....	459 27		
			3,002 68	
				\$22,392 03

Tabular statement showing expenditures of labor and material, &c.—Continued.

MEDIUM STAGE PROTECTION.

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Horsetail Bar, west side: Revetment, 3,080 linear feet by 21½ feet (68,914 square feet).....	Labor..... Gillmore, 4 hours..... Stone, 2,219.7 yards.....	\$333 44 26 72 2,708 03	\$3,068 19	
Subsistence.....	Labor..... Rations, 412..... Coal, 25 bushels..... Miscellaneous.....	73 23 187 75 1 64 4 25		
Equipment, &c.....	Quarters, 2,496 hours..... Skiffs, &c., 1,460 hours..... Tools, &c., 2,340 hours.....	386 13 90 52 36 74	266 87	
			513 89	
				\$3,848 45

ENGINEERING, CONTINGENCIES, ETC.

Horsetail Bar, west side: Incidental work.....	Labor..... Gillmore, 19 hours..... Barge-flats, 185 hours..... Tools, &c., 897 hours..... Subsistence, 250 rations..... Miscellaneous.....	\$129 87 135 98 77 21 14 08 113 92 1 80	\$472 86	
Engineering, &c.....	Assistants, &c., surveys..... Assistants, &c., inspection..... Assistants, &c., office work..... Coal, 25 bushels..... Subsistence, 172 rations..... Subsistence, service..... Miscellaneous..... Quarters, 3,88½ hours.....	91 14 131 73 781 03 1 64 78 38 80 67 7 45 602 46		
General expense.....	Assistants, &c..... Cinchona and whisky, 5 gallons.. Telephone..... Office furniture..... Surveys, &c.....	1,315 35 9 32 689 28 37 02 131 42	1,724 50	
Contingencies.....	Ice, &c.....		2,182 39	
			79 08	
				\$4,458 83
				103,817 89

1428 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Tabular statement showing expenditures of labor and material, &c.—Continued.

PRIMARY HURDLE (767 linear feet).

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Twin Hollows, west bank:				
Preparing piles	Labor		\$109 22	
Driving piles	Labor	\$285 16		
	Pile-drivers, 253 hours	205 77		
	Gillmore, 3 hours	20 62		
	Piles, 280 (11, 144 feet)	1,030 82		
	Sisal rope, 45 pounds	4 50		
	Manila rope, 50 pounds	7 03		
	Coal, 275 bushels	19 25		
			1,573 74	
Bracing (767 linear feet) ..	Labor	217 09		
	Gillmore, 2 hours	13 08		
	Pile-drivers, 245 hours	109 27		
	Piles, 113 (4,230 feet)	388 78		
	Sisal hide rope, 20 pounds	1 35		
	Manila rope, 50 pounds	7 03		
	Spikes, 170 pounds	0 42		
	Bolts, &c., 358	147 50		
	Coal, 265 bushels	18 55		
			1,001 26	
Stringers (767 linear feet) ..	Labor	222 41		
	Gillmore, 2 hours	13 08		
	Pile-drivers, 218 hours	201 71		
	Piles, 91 (3,398 feet)	314 32		
	Sisal hide rope, 20 pounds	1 35		
	Bolts, &c., 713	100 75		
	Coal, 290 bushels	20 30		
			874 52	
Cross-stringers	Labor		108 53	
Foundation-matress (210 by 45 by 3½ feet thick).	Labor	363 91		
	Gillmore, 4 hours	27 36		
	Brush, 361.9 cords	961 21		
	Stone, 488.5 yards	460 20		
	Sisal hide rope, 30 pound	2 02		
	Manila rope, 200 pounds	30 50		
	Nails, 10 pounds	26		
	Wire, 390 pounds	17 37		
	Spikes, 145 pounds	5 48		
			1 868 31	
Wattling, 767 by 25 feet 19,209 square feet).	Labor	490 50		
	Gillmore, 4 hours	27 36		
	Brush, 91.7 cords	243 50		
	Wire, 442 pounds	20 19		
	Nails, 30 pounds	78		
	Spikes, 60 pounds	2 26		
			784 74	
Subsistence	Labor	255 97		
	Rations, 2,205	805 02		
			1,061 89	
Equipment, &c	Barge-flats, 2,160 hours	287 10		
	Quarters, 9,600 hours	300 50		
	Skiffs, &c., 1,105 hours	168 19		
	Tools, &c., 12,361 hours	249 69		
			1,005 48	
				\$8,387 69

APPENDIX U—REPORT OF MAJOR ERNST.

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Tabular statement showing expenditures of labor and material, &c.—Continued.

SECONDARY HURDLE No. 0 (625 linear feet).

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Twin Hollows, west bank:				
Preparing piles	Labor		\$32 37	
Driving piles	Labor	\$98 93		
	Gillmore, 1 hour	6 84		
	Pile-drivers, 88 hours	71 57		
	Piles, 155 (5,359 feet)	495 71		
	Sisal rope, 15 pounds	1 51		
	Sisal hide rope, 30 pounds	2 02		
	Spikes, 4 pounds	15		
	Coal, 95 bushels	6 65		
			683 38	
Foundation-matress (400 by 45 feet; woven, 160 by 45 by 1½ feet thick).	Labor, fabrication	299 57		
	Labor, sinking	77 85		
	Gillmore, 3 hours	20 52		
	Brush, 162 cords	430 27		
	Stone, 320.0 yards	310 80		
	Wire, 478 pounds	21 84		
	Nails, 134 pounds	3 47		
	Spikes, 124 pounds	4 08		
			1,160 00	
Bracing (500 linear feet)	Labor	106 33		
	Gillmore, 1 hour	6 84		
	Pile-drivers, 92 hours	74 83		
	Piles, 44 (1,471 feet)	136 07		
	Bolts, &c., 129	64 55		
	Coal, 85 bushels	5 95		
			304 57	
Stringers (500 linear feet) ..	Labor	70 03		
	Pile-drivers, 58 hours	47 17		
	Piles, 21 (830 feet)	76 78		
	Bolts, &c., 231	33 35		
	Coal, 35 bushels	2 45		
			229 78	
Wattling, 625 by 16½ feet 1 (10,250 square feet).	Labor	162 92		
	Gillmore, 1 hour	6 84		
	Brush, 50 cords	132 80		
	Wire, 150 pounds	6 85		
	Nails, 10 pounds	26		
			309 67	
Crib (125 linear feet)	Labor	52 78		
	Pile-drivers, 40 hours	32 53		
	Piles, 26 (801 feet)	82 42		
	Stone, 131.6 yards	123 98		
	Bolts, &c., 116	38 67		
	Coal, 70 bushels	4 90		
			335 28	
Equipment, &c.	Barge-flats, 1,056 hours	140 36		
	Quarters, 4,728 hours	148 00		
	Skiffs, &c., 580 hours	89 65		
	Tools, &c., 6,718 hours	135 70		
			513 71	
Subsistence	Labor	135 52		
	Rations, 1,186	433 48		
			569 00	
				\$4,236 76

1430 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Tabular statement showing expenditures of labor and material, &c.—Continued.

SECONDARY HURDLE No. 1 (250 linear feet).

Locality and subdivision of work.	Materials. &c.	Amount.	Total.	Grand total.
Twin Hollows, west bank:				
Preparing piles	Labor		\$9 29	
Driving piles	Labor	\$70 53		
	Gillmore, 1 hour	6 84		
	Pile-drivers, 50 hours	40 67		
	Piles, 57 (1,759 feet)	162 71		
	Sisal rope, 10 pounds	1 01		
	Coal, 60 bushels	4 20		
			285 96	
Bracing (250 linear feet) ...	Labor	39 25		
	Pile-drivers, 43 hours	34 97		
	Piles, 20 (687 feet)	63 55		
	Bolts, &c., 58	21 34		
	Coal, 45 bushels	3 15		
			162 20	
Stringers (250 linear feet) ..	Labor	25 91		
	Pile-drivers, 27 hours	21 96		
	Piles, 350 feet	32 38		
	Bolts, &c., 98	13 83		
	Coal, 20 bushels	1 40		
			95 48	
Foundation mattress, 238 by 30 by 3 feet thick.	Labor, fabrication	129 73		
	Labor, sinking	34 77		
	Brush, 125 cords	332 00		
	Stone, 170.5 yards	100 62		
	Wire, 260 pounds	11 88		
	Manila rope, 155 pounds	23 04		
	Nails, 60 pounds	1 55		
			694 19	
Wattling, 254 by 15½ feet (4,937 square feet).	Labor	76 11		
	Gillmore, 1 hour	6 84		
	Brush, 18.8 cords	49 93		
	Wire, 70 pounds	3 19		
	Nails, 14 pounds	30		
	Spikes, 50 pounds	1 89		
			138 32	
Equipment, &c	Barge-flats, 432 hours	57 42		
	Quarters, 1,920 hours	60 10		
	Skills, &c, 264 hours	40 18		
	Tools, &c., 2,767 hours	55 89		
			213 59	
Subsistence	Labor	64 87		
	Rations, 500	182 75		
			247 62	
				\$1,846 71

Tabular statement showing expenditures of labor and material, &c.—Continued.

SECONDARY HURDLE No. 3.

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Twin Hollows, west bank:				
Preparing piles.....	Labor.....		\$17 10	
Driving piles.....	Labor.....	\$97 24		
	Gillmore, 1 hour.....	6 84		
	Pile-drivers, 65 hours.....	52 87		
	Piles, 39 (1,336 feet).....	123 58		
	Manila rope 50 pounds.....	7 83		
	Coal, 70 bushels.....	4 90		
			293 06	
Bracing (128 linear feet)...	Labor.....	34 54		
	Pile-drivers, 19 hours.....	15 45		
	Piles, 14 (470 feet).....	43 48		
	Spikes, 65 pounds.....	2 00		
	Manila rope, 50 pounds.....	7 63		
	Bolts, &c., 47.....	20 10		
	Coal, 20 bushels.....	1 40		
			180 60	
Stringers (625 linear feet)...	Labor.....	42 50		
	Gillmore, 1 hour.....	6 84		
	Piles, 25 (783 feet).....	70 58		
	Bolts, &c., 182.....	25 69		
	Coal, 50 bushels.....	3 50		
			149 11	
Cross-stringers.....	Labor.....		41 93	
Crib.....	Manila rope, 500 pounds.....		76 25	
Foundation mattress, 128 by 35 by 1 foot thick.	Labor, fabrication.....	41 39		
	Labor, sinking.....	40 75		
	Brush, 35 cords.....	92 90		
	Stone, 35 yards.....	32 87		
	Wire, 250 pounds.....	11 42		
	Nails, 20 pounds.....	52		
	Spikes, 36 pounds.....	1 13		
			221 04	
Wattling, 648 by 12.1 feet (7,738 square feet).	Labor.....	160 73		
	Gillmore, 1 hour.....	6 84		
	Brush, 30 cords.....	79 68		
	Wire, 125 pounds.....	5 71		
	Spikes, 40 pounds.....	1 51		
			254 47	
Subsistence.....	Labor.....	82 86		
	Rations, 652.....	238 30		
			\$21 16	
Equipment, &c.....	Barge-flats, 576 hours.....	76 58		
	Quarters, 2,700 hours.....	86 39		
	Skiffs, &c., 407 hours.....	61 95		
	Tools, &c., 3,730 hours.....	75 35		
			200 25	
				\$1,804 97

SECONDARY HURDLE No. 4.

Twin Hollows, west bank:				
Preparing piles.....	Labor.....		\$31 65	
Driving piles.....	Labor.....	\$162 90		
	Gillmore, 2 hours.....	13 68		
	Pile-drivers, 99 hours.....	80 52		
	Piles, 78 (3,158 feet).....	292 12		
	Manila rope, 100 pounds.....	15 25		
	Spikes, 18 pounds.....	64		
	Coal, 140 bushels.....	9 80		
			575 00	
Bracing (275 linear feet)...	Labor.....	54 14		
	Pile-driver, 32 hours.....	26 03		
	Piles, 23 (999 feet).....	92 41		
	Spikes, 64 pounds.....	2 48		
	Manila rope, 100 pounds.....	15 25		
	Bolts, &c., 88.....	29 02		
	Coal, 40 bushels.....	2 80		
			222 13	
Stringers (1,605 linear feet).	Labor.....	83 40		
	Gillmore, 1 hour.....	6 84		
	Pile-drivers, 41 hours.....	33 35		
	Piles 47 (1,683 feet).....	155 68		
	Bolts, &c., 409.....	58 04		
	Coal, 100 bushels.....	7 00		
			344 31	

1432 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Tabular statement showing expenditures of labor and material, &c.—Continued.

SECONDARY HURDLE No. 4—Continued.

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Twin Hollows, west bank—Continued.				
Cross-stringers	Labor.....		\$82 97	
Foundation mattress, 299 by 33.6 by 1 foot thick (19,065 square feet).	Labor, fabrication	\$110 33		
	Labor, sinking.....	78 79		
	Gillmore, 1 hour.....	6 84		
	Brush, 70 cords.....	185 92		
	Stone, 210.3 yards.....	198 13		
	Sisal rope, 131 pounds.....	13 23		
	Wire, 512 pounds.....	23 38		
	Nails 30 pounds.....	77		
	Spikes, 241 pounds.....	9 10		
			624 48	
Wattling, 712 by 11.8 feet (8,427 square feet).	Labor.....	245 46		
	Gillmore, 2 hours.....	13 68		
	Brush, 43.4 cords.....	115 27		
	Wire, 368 pounds.....	16 81		
	Nails, 60 pounds.....	1 55		
	Spikes, 394 pounds.....	14 90		
			407 67	
Crib (100 linear feet).....	Labor.....	448 44		
	Barges, 710 hours.....	239 98		
	Gillmore, 4 hours.....	27 36		
	Pile-drivers, 249 hours.....	202 52		
	Manila rope, 5,255 pounds.....	801 39		
	Stone, 470.8 yards.....	443 54		
	Coal, 150 bushels.....	10 50		
			2,173 73	
Subsistence.....	Labor.....	262 07		
	Rations, 1,559.....	569 81		
			831 88	
Equipment, &c.....	Barge-flats, 1,068 hours.....	261 58		
	Quarters, 11,616 hours.....	363 61		
	Skills, &c., 1,312 hours.....	199 67		
	Tools, &c., 8,531 hours.....	172 32		
			997 18	\$6,291 00

SECONDARY HURDLE No. 5.

Twin Hollows, west bank:				
Wattling, 90 by 15 feet (1,350 square feet)	Labor.....	\$10 35		
	Brush, 20 cords.....	53 12		
			\$63 47	
Crib (90 linear feet).....	Labor.....	162 83		
	Gillmore, 2 hours.....	13 68		
	Piles, 23 (779 feet).....	72 06		
	Stone, 85 yards.....	79 98		
	Wire, 35 pounds.....	1 59		
	Nails, 6 pounds.....	15		
	Spikes, 196 pounds.....	7 50		
	Manila rope, 2,000 pounds.....	305 00		
	Bolts, &c., 221.....	60 44		
			703 29	
Subsistence.....	Labor.....	41 13		
	Rations, 261.....	95 39		
			136 52	
Equipment, &c.....	Barge-flats, 384 hours.....	51 04		
	Quarters, 1,800 hours.....	58 34		
	Skills, &c., 217 hours.....	33 03		
	Tools, &c., 1,434 hours.....	28 96		
			169 37	\$1,072 65

Tabular statement showing expenditures of labor and material, &c.—Continued.

ENGINEERING, CONTINGENCIES, ETC.

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Twin Hollows, west bank: Engineering	Assistants, &c., inspection..... Assistants, &c., office work..... Assistants, &c., surveys..... Subsistence, labor..... Subsistence, 594 rations..... Quarters, 11,016 hours..... Coal, 85 bushels.....	\$236 56 2,042 27 144 67 57 57 217 10 344 82 5 95	\$3,048 84	
General expenses, &c.....	Assistants, &c..... Cinchona and whisky, 105 gal- lons..... Telephone..... Office furniture..... Surveying instruments..... Surveys, &c.....	919 03 195 79 394 00 0 95 27 75 4 34	1,550 86	
Contingencies.....	Labor..... Piles, 21 (984) feet..... Pile-drivers, 66 hours..... Stone, 609.8 yards.....	543 18 96 57 50 43 808 05	1,504 23	\$6,103 93
				29,743 71

MEDIUM STAGE PROTECTION.

Twin Hollows, east bank: Riprapping 2,900 linear feet by 38½ feet (100,140 square feet).	Labor..... Gillmore, 5 hours..... Stone, 3,212.8 yards..... Sisal rope, 12 pounds.....	\$501 24 34 20 3,039 53 1 22	\$3,576 19	
Subsistence.....	Labor..... Rations, 707.....	124 27 258 40	382 67	
Equipment, &c.....	Quarter-boats, 71 days..... Skiffs, &c., 170 hours..... Tools, &c., 4,741 hours.....	41 07 25 88 95 76	162 71	
Engineering, &c., protec- tion work.	Assistants, &c., surveys..... Assistants, &c., inspection..... Assistants, &c., office work..... Assistants, &c., subsistence, labor..... Assistants, &c., subsistence, 45 rations.	28 38 42 50 341 17 10 57 16 44	439 06	
General expenses, &c.....	Assistants, &c..... Telephone..... Office furniture..... Survey instructions..... Survey stationery.....	93 06 40 00 1 00 2 82 44	137 32	
Contingencies.....	Labor.....	21 89		\$4,719 84

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Tabular statement showing expenditures of labor and material, &c.—Continued.

PRIMARY HURDLE (2,073 linear feet).

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total
Jim Smith's:				
Pulling piles.....	Labor.....		\$85 94	
Preparing piles.....	Labor.....		372 66	
Driving piles.....	Labor.....	\$680 67		
	Gillmore, 8 hours.....	54 72		
	Florence, 49 hours.....	70 07		
	Pile-drivers, 588 hours.....	478 81		
	Piles, 691 (20,046 feet).....	2,416 80		
	Manila rope, 280 pounds.....	42 70		
	Sisal rope, 379 pounds.....	38 30		
	Coal, 1,051 bushels.....	74 07		
			3,856 04	
Bracing (1,266 linear feet)..	Labor.....	446 78		
	Gillmore, 3 hours.....	20 52		
	Florence, 16 hours.....	22 88		
	Pile-drivers, 235 hours.....	191 13		
	Piles, 211 (8,873 feet).....	820 76		
	Wire, 100 pounds.....	4 57		
	Spikes, 25 pounds.....	94		
	Bolts, &c., 437.....	185 74		
	Coal, 327 bushels.....	22 89		
			1,716 21	
Stringers (1,260 linear feet).	Labor.....	346 91		
	Gillmore, 2 hours.....	13 68		
	Florence, 21 hours.....	30 03		
	Pile-drivers, 277 hours.....	225 29		
	Sisal rope, 331 pounds.....	33 40		
	Bolts, &c., 581.....	143 60		
	Coal, 421 bushels.....	29 47		
	Piles, 105 (4,659 feet).....	430 06		
			1,253 24	
Wattling 2,200 linear feet by 16½ feet (34,500 square feet).	Labor.....	927 24		
	Gillmore, 6 hours.....	41 04		
	Florence, 56 hours.....	80 08		
	Pile-drivers, 35 hours.....	28 47		
	Brush, 178 cords.....	472 77		
	Sisal rope, 98 pounds.....	9 89		
	Sisal hide rope, 368 pounds.....	24 80		
	Nails, 245 pounds.....	6 34		
			1,590 63	
Foundation mattress 1,250 linear feet by 56 feet by 1 foot thick (62,500 square feet).	Labor, fabricating.....	702 77		
	Labor, sinking.....	130 85		
	Gillmore, 7 hours.....	47 88		
	Florence, 17 hours.....	24 31		
	Brush, 470.9 cords.....	1,260 71		
	Stone, 375.4 cubic yards.....	353 56		
	Sisal rope, 376 pounds.....	38 00		
	Manila rope, 410 pounds.....	62 52		
	Wire, 900 pounds.....	41 13		
	Nails, 400 pounds.....	10 38		
	Spikes, 650 pounds.....	24 57		
			2,686 66	
Incidental work.....	Florence, 12 hours.....		17 16	
Subsistence.....	Labor.....	542 55		
	Rations, 4,023.....	1,470 41		
Equipment, &c.....	Quarters, 27,144 hours.....	851 61		
	Skiffs, &c., 2,777 hours.....	422 42		
	Tools, &c., 24,944 hours.....	503 86		
	Barge-flats, 4,176 hours.....	555 06		
			4,345 91	\$15,904 45

Tabular statement showing expenditures of labor and material, &c.—Continued.

SECONDARY HURDLE No. 1 (950 linear feet).

Locality and subdivision of work.	Materials, &c.	Amount.	Total.	Grand total.
Jim Smith's:				
Preparing piles.....	Labor		\$75 21	
Driving piles.....	Labor	\$178 56		
	Gillmore, 2 hours.....	43 68		
	Florence, 19 hours.....	27 17		
	Pile-drivers, 159 hours.....	129 32		
	Piles, 218 (8,172 feet).....	755 91		
	Sisal rope, 262 pounds.....	26 46		
	Coal, 345 bushels.....	24 15		
			1,155 25	
Bracing (950 linear feet)...	Labor	86 10		
	Florence, 7 hours.....	10 01		
	Pile-drivers, 55 hours.....	44 73		
	Piles, 67 (2,375 feet).....	219 69		
	Bolts, &c., 182.....	71 07		
	Coal, 122 bushels.....	8 64		
			440 14	
Wattling, 950 linear feet by 19 feet (18,050 square feet).	Labor	293 36		
	Gillmore, 2 hours.....	13 68		
	Florence, 7 hours.....	10 01		
	Pile-drivers, 20 hours.....	16 27		
	Brush, 83.4 cords.....	221 51		
	Sisal hido rope, 100 pounds.....	6 75		
	Nails, 250 pounds.....	6 47		
	Spikes, 100 pounds.....	3 78		
			571 83	
Stringers (950 linear feet)...	Labor	97 29		
	Gillmore, 1 hour.....	6 84		
	Florence, 5 hours.....	7 15		
	Pile-drivers, 67 hours.....	54 49		
	Piles, 28 (1,015 feet).....	93 89		
	Bolts, &c., 143.....	35 32		
	Coal, 150 bushels.....	10 50		
			305 48	
Foundation mattress, 950 linear feet by 30 feet by 1 foot thick (28,500 square feet).	Labor, fabricating.....	208 31		
	Labor, sinking.....	65 05		
	Gillmore, 3 hours.....	20 52		
	Florence, 15 hours.....	21 45		
	Brush, 170 cords.....	451 52		
	Stone, 318.6 yards.....	300 15		
	Sisal rope, 273 pounds.....	27 67		
	Manila rope, 110 pounds.....	16 77		
	Wire, 275 pounds.....	12 56		
	Nails, 275 pounds.....	7 12		
	Spikes, 375 pounds.....	14 17		
			1,235 79	
Subsistence.....	Labor.....	170 36		
	Rations, 1,537.....	501 78		
			732 14	
Incidental work	Florence, 16 hours.....		32 88	
Equipment, &c.....	Barge flats, 1,152 hours.....	153 12		
	Quarters, 7,488 hours.....	234 39		
	Skiffs, &c., 824 hours.....	125 42		
	Tools, &c., 8,071 hours.....	163 03		
			675 96	
Engineering, &c.....	Assistants, &c., surveys.....	81 19		
	Assistants, &c., inspection.....	180 05		
	Assistants, &c., office work.....	1,554 96		
	Assistants, &c., labor, subsistence.....	28 71		
	Assistants, &c., rations, 315, subsistence.....	115 14		
	Survey instruments.....	25 00		
	Florence, surveys.....	37 18		
	Surveys, &c.....	3 90		
			2,026 13	
General expenses, &c.....	Assistants, &c.....	825 97		
	Cinchona, &c., 60 gallons.....	111 84		
	Telephone.....	355 00		
	Office furniture.....	9 00		
			1,301 81	
Contingencies	Labor.....	454 62		
				\$8,997 24
				24,901 69

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Tabular statement showing expenditures of labor and material, &c.—Continued.

PRIMARY HURDLE (912 linear feet).

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Pulltight: Bracing (912 linear feet)...	Labor..... Gillmore, 1 hour..... Hornet, 15 hours..... Pile-drivers, 110 hours..... Coal, 50 bushels..... Piles, 76 (2,373 feet)..... Bolts, 229.....	\$230 68 6 84 14 02 89 47 3 50 219 51 83 07		
			\$647 09	
Wattling, 2,580 linear feet by 9½ feet (25,600 square feet).	Labor..... Gillmore, 3 hours..... Brush, 223.9 cords..... Hornet, 18 hours..... Wire, 90 pounds..... Nails, 218 pounds.....	511 46 20 52 594 88 16 83 4 11 5 64		
			1,153 24	
Foundation mattress, 30 linear feet by 30 feet by 1 foot thick (900 square feet).	Labor..... Brush, 10 cords.....	0 00 26 56		
			36 16	
Subsistence.....	Labor..... Rations, 1,184.....	111 71 410 82		
			522 53	
Equipment, &c.....	Quarters, 1,008 hours..... Barge-flats, 336 hours..... Quarter-boats, 720 hours..... Skiffs, &c., 413 hours..... Tools, &c., 6,003 hours.....	31 55 44 66 33 30 62 86 121 26		
			263 63	
				\$2,652 65

SECONDARY HURDLE No. 1 (960 linear feet).

Pulltight: Preparing piles.....	Labor.....		\$53 00	
Driving piles.....	Labor..... Gillmore, 2 hours..... Hornet, 10 hours..... Pile-drivers, 162 hours..... Piles, 220 (7,831 feet)..... Sisal rope, 100 pounds..... Coal, 170 bushels.....	\$193 84 13 03 17 76 131 76 724 37 10 10 11 90		
			1,103 41	
Bracing diagonal (960 lin- ear feet).	Labor, preparing..... Labor, placing..... Labor, bracing..... Pile-drivers, 26 hours..... Gillmore, 1 hour..... Hornet, 16 hours..... Piles, 80 (2,483 feet)..... Bolts, &c., 212..... Coal, 60 bushels.....	12 17 31 74 120 50 21 15 6 84 14 96 229 68 79 71 4 20		
			529 95	
Foundation mattress, 980 linear feet by 40½ feet by 1 foot thick (39,500 square feet).	Labor..... Labor, fabricating..... Labor, sinking..... Gillmore, 1 hour..... Hornet, 39 hours..... Brush, 210 cords..... Stone, 246.7 yards..... Spikes, 150 pounds.....	62 85 155 32 71 55 6 84 36 46 557 76 232 41 5 67		
			1,128 86	
Wattling, 960 linear feet by 13½ feet (13,000 square feet).	Labor..... Gillmore, 2 hours..... Hornet, 29 hours..... Brush, 121 cords..... Wire, 300 pounds..... Nails, 57 pounds.....	294 52 13 68 27 11 321 37 13 71 1 47		
			671 86	
Subsistence.....	Labor..... Rations, 1,184.....	151 12 432 75		
			583 87	
Equipment, &c.....	Barge-flats, 504 hours..... Quarters, 1,512 hours..... Quarter-boats, 1,008 hours..... Skiffs, &c., 413 hours..... Tools, &c., 7,829 hours.....	66 99 47 33 46 62 62 86 158 14		
			381 94	
				\$4,452 80
				7,105 54

APPENDIX U—REPORT OF MAJOR ERNST.

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Tabular statement showing expenditures of labor and material, &c.—Continued.

SECONDARY HURDLE No. 2 (1,560 linear feet).

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Pulltight:				
Driving piles	Labor.....	\$445 36		
	Gillmore, 2 hours	13 68		
	Hornet, 34 hours	31 79		
	Pile-drivers, 276 hours	224 48		
	Piles, 366 (14,677 feet)	1,357 03		
	Coal, 329 bushels	23 03		
			\$2,095 97	
Bracing (1,560 linear feet) ..	Labor.....	439 01		
	Gillmore, 2 hours	13 06		
	Hornet, 21 hours	19 03		
	Pile-drivers, 109 hours	88 65		
	Piles, 137 (4,970 feet)	459 73		
	Bolts, 323	118 58		
	Coal, 200 bushels	14 00		
			1,153 88	
Stringers (1,560 feet)	Labor.....	161 20		
	Hornet, 23 hours	21 50		
	Pile-drivers, 126 hours	102 48		
	Piles, 53 (2,334 feet)	215 00		
	Bolts, 290	71 03		
	Coal, 220 bushels	15 40		
			578 11	
Wattling, 1,560 linear feet by 12½ feet (19,000 square feet).	Labor.....	222 46		
	Gillmore, 1 hour	6 84		
	Hornet, 120 hours	112 20		
	Brush, 135.3 cords	350 35		
	Nails, 250 pounds	6 48		
			707 33	
Foundation mattress, 1,630 linear feet by 49.1 feet by 1 foot thick (81,000 square feet).	Labor.....	692 64		
	Gillmore, 3 hours	20 52		
	Hornet, 183 hours	171 11		
	Brush, 328 cords	871 17		
	Stone, 472 yards	444 67		
	Sisal rope, 616 pounds	61 70		
	Wire, 705 pounds	32 21		
	Spikes, 1,050 pounds	30 69		
			2,333 71	
Subsistence.....	Labor.....	291 99		
	Rations, 2,603	951 40		
			1,243 39	
Equipment, &c.....	Barge flats, 926 hours	124 41		
	Quarters, 2,808 hours	87 90		
	Quarter-boats, 1,848 hours	85 47		
	Skiffs, 1,325 hours	201 66		
	Tools, &c., 14,674 hours	206 41		
			795 85	
				\$8,908 24

SECONDARY HURDLE No. 5 (2,067 linear feet).

Pulltight:				
Removing obstructions	Labor		\$39 68	
Pulling drift	Labor		85 66	
Preparing piles	Labor		153 15	
Driving piles	Labor	\$860 54		
	Gillmore, 5 hours	33 56		
	Hornet, 84 hours	78 54		
	Pile-drivers, 703 hours	595 32		
	Pile timber, 580 (24,363 feet)	2,160 77		
	Coal, 1,460 bushels	96 91		
	Manila rope, 3,102 pounds	459 62		
	Sisal rope, 200 pounds	21 40		
	Spikes, 135 pounds	5 00		
	Miscellaneous	17 68		
			4,329 24	
Bracing (2,067 linear feet) ..	Labor	347 95		
	Gillmore, 1 hour	6 68		
	Pile-drivers, 244 hours	206 67		
	Pile timber, 212 (7,795 feet)	647 78		
	Bolts, &c., 468	218 06		
	Coal, 310 bushels	20 66		
	Miscellaneous	5 10		
			1,452 90	

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Tabular statement showing expenditures of labor and material, &c.—Continued.

SECONDARY HURDLE No. 5 (2,067 linear feet)—Continued.

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Pulltight—Continued.				
Stringers (2,067 linear feet).	Labor	\$268 48		
	Gillmore, 1 hour	6 68		
	Pile timber, 88 (3,336 feet)	292 76		
	Pile-drivers, 149 hours	125 52		
	Bolts, 433	80 08		
	Coal, 175 bushels	11 81		
	Miscellaneous	2 50		
			\$787 83	
Wattling, 987 linear feet by 20.2 feet (20,000 square feet).	Labor	362 16		
	Gillmore, 2 hours	13 68		
	Hornet, 46 hours	43 01		
	Brush, 96.4 cords	256 04		
	Nails, 200 pounds	5 18		
			680 07	
Foundation mattress, 2,157 linear feet by 59½ feet (127,900 square feet).	Labor	1,771 73		
	Gillmore, 3 hours	20 36		
	Hornet, 43 hours	40 20		
	Brush, 668.5 cords	2,009 69		
	Stone, 1,228 cubic yards	1,372 18		
	Sisal rope, 1,098 pounds	116 12		
	Wire, 887 pounds	40 12		
	Spikes, 1,430 pounds	53 23		
	Nails, 689 pounds	17 37		
	Miscellaneous	13 45		
			5,454 45	
Subsistence.....	Labor	601 18		
	Rations, 4,924	2,099 90		
	Coal, 207 bushels	13 58		
	Miscellaneous	33 66		
			2,748 32	
Incidental work	Labor	93 12		
	Gillmore, 17 hours	113 66		
			206 68	
Equipment	Wharf-boat, 1,416 hours	219 06		
	Quarters, 1,512 hours	47 33		
	Quarter-boats, 2,424 hours	178 28		
	Barge-flats, 504 hours	66 99		
	Skiffs, &c., 7,106 hours	502 80		
	Tools, &c., 28,620 hours	495 38		
			1,509 84	
Engineering, &c.....	Assistants, surveys	208 00		
	Hornet, surveys, 20 hours	18 70		
	Instruments, surveys	55 59		
	Surveys, &c.	30 41		
	Assistants, &c., inspection	725 10		
	Assistants, &c., office	2,403 72		
	Miscellaneous, office	8 82		
	Subsistence, labor	29 25		
	Rations, subsistence, 439	176 90		
	Wharf-boat, 48 hours	7 43		
	Quarter-boats, 1,464 hours	134 97		
	Skiffs, 510 hours	31 62		
	Tools, 160 hours	2 50		
			3,833 07	
General expenses.....	Assistants, &c.	1,421 28		
	Cinchona	37 28		
	Telephone	663 47		
	Office furniture	25 03		
			2,147 06	
Contingencies			198 21	
				\$23,626 16
Total				39,639 94

Tabular statement showing expenditures of labor and material, &c.—Continued.

HURDLE (900 linear feet).

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Chesley Island:				
Preparing piles	Labor		\$67 16	
Driving piles	Labor	\$536 08		
	Gillmore, 10 hours	68 40		
	Pile-drivers, 400 hours	326 88		
	Piles, 322 (12,879 feet)	1,191 31		
	Sisal rope, 100 pounds	10 10		
	Manila rope, 1,693 pounds	258 18		
	Coal, 320 bushels	22 40		
			2,413 35	
Bracing (1,032 linear feet) .	Labor	235 59		
	Gillmore, 4 hours	27 36		
	Pile-drivers, 192 hours	156 16		
	Piles, 172 (6,277 feet)	580 63		
	Sisal rope, 52 pounds	5 25		
	Bolts, &c., 317	140 44		
	Coal, 133 bushels	9 31		
			1,154 74	
Stringers (1,560 linear feet) .	Labor	342 42		
	Gillmore, 6 hours	41 04		
	Pile-drivers, 187 hours	160 23		
	Piles, 120 (4,687 feet)	493 55		
	Sisal rope, 316 pounds	32 00		
	Bolts, 419	83 40		
	Coal, 100 bushels	7 00		
			1,099 64	
Wattling, 435 linear feet by 11.7 feet (5,100 square feet).	Labor	201 82		
	Gillmore, 2 hours	13 68		
	Brush, 20 cords	53 12		
			268 62	
Foundation mattress, 465 linear feet by 38½ feet (17,745 square feet).	Labor fabrication	232 25		
	Labor sinking	85 34		
	Gillmore, 4 hours	27 36		
	Brush, 46.2 cords	122 71		
	Stone, 626.8 yards	590 50		
	Sisal rope, 356 pounds	36 00		
	Sisal hide rope, 75 pounds	5 06		
	Wire, 400 pounds	18 28		
	Spikes, 150 pounds	5 67		
			1,123 17	
Removing obstructions	Pile-drivers, 28 hours		22 77	
Incidental work	Coal, 32 bushels	2 24		
	Rations, 314	114 77		
			117 01	
Equipment, &c	Barge-flats, 1,104 hours	146 74		
	Quarter-boats, 3,720 hours	172 27		
	Skiffs, &c., 799 hours	121 61		
	Tools, &c., 11,574 hours	233 70		
			674 41	
Subsistence	Labor	222 90		
	Rations, 1,920	701 76		
			924 66	
Engineering, &c. (contraction work).	Assistants, &c., surveys	36 63		
	Assistants, &c., inspection	241 84		
	Assistants, &c., office work	618 00		
	Assistants, &c., labor subsistence	8 41		
	Assistants, &c., 232 rations	84 80		
			989 68	
				\$8,855 21

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Tabular statement showing expenditures of labor and material, &c.—Continued.

MEDIUM STAGH PROTECTION.

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Chesley Island:				
Riprapping, 4,885 linear feet by 27 feet (132,240 square feet).	Labor.....	\$033 42		
	Gillmore, 11 hours.....	75 24		
	Stone, 3,077.9 yards.....	3,704 02		
	Nails, 25 pounds.....	05		
			\$4,774 23	
Subsistence.....	Labor.....	250 03		
	Rations, 1,219.....	445 55		
			695 58	
Engineering, &c. (protection work).	Assistants, &c., office work.....	178 83		
	Assistants, &c., inspection.....	159 30		
	Assistants, &c., surveys.....	20 09		
	Assistants, &c., labor subsistence	9 50		
	Assistants, &c., rations, 132; subsistence.....	48 25		
	Coal, 10 bushels.....	70		
	Surveys, &c., stationery.....	2 42		
			419 75	
Equipment, &c.....	Barge-flats, 90 hours.....	12 76		
	Quarter-boats, 1,704 hours.....	78 81		
	Skiffs, &c., 508 hours.....	86 45		
	Tools, &c., 6,638 hours.....	134 08		
			312 10	
				\$6,201 66

GENERAL EXPENSE, CONTINGENCIES, ETC.

Chesley Island:				
General expense, &c.....	Assistants, &c.....	\$511 86		
	Cinchona and whisky, 35 gallons	65 24		
	Telephone.....	220 00		
	Office furniture.....	5 50		
	Surveying instruments.....	15 45		
			\$818 05	
Contingencies, &c.....	Labor.....		225 55	
				\$1,043 60
Total.....				16,100 47

Tabular statement showing expenditures of labor and material, &c.—Continued.

LOW-WATER PROTECTION.

Locality and subdivision of work.	Material, &c.	Amount.	Total.	Grand total.
Foster's Island:				
Removing obstructions....	Labor.....		\$3 85	
Preparing piles.....	Labor.....		144 25	
Driving piles.....	Labor.....	\$195 18		
	Gillmore, 2 hours.....	13 08		
	Piles, 247 (11,242 feet).....	1,039 80		
	Iron, 207 pounds.....	5 34		
	Bolts, &c., 27.....	1 24		
	Coal, 950 bushels.....	24 50		
	Pile-drivers, 235 hours.....	191 13		
			1,470 90	
Foundation mattress, 5,284 linear feet by 120 feet (634,080 square feet).	Labor fabricating.....	3,545 05		
	Labor sinking.....	150 43		
	Labor securing.....	504 42		
	Gillmore, 33 hours.....	225 78		
	Brush, 4,702.3 cords.....	12,491 88		
	Stone, 1,552.7 yards.....	1,457 72		
	Manila rope, 122 pounds.....	18 60		
	Sisal rope, 863 pounds.....	87 74		
	Sisal hide rope, 31 pounds.....	2 09		
	Wire, 9,074 pounds.....	414 53		
	Nails, 681 pounds.....	17 64		
	Spikes, 4,922 pounds.....	187 12		
			19,112 00	
Subsistence.....	Labor.....	677 47		
	Rations.....	2,375 15		
			3,052 62	
Equipment, &c.....	Barges, 1,010 hours.....	341 38		
	Barges, flats, 2,184 hours.....	290 29		
	Pile-driver hull, 2,304 hours.....	75 29		
	Quarters, 29,232 hours.....	915 02		
	Skiffs, &c., 1,606 hours.....	244 44		
	Ways, 970 hours.....	987 83		
	Tools, &c., 40,244 hours.....	808 37		
			3,362 62	
Incidental work.....	Rations, 239.....		87 36	
				\$27,233 66

MEDIUM STAGE PROTECTION.

Foster's Island:				
Wrapping, 5,284 linear feet by 434 feet (228,600 square feet).	Labor.....	\$1,002 05		
	Gillmore, 7 hours.....	47 88		
	Stone, 6,121.8 yards.....	5,743 41		
			\$6,793 34	
Subsistence.....	Labor.....	221 02		
	Rations, 1,537.....	561 77		
			782 79	
Equipment, &c.....	Barge-flats, 144 hours.....	10 14		
	Pile-drivers, 144 hours.....	4 71		
	Quarters, 4,806 hours.....	152 74		
	Quarter-boats, 672 hours.....	31 08		
	Skiffs, &c., 162 hours.....	25 26		
	Tools, &c., 9,071 hours.....	183 23		
			416 16	
Engineering, &c.....	Assistants, &c., surveys.....	118 21		
	Assistants, &c., inspection.....	144 65		
	Assistants, &c., office work.....	821 44		
	Assistants, &c., labor subsistence.....	115 20		
	Assistants, &c., rations, 381.....	139 26		
			1,338 76	
General expense, &c.....	Assistants, &c.....	907 40		
	Florence, 10 hours, survey.....	14 30		
	Cinchona, 45 gallons.....	83 88		
	Telephone.....	390 00		
	Office furniture.....	10 00		
	Survey instruments.....	27 40		
	Stationery.....	4 25		
			1,437 23	
Contingencies.....	Labor.....		514 90	
				\$11,283 18
Total.....				88,516 84

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2.

REPORT OF MR. D. M. CURRIE, ASSISTANT ENGINEER.

SAINT LOUIS, MO., June 30, 1884.

SIR: I have the honor to transmit herewith the reports upon the works under my supervision for improving the Mississippi River in the vicinity of Saint Louis for the fiscal year ending June 30, 1884.

Very respectfully, your obedient servant,

D. M. CURRIE,
Assistant Engineer.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

THE IMPROVEMENT OF THE MISSISSIPPI RIVER IN THE VICINITY OF SAINT LOUIS, MISSOURI.

The engineering staff was composed of the persons named in the last report with the exception of Assistant Engineers J. W. Irwin and S. B. Cady, who resigned during the year. Its organization was similar to that inaugurated in 1882.

A want of available funds limited operations to such extension and repair of works previously begun as were necessary to prevent the loss of a part of the results which had already been obtained. To this end work was done at the following-named places, reports giving the details of the operations at each of them, by the assistant last in charge, being forwarded herewith as part of this report.

Cahokia Chute. Report of Mr. J. O. Holman.

Horsetail Bar, east side. Report of Mr. E. D. Libby.

Horsetail Bar, west side. Report of Mr. J. E. Savage.

Twin Hollows, west side. Report of Mr. W. S. Mitchell.

Twin Hollows, east side. Report of Mr. B. E. Johnson.

Pulltight. Report of Mr. C. D. Lamb.

Chesley Island. Report of Mr. C. V. Mersereau.

Jim Smith's. Report of Mr. J. O. Holman.

Foster's Island. Report of Mr. J. E. Savage.

Supply Depot. Report of Mr. C. L. Stevenson.

Field operations, which were practically suspended at the close of last year, were resumed about the middle of July, and were closed for the fall season about the last of November, although at several localities they were continued on a small scale somewhat longer. They were resumed about the 10th of March and were continued until the 1st of June.

The weather and stages of the river were probably as favorable for the prosecution of the work as may generally be expected.

The flood which ended in July had been the prevailing stage of the spring. It damaged considerably the hurdles at Cahokia Chute, Horsetail Bar, east side; Twin Hollows, west side; Pulltight, and Jim Smith's, and heavy deposits of sediment were made within the space allotted to the river bed at several points within the reach under improvement, but at none of these were works under process of construction. During a few days, on the approach of low water, the changes in the direction of the channel were abrupt in the crossings to and from the Missouri Bluff at the lower end of Twin Hollows, and in that at Sulphur Springs the depth was scant. On the contrary, a decided improvement in direction, depth, and available width of navigable channel was effected during the flood by those works which were in an advanced state.

The material procured for construction, in addition to that on hand from last season, was obtained by the methods which have been in vogue for several years. Brush was brought from several localities between Alton and Kaskaskia, and was obtained by hired labor and purchase by royalty. In all 13,493.64 cords were received. Piles were procured from John Cleary under his contract of last year until it was completed at the end of September. After that date they were purchased from him. There were delivered at the works 7,438 sticks, 295,838 linear feet, of pile timber in rafts and on barges at Mr. Cleary's expense.

Stone was purchased in open market from several quarries within the reach under improvement. It was delivered at the quarries upon barges belonging to the United States, and aggregated 26,906.43 cubic yards.

Few additions were needed during the year to the supply of other materials already on hand; 581 pounds of iron and 5,576 bolt-ends were purchased and delivered at the supply depot, where the iron was wrought into bolts, clevises, and other forms needed in construction.

All supplies for the equipment and maintenance of parties in the field were collected at the supply depot and were issued from there as required. Ordinary repairs

to the machinery and hulls of all vessels, to the tools and appliances and to the portable shanties, were also made at this place.

The plant deteriorated greatly from ordinary wear, and during the second half year was reduced by the withdrawal of a model barge and twelve barge-flats, which were worn out and condemned. No additions having been made, it requires an equivalent for the loss of these vessels to restore its efficiency and to adapt it to the employment of 2,000 men, which number was considered its capacity one year ago.

The plant now comprises 2 tow-boats, 17 model barges, 18 barge-flats, 20 pile-drivers, 1 hydraulic excavator, 2-ways barges for mattresses, 4 quarter-boats, 174 sections of portable quarters, 83 flats, 48 yawls, 80 skiffs, and the required tools and appliances.

One of the tow-boats was not in commission during the year; the other, the General Gillmore, towed the material, pile-drivers, quarter-boats, and all other vessels; transported supplies, made inspection trips, and did all other work required. It was in commission from July 1 to December 15, and from March 10 to June 10, and in that time rendered 3,629 hours of actual service.

The remainder of the plant was not worked to its full capacity, only those vessels being used which were needed by the small force employed.

Employés away from Saint Louis were supplied with quarters, subsistence, and simple medicines as part of their compensation.

Communication by telephone was maintained throughout the working season between the office in Saint Louis, the depot, and the localities at which works were in progress on the west side, and with those on the east side by messengers through the nearest telephone station; and assistants signaled their wants to the tow-boat by means of the code published in the regulations of 1883.

The condition of the improvements at the beginning of the year and the quantities of the different classes of work done during the year at the several localities are shown below.

CAROLIA CHUTE.

The work at this place was to repair hurdle No. 1 and to repair and complete No. 2.

Mr. C. D. Lamb was resident engineer in charge of the work during the first half year. He was assisted by Mr. Gerald Bagnall and Mr. E. F. Officer, assistant engineers. During the second half year Mr. J. O. Holman was resident engineer in charge, and was assisted by Mr. Bagnall alone.

When work was resumed in July two gaps, each about 200 feet in length, were found in line No. 1. One was located in the middle of the line, the other was in the end adjoining Arsenal Island. In line No. 2 a section 400 feet in length remained to be watted and braced to complete the hurdle, and a breach about 30 feet long was found at each end. Work was finished about the middle of August.

During the flood of March and April other breaches were formed in both lines, and were repaired in April and May. These breaches consisted of two gaps in line No. 1, one 75 feet in length about 300 feet from the Illinois shore, the other 325 in length in the middle of the line. In addition, 450 feet of the hurdle next to the island, having been damaged, was repaired. In line No. 2 there were two gaps, one of which adjoined the island, and was 190 feet in length; the other was located near the east end of the line, and was 300 feet in length.

In making these repairs the following amounts of work were done:

Description of work.	Hurdle No. 1.	Hurdle No. 2.
Piles driven	number..	
Braces placed	305	226
Stringers placed	90	115
.....do.....	33	32
Mattress fabricated and sunk	square feet..	46,000
Mattress fabricated and sunk	linear feet..	500
Mattling placed	square feet..	7,250
Mattling placed	linear feet..	650
	650	600

Reference is made to the report of Mr. J. O. Holman for further details.

HORSETAIL BAR, EAST SIDE.

Mr. E. D. Libby was resident engineer in charge, and was assisted by Mr. C. P. Mitchell and Mr. S. B. Cady during the first half year, and by Mr. Mitchell, Mr. C. V. Mersereau, and Mr. B. E. Johnson during the second half year.

The work at this place was to repair secondary hurdles Nos. 27 and 30, to construct two new lines, Nos. 27½ and 29½, and to complete and repair the Carroll's Island Hurdle.

Secondary hurdle No. 27 was in such a damaged condition in July that it did not effectually obstruct the flow of water. About 300 linear feet of the line, in two sections, both located in the east half of the hurdle, were uninjured. In the remainder

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of the line a considerable portion of the mattress was still in position, but the wattling was badly torn and the piles displaced. But few of the latter could be used in making the repairs. This was thoroughly done in the first half year. When the ice gorge broke up in March some damage was sustained, but to ascertain its extent or to repair it has not been practicable, as the line has been continually submerged.

Hurdle No. 30 was also in a badly damaged condition in July. Only short sections near the east end and across the central bar remained intact. The line was repaired on both sides of the bar during the fall season and was again broken near the west end at the close of the season. This break was not repaired.

The construction of line No. 27½ was begun about the last of March and continued until the end of May, when it was suspended on account of an exhaustion of funds. It was completed, with the exception of wattling, a distance of 1,325 feet from shore.

Work upon No. 29½ was begun March 29, and was continued with such force as could be economically employed until the close of field operations at the end of May. It was completed, with the exception of wattling, a distance of 1,450 feet from shore.

During the summer flood two gaps, 80 feet and 75 feet in length, were formed in the Carroll's Island Hurdle, at 600 feet and 1,300 feet, respectively, from the island. Several piles and braces were displaced in the next 900 feet, and the excavation which had been made around the island end of the hurdle was refilled.

The line was completed and repaired during the fall.

It was broken again in March and April, gaps 550 feet, and 200 feet in length being formed. After some extension these gaps were repaired by rebuilding 1,325 feet of the hurdle next to the Illinois shore.

The amounts of work done in each hurdle are shown in the following statement:

Description of work.	No. 27.	No. 27½.	No. 29½.	No. 30.	Carroll's Island.
Piles placed..... number..	425	504	519	323	683
Braces placed..... do.....	144	167	231	116	418
Stringers placed..... do.....	55	72	84	50	152
Cross-stringers placed..... do.....		2	3		106
Mattress fabricated and sunk..... square feet..	26,500	114,225	118,240	34,000	155,050
Mattress fabricated and sunk..... linear feet..	795	3,435	1,478	1,100	1,950
Wattling placed..... square feet..	30,110			23,715	16,420
Wattling placed..... linear feet..	1,780			1,405	970
Wattled curtains..... square feet..	9,842			8,170	
Wattled curtains..... linear feet..	866			950	

Reference is made to the report of Mr. E. D. Libby for further details.

HORSETAIL BAR, WEST SIDE.

These works have heretofore been carried on as a part of the general improvement at Horsetail Bar, but this year it was treated as a separate locality. No work was done during the first half-year.

At the beginning of the spring season the newly made land within the space inclosed by the hurdles had lost a triangular strip 350 feet wide at Dike No. 1, and diminishing to a point at 350 feet below the mouth of the River Des Peres. The primary line had been destroyed from its intersection with secondary hurdle No. 1 to the dike, and the secondary lines had lost their outer ends. The work was, therefore, the protection of the bank, from the mouth of the River Des Peres to Dike No. 1, from further erosion, and was under the immediate supervision of Mr. J. E. Savage, assisted by Mr. J. L. Duffy.

Below the contour of standard low water this bank, 3,860 feet in length, was protected with a mattress 100 feet wide placed in a single section. The medium stage protection, consisting of a stone revetment, was brought to the contour 6 feet above standard low water, and extended over 2,930 linear feet of the bank, beginning at a point 800 feet below the River Des Peres. Between this work and the dike, 150 feet, the revetment was brought to 13 feet above standard low water.

Operations were begun about the middle of March and were continued until the last of May, during which time the following amounts of work were done:

Low-water protection:

Piles driven..... number..	281
Mattress fabricated and sunk..... square feet..	388,000
Mattress fabricated and sunk..... linear feet..	3,860

Medium stage protection:

Stone revetment placed..... square feet..	68,914
Stone revetment placed..... linear feet..	3,020

Reference is made to the report of Mr. J. E. Savage for further details.

TWIN HOLLOWS, WEST SIDE.

At this place the primary hurdle and secondaries, Nos. 1, 3, 4, 5, were to be repaired and secondary No. 0 to be constructed.

Work was confined to the first half-year, beginning about the middle of July, and ending at the close of the season, and was under the supervision of Mr. W. S. Mitchell, assisted by Mr. J. L. Duffy and Mr. E. D. Frasier.

In the primary line a section of crib-work, 250 feet long, next to the shore, was in good condition, but the next section of the same length was unserviceable. This latter, at one time, connected with the piling at Station 6. The hurdle was gone with the exception of the mattress between Stations 6 and 11 + 17. Short sections of piling, with wattling, remained between 11 + 17 and 30; it was intact from 30 to 70, 82 to 94, 104 to 114, and from 115 + 25 to the lower end of the line. It was damaged from 70 to 82, and destroyed from 114 to 115 + 25. The space between 94 and 104 was occupied by a higher bar over which no hurdle had ever been built.

A large volume of water passed through the gap above Station 11 + 17 with considerable velocity, but through the other gaps only small volumes flowed with feeble currents.

The only work attempted in this line was to repair the upper gap. This was done by building a hurdle from the end of the unbroken crib to Station 6 and thence to Station 11 + 17. Above Station 6 a mattress 45 feet wide, 3½ feet thick, was placed to give additional support to the piles which were driven to bed-rock, the small depths of the overlying deposit being insufficient to hold them. Below Station 6 no mattress was constructed the piles being driven through that originally placed.

Secondary hurdle No. 0 was located midway between the head of the works and hurdle No. 1, in order to obstruct more effectually the stream of water flowing down the shore. In its construction two lines of piles were driven and braced. They were protected with a mattress 45 feet wide and woven in one section from the primary hurdle to within 125 feet of the shore, which was as far as the piles could be driven. The connection with the shore was made with a crib floored with a mattress 45 feet wide and 1½ feet thick.

Secondary hurdle No. 1, though somewhat damaged, was in serviceable condition from the primary line to Station 6 + 50, entirely destroyed from the latter point to the east end of the crib-work at Station 8, and intact from there to the shore.

The hurdle between Stations 6 + 50 and 8 was rebuilt.

Secondary hurdle No. 2 was considerably damaged in the west half of the line, several distinct breaches having been made. It was not repaired as it could not be reached by the pile-drivers, owing to the shoal water on the upper side of it, and the next hurdle barring access from below.

Line No. 3 was found in the condition in which it was left at the close of last year, namely, with a gap between Stations 10 + 50 and 11 + 50, and unwattled from Station 7 to Station 10 + 50. The gap was closed and the line was repaired and completed.

In hurdle No. 4 gaps existed between Station 10 and the east end of the crib (12 + 60) and between the west end of the crib (14) and the shore.

The two cribs which had been carried on flats through the June flood were placed and the hurdle was constructed across the remainder of the gap, completing the line.

Secondary hurdle No. 5 was intact as far as it had been constructed. Gaps still existed between Stations 11 + 25 and 13 + 60 and between 15 + 10 and the shore. A shore-crib was placed in the latter gap and the old crib-work was repaired.

The following table shows the amounts of work done in each hurdle:

Description of work.	Primary.	No. 0.	No. 1.	No. 3.	No. 4.	No. 5.
Piles driven.....number..	280	155	57	39	78	.....
Braces placed.....do.....	113	44	20	14	22	.....
Stringers placed.....do.....	51	21	11	14	25	.....
Cross-stringers placed.....do.....	40	.....	.....	11	22	.....
Mattress fabricated and sunk.....square feet..	9,450	28,170	7,140	4,490	10,065	.....
Mattress fabricated and sunk.....linear feet..	210	626	238	128	299	.....
Wattling placed.....square feet..	19,209	10,250	4,937	7,738	8,427	1,350
Wattling placed.....linear feet..	767	625	254	648	712	90
Crib-work.....do.....	.....	.....	.....	.....	190	.....
Crib-work constructed and placed.....do.....	.....	125	.....	.....	.....	90

For further details reference is made to the report of Mr. W. S. Mitchell.

TWIN HOLLOWS, EAST SIDE.

The work at this locality was to extend the medium stage protection over such portions of the bank as had a slope suitable to receive the stone revetment, and to extend the protection down-stream about 100 feet to stop an erosion of the bank by an eddy, which was acting against it.

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When work began the protection previously placed was found in good condition to the following heights above standard low water :

	Feet.
From Station 0 to Station 49.....	16
From Station 49 to Station 60.....	8
From Station 60 to Station 61 + 25.....	12
From Station 61 + 25 to Station 74 + 25.....	0
From Station 74 + 25 to Station 76.....	12
From Station 76 to Station 78.....	0
From Station 78 to Station 86 + 50.....	12

The extension of this revetment was made during the latter part of the first half-year under the direction of Mr. B. E. Johnson, in whose report the details of the work are given.

At the close of the season the revetment had been carried to the following heights above standard low water :

	Feet.
From Station 0 to Station 53.....	16
From Station 53 to Station 55.....	12
From Station 55 to Station 59.....	14
From Station 59 to Station 61 + 25.....	12
From Station 61 + 25 to Station 63 + 75.....	14
From Station 63 + 75 to Station 70 + 25.....	8
From Station 70 + 25 to Station 72 + 25.....	10
From Station 72 + 25 to Station 75 + 75.....	16
From Station 75 + 75 to Station 76.....	0
From Station 76 to Station 78.....	8
From Station 78 to Station 86 + 50.....	12
From Station 86 + 50 to Station 87 + 50.....	8

In the aggregate 2,900 linear feet or 106,140 square feet of the bank were revetted.

PULLTIGHT.

The completion and repair of the primary line and the construction of secondary hurdles Nos. 1, 2, and 5 made up the work of the year at this locality.

Mr. C. D. Lamb was in immediate charge. He was assisted by Mr. E. F. Officer, and also by Mr. A. F. Freis during the last half-year.

The primary line was damaged during the summer flood, a part of the wattling, diagonal braces, and piling having been displaced.

The hurdle was completed and repaired for a length 2,540 feet from shore.

In secondary hurdle No. 1 the piles which had been driven during the last year were overturned and covered with drift-wood so that they could not be used in the reconstruction of the line. The hurdle was therefore relocated about 50 feet below the original line and was completed.

Hurdle No. 2 was begun 2,000 feet below No. 1, and was completed from the shore for a length of 1,560 feet to a point at which it would intersect the primary line produced.

Hurdle No. 5 was located 6,000 feet below No. 2 and about 1,000 feet below the head of Beard's Island.

This line was the last work of the first half-year and was completed about the 20th of November. When the ice gorge broke in March a small breach was made in it. This breach widened so rapidly under the swift currents and heavy masses of drift-wood during the high water of April that to repair it required the rebuilding of the entire line. This was done upon a location just above its former site.

The amounts of work done on each hurdle are given in the following statement :

Description of work.	Hurdles.			
	Primary.	No. 1.	No. 2.	No. 5.
Piles driven.....number.....		220	370	572
Braces placed.....do.....	76	86	132	212
Stringers placed.....do.....			42	92
Mattress fabricated and sunk.....square feet.....	900	39,500	81,000	127,900
Mattress fabricated and sunk.....linear feet.....	30	980	1,630	2,157
Wattling placed.....square feet.....	25,000	13,000	19,000	20,000
Wattling placed.....linear feet.....	2,580	960	1,560	987

For the details of the work reference is made to the report of Mr. C. D. Lamb.

CHESLEY ISLAND.

The completion of the hurdle and the medium stage protection of the island was the work to be done at this place.

Operations were confined to the first half-year, and were under the supervision of Mr. C. V. Mersereau, assisted by Mr. B. E. Johnson.

The construction of the hurdle presented some difficulty because of the obstruction, by deposits made during the summer flood, of the outlet left for the Meramec River above the head of the island.

The line was completed, with the exception of wattling, but was broken later in the season. The breach was not repaired, although the bottom was revetted with stone to prevent further enlargement.

The medium stage protection which had been previously placed was found in good condition, and the bank had been graded by the flood to the full height to which the revetment was to be carried.

The protection was completed, and ranges in height from 16 feet to 21 feet on the west side, and from 19 feet to 23 feet around the head of the island.

The following statement gives the amounts of work done:

Medium stage protection:	
Stone revetment placed.....	square feet.. 132,000
Bank revetted	linear feet.. 4,500
Hurdle:	
Piles driven	number.. 305
Braces placed	do.... 172
Stringers placed	do.... 121
Mattress fabricated and sunk	square feet.. 18,000
Mattress fabricated and sunk	linear feet.. 465
Wattling placed.....	square feet.. 5,700
Wattling placed.....	linear feet.. 435

For details of the work reference is made to the report of Mr. Mersereau.

JIM SMITH'S.

The damages previously reported to the works at this locality had been slightly increased during the summer flood.

The repair of the branch FF, of the primary line, and the reconstruction of secondary hurdle No. 1, constituted the work to be done during the season.

Operations were carried on during the first half year only, and were under the direction of Mr. J. O. Holman, assisted by Mr. Freis and Mr. Johnson.

The primary line was rebuilt from station 0 to station 17+50, and was extensively repaired as far as station 34.

Secondary hurdle No. 1 was entirely reconstructed.

The amounts of work done are given in the following table:

Description of work.	Hurdles.	
	Primary.	No. 1.
Piles driven	691	218
Braces placed	211	67
Stringers placed.....	115	28
Mattress fabricated and sunk	62,500	28,500
Mattress fabricated and sunk	1,250	950
Wattling placed.....	34,500	18,050
Wattling placed.....	2,200	950

For the details of the work reference is made to the report of Mr. Holman.

FOSTER'S ISLAND.

The protection of the west bank of this island was resumed at a point about 2,500 feet below the lower end of the work done during the fall of 1882.

Operations were conducted during the first half-year under the direction of First Lieut. F. V. Abbot, Corps of Engineers, assisted by Mr. Savage, until the end of September, and from that date until the end of the season under Mr. Savage, assisted by Mr. Bagnall.

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The low-water protection was extended a distance of 5,284 feet, to the foot of the island, by a continuous mattress 120 feet in width.

The medium stage protection was carried to the contour 9 feet above standard low water from the upper point of the work, a distance of 5,030 feet, down-stream, and to the 13-foot contour for 254 feet, to the lower end of the work.

The following are the amounts of work done during the season:

Low-water protection:

Mattress fabricated and sunk	square feet..	634, 080
Mattress fabricated and sunk	linear feet..	5, 284
Piles driven	number..	302

Medium stage protection of 5,280 linear feet of bank:

Stone revetment placed	square feet..	228, 660
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The details of the work are given in the report of Mr. Savage.

The service of plant and the quantities of labor and material expended are shown in detail in the accompanying tables, as follows:

Construction of hurdles, detail, Tables I to IX inclusive.

Bank protection, detail, X to XIV inclusive.

Construction of hurdles consolidated, X to XV inclusive.

Bank protection consolidated and grand total, X to XVI inclusive.

Engineering, X to XVII inclusive.

Subsistence, X to XVIII inclusive.

Procuring material and miscellaneous supplies, X to XIX inclusive.

Care of plant and general incidental work, X to XX inclusive.

Construction of hurdles; labor, service of equipment and material expended per unit of work, X to XXI inclusive.

Bank protection; labor, service of equipment and material expended, per unit of work, X to XXII inclusive.

The consolidated statements in Tables XV and XVI, showing the service of vessels and the expenditures of labor and material in the construction of large amounts of the several classes of work, furnish reliable data for approximate estimates of the cost of similar constructions.

The expenditures per unit of work on hurdles and bank protection will be found in Tables XXI and XXII, respectively. The item of crib construction was omitted from these tables for the reasons that the form is suitable only when piles cannot be driven, that a large portion of the expenditures for them was made last year and does not appear in Tables VIII and XV, and that the length built this year was not sufficient to form a basis for an estimate per unit of work.

The items shown in the construction of the hurdles may be combined at will in making estimates for contemplated works. Some of the hurdles from which the data were obtained contained two and others contained three rows of piles; some were wattled and some were not. The form built during the last half year consisted of three rows of piles with braces, stringers and foundation mattress. In height they varied with the prevailing stages of the river, extending from 16 to 26 feet above standard low water.

Additional height increases the quantity of work to be done and its cost per unit, but does not necessarily increase the total cost of the improvement as the static force of masses of drift-wood and ice accumulated by gradual collection may not injure the line which holds it, but which the dynamic force consequent upon submergence destroys, necessitating reconstruction. Reference can be made to several instances in which hurdles not submerged have withstood without injury the pressure of enormous fields of drift-wood, while other lines having less height were either seriously damaged or totally destroyed by similar fields when set in motion by the flood.

The forms of construction used in bank protection have been severely tested without failure in a single instance. The cost per square unit is constant within reasonable limits of quantity of work and the circumstances under which it was done, making the items given in the table reliable for combination in estimates for similar work.

Very respectfully, your obedient servant,

D. M. CURRIE,
Assistant Engineer.

TABLE I.—Labor, service of equipment, and material expended in driving piles during the fiscal year ending June 30, 1964.

Location.	Number driven.	Aggregate depth driven.	Linear feet of line.	Hours labor.							Hours equipment service.						
				Overseers.	Suboverseers.	Master pile-drivers.	Engineer pile-drivers.	Master laborers.	Watchmen.	Laborers.	Tow-boats and crew.	Steam launches and crew.	Pile-drivers.	Pile.	Yaws.	Skids.	
Calabria Chute:																	
Hurdle No. 1.....	395	6,100	1,500	63	60	439	419	20	290	3,388	4						
Hurdle No. 2.....	236	3,381	530		95	493	503		558	3,005	6						
Total.....	631	9,481	2,030	63	155	932	922	20	848	6,393	10						
Horsetail Bar, east bank:																	
Secondary hurdle No. 27.....	425	4,948	1,700	70	30	700	670		260	3,900	7						
Secondary hurdle No. 30.....	323	4,719	1,292		30	430	420		130	2,423	4						
Secondary hurdle No. 274.....	492	7,900	1,325	126	65	602	608	50	325	4,107	7						
Secondary hurdle No. 294.....	345	7,732	1,450	71	25	742	744		275	4,035	6						
Carroll's Island Hurdle.....	696	10,286	2,016	264	80	1,119	1,109	200	300	7,205	18						
Total.....	2,481	35,651	7,783	530	330	3,593	3,551	250	1,290	21,680	40						
Twin Hollows, west bank:																	
Primary hurdle.....	280	2,462	767	78	40	314	314	10	181	2,412	3						
Secondary hurdle No. 0.....	155	1,612	590	20		95	95	34	55	886	1						
Secondary hurdle No. 1.....	57	421	250	16		90	90	50	50	381	1						
Secondary hurdle No. 3.....	39	260	128	39		66	96		253	501	1						
Secondary hurdle No. 4.....	78	818	275	62	16	143	133	67	401	945	2						
Total.....	609	5,603	1,920	215	56	708	728	111	940	5,095	8						
Pulllight:																	
Secondary hurdle No. 1.....	220	3,293	960	40	160	260	100	30	100	1,780	2						
Secondary hurdle No. 2.....	370	6,079	1,560	80	10	340	320	30	250	2,880	2						
Secondary hurdle No. 5.....	572	9,125	2,167	315		1,165	1,165	10	750	9,361	5						
Total.....	1,162	19,497	4,687	435	170	1,765	1,585	70	1,100	14,021	9						

TABLE I.—Labor, service of equipment, and material expended in driving piles during the fiscal year ending June 30, 1884—Continued.

Location.	Number driven.	Aggregate depth driven.	Linear feet of line.	Hours labor.							Hours equipment service.					
				(Overseers.	Suboverseers.	Master pile-drivers.	Engineer pile-drivers.	Master laborers.	Watchmen.	Laborers.	Tow-boats and crew.	Steam launches and crew.	Pile-drivers.	Klats.	Trawl.	Skiffs.
Chesley Island Hurdle.....	305	4,083	900	50	.....	610	620	70	90	3,736	10	.....	400	50	560	1,950
Jim Smith's:																
Primary hurdle.....	601	8,820	2,073	271	161	699	719	80	680	6,713	8	49	588	1,760	.....	3,000
Secondary hurdle No. 1.....	218	2,659	950	43	10	198	198	.....	50	1,675	2	19	159	.....	.....	630
Total.....	909	11,479	3,023	314	171	897	917	80	730	8,388	10	68	747	1,760	.....	3,650
Grand total.....	6,067	84,794	20,343	1,607	782	8,505	8,323	601	4,498	59,313	87	360	6,055	2,735	1,170	16,254

TABLE I.—Labor, service of equipment, and material expended in driving piles during the fiscal year ending June 30, 1884—Continued.

MATERIAL.															
Location.	Piles.						Rope.						Spikes.		Miscellaneous.
	30 to 35 feet.		36 to 45 feet.		46 to 60 feet.		Manilla, 1-inch.	Manilla, assorted sizes.	Sisal, 1-inch.	Sisal, 1-inch.	Sisal, 1-inch.	Sisal hide.	Iron, round, 1/2-inch.		
	Sticks.	Linear feet.	Sticks.	Linear feet.	Sticks.	Linear feet.							6-inch.	8-inch.	
Cahokia Chute:															
Hurdle No. 1.....	215	7,236	178	6,946	2	95									\$23 07
Hurdle No. 2.....	32	1,051	160	6,431	34	1,649									12 00
Total	247	8,287	338	13,377	36	1,744									35 07
Horsetail Bar, east bank:															
Secondary hurdle No. 27.....	156	4,782	226	8,974	48	2,380	54	250	45						23 21
Secondary hurdle No. 30.....	185	5,534	135	5,383	3	155	35	148	74						17 40
Secondary hurdle No. 27 1/2.....	33	1,089	361	14,309	125	6,288		805	200						625 14 50
Secondary hurdle No. 29 1/2.....	117	3,898	348	14,351	54	2,592		784	25						700 18 18
Carroll's Island Hurdle.....	191	5,985	391	14,891	107	5,347	18	1,090	175						801 21 31
Total	682	21,288	1,461	57,908	337	16,762	107	3,086	519						94 60
Twin Hollows, west bank:															
Primary hurdle.....	80	2,617	155	6,338	45	2,189		50							275 10 25
Secondary hurdle No. 0.....	106	3,313	39	1,886	10	490									35 3 00
Secondary hurdle No. 1.....	51	1,507	6	252											60
Secondary hurdle No. 3.....	23	703	15	580	1	53		50							70 31 22
Secondary hurdle No. 4.....	28	932	43	1,886	7	340		100							140 59 40
Total	288	9,072	258	10,642	63	3,042		200							103 97
Pulltight:															
Secondary hurdle No. 1.....	152	5,047	61	2,440	7	344									170 18 62
Secondary hurdle No. 2.....	29	907	292	11,595	45	2,175									329 80
Secondary hurdle No. 5.....	65	2,222	384	15,639	131	6,512									1,460 19 98
Total	246	8,176	737	29,664	183	9,031									1,959 39 40

TABLE II.—Labor, service of equipment, and material expended in placing braces during the fiscal year ending June 30, 1884.

Location.	Hours labor.										Hours service of equipment.					MATERIAL.						
																Pile timber.						
	Number placed.	Linear feet of line.	Overseers.	Suboverseers.	Master pile-drivers.	Engineers pile-drivers.	Master laborers.	Watchmen.	Laborers.	Tow-boys and crew.	Steam launches and crew.	Pile-drivers.	Plats.	Yaws.	Skids.	30 to 35 feet.	36 to 45 feet.	46 to 60 feet.	Linear feet.	Sticks.	Linear feet.	Sticks.
Cahokia Chute:																						
Hurdle No. 1.....	90	595	55		117	117		100	1,074	4		78	270		193	39	1,240	39	1,536	4	188	
Hurdle No. 2.....	115	690	47		290	290		140	1,663	6		155	200		174	77	2,390	47	1,829	5	239	
Total.....	205	1,285	102		407	407		240	2,737	10		233	530		367	116	3,630	86	3,365	9	427	
Horsetail Bar, east bank:																						
Secondary hurdle No. 27.....	144	1,728		40	120	110	90	60	1,385	2		93	780	90	340	54	1,797	45	1,700	1	47	
Secondary hurdle No. 30.....	116	1,392		50	20	20	140	30	1,195	2		27	650	80	290	67	2,116	29	1,110	4	194	
Secondary hurdle No. 27½.....	167	1,320			311	309	150	60	1,762	6	20	187	380		440	63	1,992	79	2,993	25	1,209	
Secondary hurdle No. 29½.....	231	1,325	40	10	257	258	120	110	2,266	6	20	226	450		330	100	3,146	113	4,513	18	918	
Carroll's Island Hurdle.....	418	2,738	150	70	480	420	300	130	4,172	10	25	420	1,560	260	920	225	7,147	158	9,313	75	3,660	
Total.....	1,076	8,503	190	170	1,188	1,117	800	390	10,780	26	65	933	3,820	430	2,320	509	16,198	424	16,629	123	5,028	
Twin Hollows, west bank:																						
Primary hurdle.....	113	767	57		290	300	26	167	1,176	2		245			500	47	1,560	62	2,440	4	203	
Secondary hurdle No. 0.....	44	500	22		128	128		66	470	1		92			200	37	1,185	6	232	1	50	
Secondary hurdle No. 1.....	20	250	7		46	46		33	173			43			100	15	498	5	189			
Secondary hurdle No. 3.....	14	128	4	8	14	14	25	40	224			19			150	11	360	3	110			
Secondary hurdle No. 4.....	23	275	15	8	39	39	20	50	291			32			300	11	435	5	225	7	339	
Total.....	214	1,920	105	16	517	527	71	356	2,334	3		431			1,250	121	4,042	81	3,196	12	592	
Pullright:																						
Primary hurdle.....	76	912	40		180	140	160	120	1,326	1	15	110			180	70	2,140	6	233			
Secondary hurdle No. 1.....	86	960	50	40	130	50	10	160	1,086	1	16	26	50		50	77	2,368	3	115			
Secondary hurdle No. 2.....	132	1,560	50		160	160	230	150	3,466	2	21	108	310		390	64	2,067	65	2,519	8	384	
Secondary hurdle No. 5.....	208	2,067	125		595	590	120	200	2,770	1		244	525		445	73	2,447	136	5,206	3	142	
Total.....	502	5,499	265	40	1,065	940	520	720	8,648	5	52	489	885		1,065	284	9,022	210	8,073	11	526	

TABLE II.—Labor, service of equipment, and material expended in placing braces, &c.—Continued.

Location.	Number placed.	Linear feet of line.	Hours labor.							Hours service of equipment.						MATERIAL.					
			Hours labor.							Hours service of equipment.						Pile timber.					
			Overseer.	Suboverseers.	Master pile-drivers.	Engineers pile-drivers.	Master laborers.	Watchmen.	Laborers.	Tow-boats and crew.	Steam launches and crew.	Pile-drivers.	Plats.	Yaws.	Skiffs.	Sticks.	Linear feet.	30 to 35 feet.	36 to 45 feet.	46 to 60 feet.	Sticks.	Linear feet.
Chesley Island Hurdle.....	172	1,032	20		240	260		10	1,441	4	192	210	210	800	92	3,015	67	2,610	13	652	
Jim Smith's:																					
Primary hurdle.....	211	1,266	133	242	60	205		130	3,063	3	16	235	3,700	130	800	56	1,795	84	3,336	72	3,742
Secondary hurdle No. 1.....	67	950	25		65	65		30	565		7	35	1,000		200	35	1,045	27	1,082	5	248
Total.....	278	2,216	158	242	125	330		160	3,648	3	23	290	4,700	130	1,000	90	2,840	111	4,718	77	3,900
Grand total.....	2,447	20,455	840	468	3,542	3,581	1,391	1,870	20,588	51	140	2,588	10,145	770	6,802	1,202	38,747	979	38,291	245	72,215

TABLE II.—Labor, service of equipment, and materials expended in placing braces, &c.—Continued.

Location.	MATERIAL.																								
	Rope.			Wire.		Spikes.			Drift-bolts.				Screw-bolts.			Clevises.				Coal.	Miscellaneous.				
	Manila, assorted sizes.	Steel, 8-inch.	Steel, 2-inch.	Steel, hide.	No. 8.	No. 12.	6-inch.	8-inch.	10-inch.	12-inch.	14-inch.	15-inch.	18-inch.	1-inch ring-bolts.	18-inch.	20-inch.	24-inch.	12-inch.	14-inch.			16-inch.	18-inch.	24-inch.	
Cahokia Chute:	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	Bush.		
Hurdle No. 1.....											24	25	50					22	60	52		6	136	\$12 50	
Hurdle No. 2.....											26	15	80					22	59	48		6	324	11 00	
Total.....											50	40	130					22	119	100		6	460	23 50	
Horsetail bar, east bank.....																									
Secondary hurdle No. 27.....	49								105							10			57	70			109	5 80	
Secondary hurdle No. 30.....	25	60							190				236					27	58	11			544	5 80	
Secondary hurdle No. 27½.....									50				219		87			44	72	45	18		200	7 86	
Secondary hurdle No. 29½.....									65				236	245	13	20	79		40	51	64		132	1 39	
Carroll's Island Hurdle.....	74	140	95						360				700	13	107	79	10	136	403	363	18		521½	7 01	
Total.....	148	200	95						50	423													1,016½	27 86	
Twin Hollows, west bank:																									
Primary hurdle.....	50			20				75	95		46				86	27	34	53					265	5 81	
Secondary hurdle No. 0.....															45								26	85	
Secondary hurdle No. 1.....															20								18	45	
Secondary hurdle No. 3.....	50							65							20								12	20	
Secondary hurdle No. 4.....	100							14	50						4	10	11	2					16	40	
Total.....	200			20				89	210		46				155	37	45	134					167	455	
Pulltight:																									
Primary hurdle.....											30		69					49	81				50	8 73	
Secondary hurdle No. 1.....											72		20					40	28	34	18		60		
Secondary hurdle No. 2.....											155		34						72	12	50		200	4 15	
Secondary hurdle No. 5.....											38	10	46					81	43	86	75	9	310	5 10	
Total.....											295	10	169					81	43	119	229	134	143	620	17 98

TABLE II.—Labor, service of equipment, and material expended in placing braces, &c.—Continued.

MATERIAL.																								
Location.	Rope.				Wire.		Spikes.		Drift-bolts.				Screw-bolts.			Clevises.					Washers.	Coal.	Miscellaneous.	
	Mantle, assorted sizes.	Steel, 8-inch.	Steel, 4-inch.	Steel hide.	No. 9.	No. 12.	6-inch.	8-inch.	10-inch.	12-inch.	14-inch.	15-inch.	18-inch.	1-inch ring-bolts.	18-inch.	20-inch.	24-inch.	12-inch.	14-inch.	16-inch.				18-inch.
Chesley Island Hurdle	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	Bush.	19 50
Jim Smith's					100			25				223								198	16			327 29 65
Primary hurdle												101								55	26			122 5 00
Secondary hurdle No. 1					100			25				324								253	42			449 34 65
Total					100			25				324								253	42			449 34 65
Grand total	348	261	35	20	100	300	80	285	423	345	326	1,343	37	262	134	189	330	444	702	945	83	6	167 3,134	169 40

TABLE III.—Labor, service of equipment, and material expended in placing stringers during the fiscal year ending June 30, 1884.

Location.	Number placed.	Linear feet of line.	Hours labor.							Hours service of equipment.				
			Overseers.	Suboverseers.	Master pile-drivers.	Engineer pile-drivers.	Master laborers.	Watchman.	Laborers.	Tow-boats and crew.	Steam launches and crew.	Pile-drivers.	Plats.	Yaws.
Cahokia Chute:														
Hurdle No. 1.....	43	850	11		53	58		20	537	1		58	130	84
Hurdle No. 2.....	32	490		10	183	173		82	1,011	1		143	240	164
Total.....	75	1,340	11	10	236	231		102	1,548	2		201	370	248
Horsetail Bar, east bank:														
Secondary hurdle No. 27.....	55	1,273		30	20	20	120	30	1,002			18	703	330
Secondary hurdle No. 30.....	50	1,465		20	10	10	140	30	1,085			7	630	250
Secondary hurdle No. 27A.....	74	1,320			252	282	150	100	1,568	5	20	141	300	370
Secondary hurdle No. 29A.....	84	1,450			224	224	40	70	1,337	5	20	151	220	490
Carroll's Island Hurdle.....	348	5,018	120	310	571	591	470	170	8,594	10	20	410	2,710	2,132
Total.....	611	10,526	120	360	1,077	1,127	920	400	13,586	20	60	730	5,620	3,602
Twin Hollows, west bank:														
Primary hurdle.....	91	767	64		326	326	41	108	1,265	2		248		250
Secondary hurdle No. 0.....	21	500	8		80	80		66	324			58		200
Secondary hurdle No. 1.....	11	250	5		29	29		23	111			27		50
Secondary hurdle No. 3.....	25	625	17	47	70	10	40	30	649	1				120
Secondary hurdle No. 4.....	47	1,605	45	100	48	48	43	50	1,164	1		41		200
Total.....	195	3,747	139	147	493	493	124	373	3,513	4		374		820
Pulltight:														
Secondary hurdle No. 2.....	42	1,560	30		170	170		90	730		23	125	200	170
Secondary hurdle No. 5.....	92	2,067	100		305	245	110	260	2,672	1		149	275	260
Total.....	134	3,627	130		475	415	110	350	3,402	1	23	275	475	430
Chesley Island Hurdle.....	121	1,560	60		280	290	20	20	2,338	6		197	240	930

TABLE III.—Labor, service of equipment, and material expended in placing stringers, &c.—Continued.

Location.	Number placed.		Linear feet of line.		Hours labor.								Hours service of equipment.					Skills.
					Overseers.	Suboverseers.	Master pile-drivers.	Engineer pile-drivers.	Master laborers.	Watchman.	Laborers.	Tow-boat and crew	Steam launches and crew.	Pile-drivers.	Plots.	Yaws.		
Jim Smith's:																		
Primary hurdle.....	115		1,260		111	190	122	267		40	2,149	2	21	277	3,600	200	1,000	
Secondary hurdle No. 1.....	28		950		20		72	72		70	579	1	5	67	450		200	
Total.....	143		2,210		131	190	194	339		110	2,728	3	26	344	4,050	200	1,200	
Grand total.....	1,279		23,010		591	707	2,755	2,895	1,174	1,345	27,115	36	109	2,121	10,753	1,175	7,230	

TABLE III.—Labor, service of equipment, and material expended in placing stringers, &c.—Continued.

MATERIAL.																			
Location.	Pile timber.						Rope.				Bolts, drift, 18-inch.	Screw-bolts.				Coal.	Miscellaneous.		
	30 to 35 feet.		36 to 45 feet.		46 to 60 feet.		Manilla, assorted sizes.	Sisal 1/4-inch.	Sisal 3/8-inch.	Sisal hide.		Spikes, 10-inch.	18-inch.	20-inch.	22-inch.			24-inch.	Washers.
	Sticks.	Linear feet.	Sticks.	Linear feet.	Sticks.	Linear feet.													
Cahokia Chute:																			
Hurdle No. 1.....	8	244	10	414	13	621	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	No.	No.	No.	No.	Bush.	\$1 50		
Hurdle No. 2.....	13	434	23	913	3	145										74	1 75		
Total	21	678	33	1,327	16	766										217	3 25		
Horsetail Bar, east bank:																			
Secondary hurdle No. 27....	15	501	39	1,442	9	453	12										5 80		
Secondary hurdle No. 30....	32	1,151	14	521	2	116	12										5 80		
Secondary hurdle No. 27 1/2....	9	282	29	1,289	34	1,717		60			130						7 35		
Secondary hurdle No. 29 1/2....	18	571	37	1,490	29	1,453			85								3 53		
Carroll's Island Hurdle	171	5,848	134	5,200	77	3,724	50	174	200								25 34		
Total	245	8,353	253	9,922	151	7,463	74	234	377		130					1,163	47 82		
Twin Hollows, west bank:																			
Primary hurdle.....	54	1,668	15	598	22	1,132				20							4 40		
Secondary hurdle No. 0.....	7	235	11	449	3	146											1 00		
Secondary hurdle No. 1.....	8	212	1	38	2	100											20		
Secondary hurdle No. 3.....	18	552	6	163	1	48											19 18		
Secondary hurdle No. 4.....	35	1,179	8	317	4	187											55 40		
Total	122	3,846	41	1,565	32	1,613				20						691	79 98		
Pulltight:																			
Secondary hurdle No. 2.....	2	68	27	1,102	24	1,164											1 74		
Secondary hurdle No. 5.....	38	1,209	38	1,626	12	601											2 50		
Total	40	1,277	65	2,628	36	1,765											4 24		
Chesley Island Hurdle	47	1,523	49	1,894	24	1,270		155	161							100	15 50		

TABLE IV.—Labor, service of equipment, and material expended fabricating foundation mattress during the fiscal year ending June 30, 1884.

Location.	Work done.		Hours labor.							Hours equipment.					
	Linear feet.	Square feet.	Overboats.	Suboverboats.	Master drivers.	Engineer drivers.	Master laborers.	Watchmen.	Laborers.	Low-boats and crows.	Laniches.	Large floats.	Flats.	Yaws.	Skins.
Cahokia:															
	Hurdle No. 1.....	825	46,000	100			70	340	3,930	7	9	180	480	170	180
	Hurdle No. 2.....	380	44,800				132	230	5,228	8		581	1,070	421	382
Total.....	1,405	90,800	109	442			202	570	9,158	15	9	771	1,550	591	562
Horsetail Bar, east bank:															
	Secondary hurdle No. 27.....	795	26,500	30	140			20	1,289	8			540	170	670
	Secondary hurdle No. 30.....	1,100	34,900		190		30	30	1,922				1,900	230	870
	Secondary hurdle No. 27½.....	1,435	114,225	95	365			260	7,689	3	50		2,680	530	700
	Secondary hurdle No. 29½.....	1,478	118,240	105	340		70	250	7,588	3	50		3,030	760	800
	Carroll's Island Hurdle.....	1,900	135,050	60	370		90	110	6,154	6	45		2,530	670	920
Total.....	6,708	448,915	290	1,405			190	670	24,062	17	145		11,680	2,320	3,960
Twin Hollows, west bank:															
	Primary hurdle.....	210	9,450	75	113		132	75	2,474	4			2,250	600	250
	Secondary hurdle No. 0.....	636	28,170	89	134		2	102	2,634	3			2,600	400	60
	Secondary hurdle No. 1.....	238	7,140	36	52			50	1,157				1,000	200	50
	Secondary hurdle No. 3.....	128	4,490	21	35				316				1,350	250	35
	Secondary hurdle No. 4.....	299	10,065	37	112		40		930	1			2,000	400	250
Total.....	1,501	59,315	258	446			174	227	7,511	8			8,600	1,850	645
Pullditch:															
	Primary hurdle.....	30	900		100		10		90						10
	Secondary hurdle No. 1.....	980	39,500	60	100			170	1,587	1	20		1,200	150	770
	Secondary hurdle No. 2.....	1,630	81,000	150	260			450	4,114	3	92		4,350	910	2,010
	Secondary hurdle No. 5.....	2,157	127,900	485	915		90	1,065	17,633	3	23		4,722	422	1,720
Total.....	4,797	249,300	695	1,275	40	40	100	1,655	23,423	7	135		10,362	1,542	4,510
Chesley Island Hurdle															
	465	17,745	140				130		1,775	4			1,680	140	300

TABLE IV.—Labor, service of equipment, and material expended fabricating foundation mattress, &c.—Continued.

Location.	Work done.		Hours labor.						Hours equipment.						
	Linear feet.	Square feet.	(Overseers.	Suboverseers.	Master drivers.	Engineer drivers.	Master laborers.	Watchmen.	Laborers.	Tow-boys and crews.	Launches.	Barge-days.	Plats.	Yaws.	Skins.
Jim Smith's:															
Primary hurdle	1,250	62,500	120	250			10	150	5,811	7	17		2,900	1,260	1,100
Secondary hurdle No. 1	950	28,500	62	62			20	30	2,800	3	15		1,900	200	500
Total	2,200	91,000	182	312			30	180	8,611	10	32		4,800	1,460	1,600
Grand total	17,076	957,075	1,674	3,880	40	40	826	3,332	74,541	61	321	771	38,672	7,843	11,577

TABLE IV.—Labor, service of equipment, and material expended fabricating foundation mattresses, etc.—Continued.

[illegible]

TABLE V.—Labor, service of equipment, and material expended sinking foundation mattress during the fiscal year ending June 30, 1884.

Location.	Work done.		Hours labor.						Hours equipment.					Material.		
	Linear feet.	Square feet.	Overseers.	Suboverseers.	Master drivers.	Engineer drivers.	Master laborers.	Watchmen.	Laborers.	Tow-boys and crew.	Launches.	Plats.	Vauls.		Skins.	
Cahokia:																
Hurdle No. 1.....	825	46,000	5	40	40		10	60	867	1		70	40	30	Cu. yards.	
Hurdle No. 2.....	580	44,800	54				34	50	1,405	2		150	147	172	426.5	
Total	1,405	90,800	5	94	40		44	110	2,272	3		220	187	202	770.5	
Horsetail Bar, east bank:																
Secondary hurdle No. 27.....	795	26,500		80				20	867						309.8	
Secondary hurdle No. 30.....	1,100	34,900		100				30	1,062						335.5	
Secondary hurdle No. 274.....	1,435	114,225	10	45		20	20	20	1,557	2	5	180	190	80	546.1	\$1 07
Secondary hurdle No. 294.....	1,478	118,240	50	50		50	10	10	1,791	1	5	200		90	719.4	1 55
Carroll's Island Hurdle.....	1,900	155,050	10	90		20	10	10	2,271	2	7	200	90		887.0	80
Total	6,708	448,915	20	305			90	90	7,548	5	17	580	280	170	2,837.8	4 02
Twin Hollows, west bar:																
Primary hurdle.....	210	9,450	27				15	20	685						488.5	
Secondary hurdle No. 0.....	626	28,170	23	35				34	677						329.9	
Secondary hurdle No. 1.....	238	7,140	12	18				14	293						170.5	
Secondary hurdle No. 3.....	128	4,490	2	5			53		431						35.0	
Secondary hurdle No. 4.....	299	10,065	32	67			15	40	371						210.3	
Total	1,501	59,215	96	125			83	108	2,057						1,234.2	
Pultight:																
Primary hurdle.....	30	900														
Secondary hurdle No. 1.....	980	39,500		40	30				810						246.7	
Secondary hurdle No. 2.....	1,630	81,000		90			30		1,782						472.0	
Secondary hurdle No. 5.....	2,157	127,900	185	275	60	110	190	485	6,730			20	345	63	1,226.0	
Total	4,797	249,300	185	405	90	140	220	485	9,322			130	345	69	1,944.7	
Chesley Island Hurdle.....	465	17,745	20	40					825						625.8	

TABLE V.—Labor, service of equipment, and material expended sinking foundation mattress, &c.—Continued.

Location.	Work done.		Hours labor.						Hours equipment.					Material.		
	Linear feet.	Square feet.	(Overseers.	Suboverseers.	Master drivers.	Engineer drivers.	Master laborers.	Watchmen.	Laborers.	Pow-boats and crew.	Launches.	Flots.	Yaws.	Skills.	Stone.	Miscellaneous.
Jim Smith's:															Cu. yards.	
Primary hurdle.....	1,250	62,500		70			10		1,195						375.4	
Secondary hurdle No. 1.....	950	28,500	23	40			20		578						318.6	
Total.....	2,200	91,000	23	110			30		1,773						694.0	
Grand total.....	17,076	957,675	349	1,139	130	140	467	793	24,398	8	147	1,145	536	536	8,108.0	\$4 02

TABLE VI.—Labor, service of equipment and material expended rattling during the fiscal year ending June 30, 1884.

Location.	Work done.		Hours labor.							Hours equipment.					
	Linear feet.	Square feet.	Overseers.	Suboverscers.	Master drivers.	Engineer drivers.	Master laborers.	Watchmen.	Laborers.	Tow-boys and crew.	Launches.	Pile-drivers.	Plats.	Yaws.	Skids.
Cahokia:															
Hurdle No. 1.....	650	7,250	50	140	20			170	1,508	2	10		58	20	40
Hurdle No. 2.....	600	8,400	40	100	100				654	2	5		25		
Total.....	1,250	15,650	90	240	120			170	2,162	4	15		83	20	40
Horsetail Bar, east bank:															
Secondary hurdle No. 27.....	1,780	30,110		300				40	3,851	5			2,050	340	1,340
Secondary hurdle No. 30.....	1,465	23,215		210			10	30	2,944	4			1,880	220	1,950
Carroll's Island Hurdle.....	1,970	16,420	50	240	30	30		40	3,458	4			3,060	330	1,590
Total.....	4,215	69,745	50	750	30	30	10	110	10,253	13			7,020	890	3,880
Twin Hollows, west bank:															
Private Hurdle.....	767	19,209	145	248				195	4,349	4			5,010	1,000	450
Secondary hurdle No. 0.....	625	10,250	39	65				54	1,483	1			2,000	450	80
Secondary hurdle No. 1.....	254	4,937	28	38				19	652	1			700	200	40
Secondary hurdle No. 3.....	648	7,837	77	104				245	1,509	1			1,500	350	
Secondary hurdle No. 4.....	712	8,427	57	122			20	52	4,463	2			2,000	450	250
Secondary hurdle No. 5.....	90	1,350	3	7					90				600	150	80
Total.....	3,096	52,010	349	584			20	565	9,546	9			11,800	2,600	900
Pulltight:															
Private hurdle.....	2,580	25,000	100	160				280	4,572	3	18		2,760		1,180
Secondary hurdle No. 1.....	1,960	13,000	30	90	100	80		30	2,428	2	20		1,230	90	240
Secondary hurdle No. 2.....	1,560	19,000	100	90			10	300	1,607	1	120		4,000	310	120
Secondary hurdle No. 5.....	987	20,000	70	40	70		150	110	3,187	2	46		1,830	210	560
Total.....	6,087	77,000	300	380	170	80	380	780	11,794	8	213		9,820	610	1,800
Chesley Island Hurdle.....	435	5,100	80				50		1,334	2			320	80	280

TABLE VI.—Labor, service of equipment and material expended waiting, &c.—Continued.

Location.	Work done.		Hours labor.								Hours equipment.				
	Linear feet.	Square feet.	Overseers.	Suboverseers.	Master drivers.	Engineer drivers.	Master laborers.	Watchmen.	Laborers.	Tow-boys and crew.	Lantern-bearers.	Pile-drivers.	Plats.	Yaws.	Skids.
Jim Smith's:															
Private hurdle	2,200	34,500	115	240	34	34	180	40	8,494	6	56	35	5,500	1,050	1,830
Secondary hurdle No. 1	956	18,050	55	15	20	20	90	80	2,639	12	7	20	2,400	370	370
Total	3,156	52,550	170	255	54	54	270	120	11,133	18	63	55	7,900	1,420	2,200
Grand total	18,233	272,655	1,039	2,209	374	164	730	1,745	46,252	44	291	55	36,943	5,620	9,160

TABLE VI.—Labor, service of equipment and material expended waiting, &c.—Continued.

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TABLE VII.—Labor, service of equipment, and material expended in constructing curtains during the fiscal year ending June 30, 1884.

Labor, equipment, material, &c.	Horsetail Bar, east bank.		Total.
	Secondary hurdle No. 30.	Secondary hurdle No. 27.	
Work done:			
Linear feet.....	866	950	1,816
Square feet.....	9,842	8,170	18,012
Hours labor:			
Suboverseer.....	150	30	180
Watchmen.....	20	20	40
Laborers.....	1,564	524	2,088
Hours equipment:			
Tow-boats and crew.....	2	1	3
Flats.....	540	620	1,160
Yaws.....	170	70	240
Skiffs.....	760	280	950
Material:			
Brush, cords.....	70	50	120
Nails, 10-penny.....	109		109
Nails, 20-penny.....	30		30
Miscellaneous.....	\$3 50	\$2 30	\$5 80

TABLE VIII.—*Labor, service of equipment, and material expended constructing cribs, during the fiscal year ending June 30, 1884.*

Labor, equipment, material, &c.		Twin Hollows, west bank.				Total.
		Secondary hur- dle No. 2.	Secondary hur- dle No. 3.	Secondary hur- dle No. 4.	Secondary hur- dle No. 5.	
Work done:						
Linear feet		125		190	90	425
Square feet		1, 250		5, 535	1, 260	8, 045
Hours labor:						
Overseers		11		196	26	233
Suboverseers				252	144	396
Master drivers		52				52
Engineer drivers		52				52
Master laborers				340	30	370
Watchmen		42		351	19	412
Laborers		274		3, 167	1, 344	4, 785
Hours equipment:						
Tow-boats and crew				4	2	6
Pile-drivers		40		249		289
Barges				710		710
Plats				5, 200	900	6, 100
Yaws				1, 070	300	1, 370
Skiffs				500	140	640
Material:						
Piles, 30 to 35 feet	{ sticks	17			14	31
	{ feet	523			425	948
Piles, 36 to 45 feet	{ sticks	8			9	17
	{ feet	317			354	671
Piles, 46 to 60 feet	{ sticks	1				1
	{ feet	51				51
Stone	cubic yards	131. 0		470. 8	85. 0	687. 4
Rope, manila, assorted sizes	pounds		500	5, 255	2, 000	7, 755
Wire, No. 14	do				35	35
Nails, 20-penny	do				6	6
Spikes, 6-inch	do				45	45
Spikes, 8-inch	do				95	98
Spikes, 10-inch	do				53	53
Screw-bolts, 18-inch	number	7			24	31
Screw-bolts, 20-inch	do				34	34
Screw-bolts, 24-inch	do	40			34	74
Washers	do	36			83	119
Clevises, 18-inch	do	33			46	79
Coal	bushels	70		150		220
Miscellaneous		\$1 00		\$25 00	\$40 00	\$65 00

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TABLE IX.—Labor, service of equipment, and material expended in incidental work during the fiscal year ending June 30, 1884.

CONSTRUCTING HURDLES.

Location.	Hours labor.						
	Overseers.	Suboverseers.	Master drivers.	Engineer drivers.	Master laborers.	Watchmen.	Laborers.
Cahokia Hurdle No. 2.....		9	95	95	34	40	1,254
Horsetail Bar:							
East bank.....	40	70	305	305	10	870	3,030
East bank, secondary hurdle No. 27.....	10	70	60	60		110	548
East bank, secondary hurdle No. 30.....		60	20	20	10		584
East bank, secondary hurdle No. 27½.....			171	165			785
East bank, secondary hurdle No. 20½.....			256	255			1,195
East bank, Carroll's Island Hurdle.....			30	30			118
Pulltight, secondary hurdle No. 5.....	35	10	60	60	10	50	1,327
Chesley Island Hurdle.....	90				100	200	1,496
Jim Smith's:							
Primary.....	20	40	20				229
Secondary hurdle No. 1.....	40	30			20	70	559
Total.....	235	280	1,017	990	184	1,340	11,125

Location.	Hours equipment.						Material.
	Tow-boats and crew.	Launches.	Pile-drivers.	Flats.	Yaws.	Skiffs.	
Cahokia Hurdle No. 2.....	2		81	180	27	120	Bush.
Horsetail Bar:							
East bank.....	34						\$4 25
East bank, secondary hurdle No. 27.....			49				
East bank, secondary hurdle No. 30.....			10				
East bank, secondary hurdle No. 27½.....			146			190	2 29
East bank, secondary hurdle No. 20½.....			194			235	2 45
East bank, Carroll's Island Hurdle.....			140			10	
Pulltight, secondary hurdle No. 5.....	17						
Chesley Island Hurdle.....			28			32	6 50
Jim Smith's:							
Primary.....		12					
Secondary hurdle No. 1.....		16					
Total.....	53	28	618	180	27	120	467 15 49

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TABLE XII.

LOW-WATER PROTECTION—CONSTRUCTING MATTRESS.

Labor, equipment, &c.	Horsetail Bar, west bank.	Foster's Island.	Total.
Work done:			
Linear feet	3,880	5,284	9,164
Square feet	388,000	634,080	1,022,080
Hours labor:			
Overseers	468	647	1,115
Suboverseers	616		616
Master drivers	265	447	712
Engineer drivers	235	13	248
Master laborers	500	900	1,400
Watchmen	1,280	1,700	2,989
Laborers	25,292	35,898	61,190
Hours equipment:			
Tow-boats and crew		33	33
Mattress-barges	1,122	970	2,092
Flats	4,050	8,290	12,340
Yaws	1,070	2,700	4,760
Skiffs	1,230	4,050	5,280
Material:			
Brush	2,608.8	4,702.3	7,311.1
Rope, manila, assorted sizes	601	122	723
Rope, sisal, 3-inch		165	165
Rope, sisal, 3-inch	192	240	432
Rope, sisal, 3-inch	372	458	830
Rope, sisal, hido		31	31
Wire, No. 9	301	1,685	1,986
Wire, No. 12	7,752	7,380	15,141
Nails, 6-penny	30		30
Nails, 8-penny	30		30
Nails, 10-penny	100	46	146
Nails, 20-penny	520	635	1,155
Spikes, 6-inch	2,016	2,462	4,478
Spikes, 8-inch	686	2,460	3,146
Miscellaneous	\$45 30	\$102 65	\$147 95

TABLE XIII.

LOW-WATER PROTECTION—SINKING MATTRESS.

Labor, &c.	Horsetail Bar, west bank.	Foster's Island.	Total.
Work done:			
Linear feet	3,880	5,284	9,164
Square feet	388,000	634,080	1,022,080
Hours labor:			
Overseers	80	179	259
Suboverseers	19	13	32
Master drivers	6	10	16
Engineer drivers	6	2	8
Master laborers	45	20	65
Watchmen	131	66	197
Laborers	2,260	1,112	3,372
	8		8
	949	1,010	1,959
	1,104	910	2,014
	290		290
	70		70
	1,107.4	1,552.7	2,660.1

TABLE XIV.

MEDIUM STAGE PROTECTION—REVTMENT.

Labor, &c.	Horseshall Bar, west side.	Twin Hollows, east side.	Cheesley Island.	Foster's Island.	Total.
Work done:					
Linear feet.....	3,080	2,000	4,885	5,284	16,149
Square feet.....	68,914	106,140	132,240	228,600	535,954
Hours labor:					
Overseers.....	100		500	234	894
Suboverseers.....	110	340			450
Master laborers.....			500	690	1,190
Watchmen.....	340	340	400	539	1,619
Laborers.....	2,340	4,438	6,638	8,735	22,151
Hours equipment:					
Tow-boats and crew.....	4	5	11	7	27
Barge-flats.....				60	60
Flats.....	620	340	1,380	1,080	3,420
Yaws.....	620	680	1,230	540	3,070
Skiffs.....	220	680	3,070		3,070
Material:					
Rope, sisal, 2-inch..... pounds..		12			12
Stone..... cubic yards..	2,219.7	3,212.0	3,977.0	6,121.8	15,532.3
Nails, 20-penny..... pounds..			25		25
Miscellaneous.....		\$5.50		\$25.35	\$30.85

TABLE XV.—Consolidated statement of labor, service of equipment, and material expended in construction during fiscal year ending June 30, 1884.

HURDLES.

Labor, equipment, &c.	Incidental work.	Driving piles.	Placing braces.	Placing stringers.	Cribs, constructing.	Foundation mattress, constructing.	Foundation mattress, sinking.	Wattling.	Curtains.	Total.
Details in table.....	IX.	I.	II.	III.	VIII.	IV.	V.	VI.	VII.	
WORK DONE.										
Number.....		6,087	2,447	1,270						
Aggregate depth driven.....		84,794								
Linear feet of line.....		20,343	20,455	23,010	405	17,070	17,070	18,233	1,816	
Square feet.....					8,405	957,075	957,075	272,655	18,012	
HOURS LABOR.										
Overseers.....	235	1,607	840	591	233	1,674	249	1,039		6,568
Suboverseers.....	280	782	468	707	396	3,880	1,139	2,209	180	10,050
Master pile-drivers.....	1,017	8,505	3,542	2,755	52	40	130	374		16,415
Engineer pile-drivers.....	990	8,323	3,581	2,895	52	40	140	164		16,185
Master laborers.....	184	801	1,391	1,174	370	826	467	730		5,743
Watchmen.....	1,340	4,098	1,876	1,315	412	3,332	793	1,745	40	15,881
Laborers.....	11,125	59,313	29,588	27,115	4,785	74,541	24,308	46,252	2,088	279,205
HOURS SERVICE, EQUIPMENT.										
Tow-boats and crew.....	53	88	50	36	0	61	8	44	3	349
Steam-launches.....	28	360	140	109		321	147	281		1,396
Pile-drivers.....	648	6,055	2,588	2,121	280			55		11,758
Barges.....					710					710
Barge-flats.....						771				771
Flats.....	180	2,735	10,145	10,755	6,100	38,672	1,145	36,943	1,160	107,835
Yaws.....	27	1,170	770	1,175	1,370	7,843	536	5,620	240	18,751
Skiffs.....	120	16,254	6,802	7,230	640	11,577	636	9,100	950	53,209

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TABLE XV.—Consolidated statement of labor, service of equipment, and material expended in construction during fiscal year ending June 30, 1884—Continued.

HURDLES—Continued.

Labor, equipment, &c.	Incidental work.	Driving piles.	Placing braces.	Placing stringers.	Cribs, constructing.	Foundation mattress, constructing.	Foundation mattress, sinking.	Wadding.	Curtains.	Total.
MATERIAL.										
Brush..... cords						5,303.7		1,550.6	120.0	7,004.3
Pile timber:										
30 to 35 feet..... { sticks.....	1,870	1,212	507	31						3,620
{ lin. feet.....	58,374	38,747	10,729	948						114,798
36 to 45 feet..... { sticks.....	3,387	970	502	17						4,885
{ lin. feet.....	135,143	38,291	10,741	671						193,846
46 to 60 feet..... { sticks.....	850	245	209	1						1,305
{ lin. feet.....	42,573	12,215	15,091	51						69,933
Stone..... cubic yards					687.4		8,108.0			8,795.4
Rope:										
Manila, $\frac{1}{2}$ inch..... pounds		107								107
Manila, assorted sizes, pounds		5,259	348	74	7,755	875				14,311
Sisal, $\frac{1}{2}$ inch..... pounds		604	261	389		370		984		1,782
Sisal, $\frac{3}{4}$ inch..... do		516				783				1,299
Sisal, $\frac{1}{2}$ inch..... do		850	95	809		3,614				5,428
Sisal, hide..... do		30	20	20		230		1,300		1,600
Wire:										
No. 9..... do			100			775		50		925
No. 12..... do			300			4,643				5,003
No. 14..... do					35	4,277		1,715		6,027
Iron, round, $\frac{1}{2}$ inch..... do		859								859
Nails:										
6-penny..... do						10				10
8-penny..... do								100		100
10-penny..... do						510		214	100	833
20-penny..... do						6	2,983	1,380	30	4,399
Spikes:										
6-inch..... do		4	89		45	4,318		405		4,851
8-inch..... do		608	285		98	3,309		90		4,459
10-inch..... do			423	130	53			80		686
Bolts, drift:										
12-inch..... number			345							345
14-inch..... do			326							326
15-inch..... do			1,343							1,343
18-inch..... do			63	100						163
Bolts, ring..... do			202							202
Bolts, screw:										
18-inch..... do			134	1,282	31					1,447
20-inch..... do			189	2,703	34					2,926
22-inch..... do				30						30
24-inch..... do			339	2,187	74					2,600
Clevises:										
12-inch..... do			448							448
14-inch..... do			702							702
16-inch..... do			945		79					1,024
18-inch..... do			83							83
24-inch..... do			6							6
Washers..... do			167	691	119					977
Coal..... bushels	46,788	514	3,134	2,941	220					15,276
Miscellaneous..... dollars	15 49	390 89	169 40	178 04	66 00	279 48	4 02	225 22	5 80	1,334 34

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TABLE XVI.—Consolidated statement of labor, service of equipment, &c.—Continued.

BANK PROTECTION.—Continued.

Labor, equipment, &c.	Incidental work.	Driving piles.	Constructing mat- tresses.	Sinking mattresses.	Revetment.	Total.	Total expended on hurdles.	Grand total.
MATERIAL.—Cont'd.								
Bolts:								
Drift, 12-inch... number							345	345
Drift, 14-inch... do							326	326
Drift, 15-inch... do		39				39	1,343	1,382
Drift, 18-inch... do							163	163
Ring... do							262	262
Screw, 18-inch... do							1,447	1,447
Screw, 20-inch... do							2,026	2,026
Screw, 22-inch... do							30	30
Screw, 24-inch... do							2,600	2,600
Clevises:								
12-inch... do							448	448
14-inch... do							702	702
16-inch... do							1,024	1,024
18-inch... do							83	83
24-inch... do							0	0
Washers... do							977	977
Coal... bushels		800				800	15,270	16,076
Miscellaneous	\$3 35	\$20 48	\$147 95		\$30 85	\$202 62	\$1,334 34	\$1,539 97

TABLE XVII.—Labor, service of equipment, and material not shown in tables of construction.

ENGINEERING.

Location.	Hours labor.						Hours equipment.				Material.		
	Assistant engi- neers.	Clerks.	Overseers.	Suboverscers.	Master laborers.	Watchmen.	Laborers.	Tow-boats and crew.	Launchers and crew.	Yawls.	Skiffs.	Coal.	Miscellaneous.
General engineering	7,200						300	261				<i>Bus.</i>	
Cahokia	2,950						461		5		360		
Horsetail Bar:													
West bank	2,000						465					25	\$7 45
East bank	11,700		10	30		70	1,186			330	172	20	8 79
Twin Hollows:													
West bank	5,170	2,210			6	50	286					85	0 46
East bank	1,260												
Pulltight	7,710					100	360		20		510		15 10
Chesley Island:													
Hurdle	1,730				100		73					10	2 00
Bank protection	1,830				100		62						1 00
Jim Smith's	4,800					770	360		26				
Foster's Island	4,700					226	303						5 00
Total	52,040	2,210	10	30	206	1,216	3,796	261	51	330	1,040	140	48 80

TABLE XVIII.—Labor, service of equipment, and material not shown in table of construction.

SUBSISTENCE.

Equipment, &c.	Hours labor.					Hours service of equipment.					Material.			
	Boarding masters.	First cook.	Second cook.	Waiters.	Laborers.	Barge flats.	Quarter boats.	Flats.	Yawls.	Skiffs.	Portable shanties, sections.	Rations.	Coal.	Miscellaneous.
												No.	Bus.	
Tow-boats.....														
Launches.....														
Pile-drivers.....			40									104		
Barges.....	10	10	130	30								30		
Barge-flats.....	120	113	103	371								1,125	8	
Brush mattresses.....	1,977	1,997	2,122	6,080		120	8,052				930	11,276		
Stone.....				80										
Piles.....	169	120	41	417							708	482		
Flats.....			30											
Yawls.....												10		
Skiffs.....												16		
Tools and appliances.....	91	89	21	89			48				5,880	105		
Portable shanties.....	20											124		
Boarding outfit.....				40										
Telephone.....	11	10	11	31							3,312	112		
Cahokia.....	340	330	210	1,230	60	816	1,776				2,448	1,830		
Horseshall Bar:														
West side.....	830	840	740	3,050	1,224				50	150	19,440	4,910	227	\$74 75
East side.....	2,625	2,065	2,025	11,000	1,439	9,755					54,745	10,474	303	108 84
Twin Hollows:														
West bank.....	1,131	1,337	1,212	4,752	1,904	0,576					43,440	6,957	306	82 30
East bank.....		350	300	520	210		888					752	60	6 82
Fulllight.....	1,640	1,620	1,500	4,950	140	2,280	8,928	140			6,840	10,274	415	86 30
Chesley Island:														
Hurricane.....	390	100	420	1,010	147	1,200	3,720					2,460	150	.....
Bank protection.....	600	70	530	1,210	40		1,704					1,351		.....
Jim Smith's.....	1,003	1,111	1,034	3,541		5,328					34,632	5,875		43 52
Foster's Island.....	1,270	1,250	2,300	4,460	611	2,328	3,120				34,128	8,037	200	17 45
Total.....	12,493	12,321	13,789	43,521	5,835	28,403	29,136	140	50	150	206,569	73,075	1,723	419 98

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TABLE XIX.—Labor, service of equipment, and material not shown in tables of construction, for the fiscal year ending June 30, 1884.

MATERIAL AND GENERAL SUPPLIES.

Employes, equipment, &c.	Brush.	Piles.	Stone.	Rope.	Wire.	Iron.	Nails.	Spikes.	Lumber.	Bolts.	Subsistence.	Fuel.	Ice.	Miscellaneous.	Total.
HOURS LABOR.															
Clerks	46	18	33	10	2	2	2	2	83	300	7,273			57	7,848
Master mechanics	2														2
Overseers	2,640	233	70												2,943
Master carpenters									15					5	20
Ship-carpenters											24				24
Blacksmiths										2,592					2,592
Sub overseers	2,758	242													3,000
Master pile-drivers	40	190													230
Engineer pile-drivers	40	140													180
Master laborers	2,070	195	50	70	10		20	20	60	28				177	3,360
Blacksmiths' helpers										2,587					2,587
Watchmen	4,645	1,203	1,813	41	0	8½	0	0	332		932			230	6,201½
Laborers	62,152	2,399	1,055,000	136	186	23	21	302		244	1,601			415½	69,689½
Teamsters with teams	25,810														25,810
HOURS EQUIPMENT.															
Tow-boats	870	505	680	3	2			1		4	380	4	100		2,564
Pile-drivers		200													200
Barges	7,030	12,080	45,438												65,454
Barge-flats	33,843	15,529	700												50,078
Yawls	225														225
Skiffs	3,070	380													4,360
MATERIAL.															
Round iron :															
¾ inch										48					48
½ inch										5,906					5,906
¼ inch										20,301					20,301
Assorted										779					779
Coal	92	255								300					647
Miscellaneous	\$230 30	\$44 72	\$3 24							\$73 95	\$20 80				\$382 07

TABLE XX.—Labor, service of equipment, and material not shown in the tables of construction, June 30, 1934—Continued.

[illegible]

TABLE XXI.—*Labor, service of equipment, and material expended in construction, per unit of work, during the fiscal year ending June 30, 1884.*

HURDLES.

Employés, material, &c.	Piling, per stick.	Bracing, per stick.	Stringing, per stick.	Foundation mattress, per 100 square feet.	Wattling, per 100 square feet.
Foremen hours.	3.25	4.01	6.35	.91	1.66
Laborers do.	9.74	12.09	21.20	10.34	16.08
Pile-drivers do.	.99	1.00	1.60		.02
Small boats do.	3.31	7.24	14.98	8.30	18.95
Brush cords.				.56	.57
Pile timber feet.	38.12	36.47	40.30		
Stone cubic yards.				.80	
Rope pounds.	1.22	.30	1.06	.61	.52
Wire do.		.19		1.01	.64
Iron, round do.	.14				
Nails do.				.30	.62
Spikes do.	.11	.33	.10	.80	.24
Bolts number.		1.12	4.93		
Clevises do.		1.00			
Coal bushels.	1.39	1.28	2.30		

TABLE XXII.—*Labor, service of equipment, and material expended in construction, per unit of work, during the fiscal year ending June 30, 1884.*

BANK PROTECTION.

Employés, material, &c.	Piling, per stick.	Foundation mattress, per 100 square feet.	Revetment, per 100 square feet.
Foremen hours.	3.18	.45	.47
Laborers do.	4.71	6.32	4.13
Pile-drivers do.	.78		
Barges do.		.59	.10
Small boats do.	2.76	2.23	1.95
Brush cords.		.72	
Pile timber feet.	40.72		
Stone cubic yards.		.26	2.90
Rope pounds.		.21	.002
Wire do.		1.68	
Iron, round do.	.46		
Nails do.		.13	
Spikes do.		.75	
Bolts do.	.37		
Coal bushels.	1.37		

3.

HORSETAIL, EAST SIDE.

REPORT OF MR. E. D. LIBBY, ASSISTANT ENGINEER.

SAINT LOUIS, MO., June 17, 1884.

SIR: I have the honor, respectfully, to submit the following report of operations for improvement of the Mississippi River at Horsetail, east side, for the fiscal year ending June 30, 1884:

From the opening of the fiscal year until the close of the working season in November field operations included the completion of Carroll's Island Hurdle and the repairs of secondary hurdles Nos. 27 and 30.

During the second half of the year the work consisted of repairs on Carroll's Island Hurdle and construction on new secondary hurdles Nos. 27½ and 29½.

At the opening of the fiscal year the river was at a flood stage, and the hurdles at this locality were entirely submerged, and remained so until after the middle of July to such an extent that the work could not be prosecuted to good advantage.

The plant was transferred on July 18 and 19 to the immediate vicinity of Carroll's Island Hurdle, and field-work was resumed.

Some injury was done to this hurdle by the high water, consisting of a break 89 feet long in hurdle and brace rows near Station 6; another, including drift, hurdle, and brace rows, 73 feet in length, near Station 13, and the loss of piles at irregular intervals in drift and brace rows from Station 13 to Station 22.

Piling was first placed to close the breaks at Stations 6 and 13, after which the placing of piles was continued to the Illinois shore. Two pile-drivers, Nos. 16 and 17, were engaged in this work, and in placing longitudinal stringers and braces, until August 24, upon which date No. 17 was transferred to secondary hurdle No. 27, No. 16 remaining on Carroll's Island, to complete the placing of stringers and braces, until August 31.

For completing the entire line 340 linear feet of foundation mattress was constructed and sunk. This included the repairs in the breaks, and in a passage-way for flats where mattress had not been placed at the close of June, 1883.

Wattling closely followed the sinking of the mattress and extended from Station 16+25 to the Illinois shore, in addition to the repairs at station 6 and 13. Nine hundred and seventy linear feet were placed, all of which was carried to the 20-foot stage of the river.

Upon August 31 and September 1 the plant remaining at this locality was transferred to secondary hurdle No. 27. A small detachment of men was, however, retained upon Carroll's Island Hurdle until September 22. The work done by this force consisted of bolting stringers and braces, and slight repairs of the wattling.

Upon the drift row longitudinal stringers were placed from Station 16 to Station 22; on the hurdle row from Station 12 to Station 24; and cross-stringers were placed from Station 4 to Station 24. Over a portion of the distance from Station 8 to 11 diagonal braces could not be placed, as the deposit by the high water reached nearly to the 20-foot stage of the river.

The effect of the high water during June and July at this locality was very marked. A large bar was formed extending above the head of Carroll's Island, and that portion of the hurdle that had been wattled, nearly to Dike 5, and below the hurdle for a long distance, connecting with the island. A considerable area of this bar north of the hurdle and island is above the 20-foot stage of the river, and a very large part of the remainder, both above and below the hurdle, is higher than the 15-foot stage. Large additions were also made to the bar, extending from secondary hurdle southward. This, at the 11-foot stage of the river, connects with the bar above Carroll's Island Hurdle.

Upon September 22 Carroll's Island Hurdle was completed; after this date the whole force was employed on No. 27 and No. 29.

An examination of these hurdles showed that a considerable portion of 27 would need replacing, *a b* and *c d* of the accompanying sketch representing the portions where repairs were not necessary.

Pile-driving on No. 27, commenced August 25 by driver No. 17 and September 1 by No. 16, was continued until the whole line had been repaired. The piling was placed immediately above the old line, in order to avoid broken portions of former work.

The construction of foundation mattress followed closely the pile-driving, but as the old mattress was in some places found intact, it was unnecessary to renew it over the entire distance where new piling was placed. From the training-wall the foundation mattress was continuous for 440 feet. Upon the eastern half of the line three sections were needed to put the mattress for the whole line in good order.

The location of these are shown by *e f*, *g h*, and *i k*, of the sketch. They were, respectively, 60, 150, and 55 feet in length. In addition to the above, 90 feet of mattress were placed to repair a break which occurred in the line about 450 feet from the training-wall.

Some portions of the mattress could not be sunk to the bottom, owing to obstructions consisting of sunken drift and broken portions of old work.

Wattling was placed continuously from the training-wall for a distance of 1,000 feet, and beyond this in detached portions as needed to repair the entire line. It was impracticable in many places to force the wattling to the bottom. At such places curtains were constructed upon flats and when completed were swung easily into place below the wattling.

The repairs of No. 27 were completed on October 20 (a gateway 20 feet in width excepted). After this date two breaks occurred, one about 350 feet from the Illinois shore and the second about 400 feet from the training-wall. The former was 60 feet and the latter 80 feet in length. These were closed and the line completed again on November 10. At the close of field-work, November 16 there was a gap of 40 feet in the line 1,000 feet from the training-wall, and near the shore two piles had been displaced. The remainder of the line was in good condition on November 28.

Repairs of secondary hurdle No. 30 were commenced on September 19, and consisted of two sections, separated by a bar that extended from No. 29 to Dike 5.

From the bar to the training-wall, a distance of 900 feet, no portion of the old work

was found to be in good condition. Inside the bar about 50 feet of the line remained near the shore; from this to the bar, about 400 feet, many piles were in place, but the wattling was either entirely gone or very much broken. Commencing on the outside of the bar, the work of repairing this line was carried forward without interruption until the close of field-work, November 10.

As at No. 27, the piling was placed a short distance above the old line. Mattress was placed over the entire distance from the training-wall to the bar, 900 feet. Wattling and curtains were also placed over the same distance. Inside the bar the repairs were fragmentary, consisting of piling at somewhat irregular intervals, and about 200 feet of foundation mattress, together with wattling from the bar nearly to the shore.

On both No. 27 and No. 30 longitudinal stringers and diagonal braces were placed wherever work has been done during the season, excepting at one point on No. 30 where two stringers were not placed. With this exception No. 30 was in complete repair (not considering the portion covered by the bar) on November 10; but before leaving the field two breaks occurred in this line on the outside of the bar. Between these a portion of the hurdle remained for several days, but heavy drifts accumulating it was carried out, making an opening 100 feet in length. Work upon this line was carried on under a great disadvantage, it being necessary to transfer much of the material used upon it from the vicinity of No. 27. This was done by small boats and flats.

The plant was removed to winter quarters at Twin Hollows on November 16, and on November 21 the entire field force had been discharged.

In accordance with your instructions of February 27, 1884, the field-work during the second half of the fiscal year was devoted to the repairs of Carroll's Island Hurdle, in which a break was made by the running ice, and to construction work upon the new secondary hurdles, 27½ and 29½.

On March 17 a portion of the plant needed for this work was taken from the engineer depot to Horsetail, east side, and on March 22 additions were made to meet the requirements of the work.

At the opening of the season the break in Carroll's Island Hurdle was 225 feet long, extending from Station 19+75 to Station 22. Across this the depth of water varied from 18 feet to 25 feet, and the current, which was very oblique to the line, was strong and swift.

Pile-driving was commenced on the eastern side of the break March 20, and was continued by three drivers until a rise in the river made it impossible to obtain satisfactory results, for which reason the drivers were moved on March 29, and opened work on the new line, No. 29½.

No further work was done on Carroll's Island Hurdle until May. Upon the 5th of May work at this point was resumed, and was pushed as rapidly as possible until the repairs were completed. During the month of April the break in this line was increased to 450 feet in length, and a second break, a short distance west of this, was caused. This was 125 feet in length. Between the latter and the large break a portion of the old line remained at the time work was resumed. On this account it seemed best to repair the breaks separately, but the current continuing to cut away the old line it was necessary to make the repairs in one reach.

Commencing at the Illinois shore, a short distance above the old line, the piling extended 1,560 feet, three rows being placed. Mattress construction was commenced as soon as the way had been cleared by the pile-drivers. It covered the whole distance embraced by the piling. Although this mattress was woven to a width of 90 feet, very little trouble was experienced in sinking it.

Longitudinal stringers were placed on both drift and hurdle rows, also diagonal braces, but no wattling was undertaken. Upon this line the repairs were completed June 6.

Construction work upon the new secondary hurdle 27½, which was located 110 feet above No. 28, was begun in March, immediately after entering the field.

The high water making it impracticable to continue the work at Carroll's Island Hurdle, the pile-drivers were removed from the latter place to the new secondary No. 29½ on March 29, and work was commenced on this line at a point 550 feet above secondary hurdle No. 30.

Although the river continued high through the months of April and May, work upon both 27½ and 29½ was carried forward without interruption until June 7.

During April the entire field force was engaged upon these lines. Six pile-drivers were employed, and as many workmen as were required to keep pace with the driving of piles. Secondary hurdle No. 27½ was extended 1,325 feet, consisting of three rows of piles, foundation mattress 80 feet in width, longitudinal stringers, and diagonal braces throughout on drift and hurdle rows. No wattling was placed during the second half of the fiscal year. Notwithstanding the high water very little loss was incurred upon either No. 27½ or No. 29½.

Upon the former line a portion of mattress near the western end of the line was

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lifted above the piling and lost. At the same point a number of piles were carried out, making a small gap in the line. Repairs were made to cover both injuries. Some difficulty was encountered in driving piles on this line, arising from the high stage of the river and the very irregular depth of water along the line.

The work on No. 29 $\frac{1}{2}$ was carried forward simultaneously with that on No. 27 $\frac{1}{2}$, and the line was extended 1,450 feet, being similar in form to 27 $\frac{1}{2}$. All portions of the work were completed as far as piling was placed, excepting a few diagonal braces for the drift row near the Illinois shore. Along this hurdle the depth of water has been such as to make the work easy and rapid. For the whole of the second half of the year, except when the river was at its highest, it may be said that the work has progressed more rapidly than it could possibly have done at a low stage of the river, as it was practicable easily to transfer material from one point to another without encountering sand-bars.

The weather during the first half of the year was very favorable for field work, but during the second half heavy rains have caused considerable interruption to the work.

Field operations closed on June 7, and on the 9th the plant had been removed to the engineer depot. The larger part of the force was discharged on the former of the above dates, and on the 9th the remainder were paid and discharged.

The sketch accompanying this report shows the work done on the different lines, gives soundings taken at the beginning and end of the year, and also shows the location and extent of sand-bars. The shore-line of Carroll's Island was determined by transit, with stadia measurements. Above No. 18 no soundings were taken during the second half of the year. The bars at that place are not as high as they were at the close of the work in November, but in other particulars there are no indications to show that they have changed materially.

The river has remained so high since March that it has been impossible to ascertain the condition of secondary hurdles 27 and 30, but from observations when the water was lowest it is evident that these lines were damaged considerably by the running out of the ice.

Forming a part of this report are tables showing the progress of work upon the different lines and giving the amount of material expended thereon.

During the first half of the year I was assisted by Messrs. C. P. Mitchell and S. B. Cady; during the second half by Messrs. C. V. Mercereau, B. E. Johnson, and C. P. Mitchell.

In closing I desire to express my thanks to each of these gentlemen for the prompt and able manner in which he has performed the duties assigned him, and for the interest he has taken in the work.

Very respectfully, your obedient servant,

E. D. LIBBY,
Assistant Engineer.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

4.

HORSETAIL, WEST SIDE.

REPORT OF MR. J. E. SAVAGE, ASSISTANT ENGINEER.

SAINT LOUIS, MO., June 18, 1884.

SIR: I have the honor to submit the following report of operations for the improvement of the Mississippi River, at Horsetail, west side, for the fiscal year ending June 30, 1884.

The revetment of the new bank at this locality was commenced March 19, in accordance with your orders of February 27, and proceeded continuously until May 31. During this time 3,880 linear feet of low-water mattress were constructed and placed, completing the low-water protection from Station 0, at the mouth of the River Des Peres, to Station 38+80, at Dike No. 1; 2,930 linear feet of bank between stations 8 and 37+30 were revetted with stone, from the inner edge of the low-water mattress to a stage 6 feet above standard low water; and the remaining 15 linear feet, between Station 37+30 and the dike, to a stage 13 feet above that plane.

The permeable works which were constructed at this locality in 1881 caused the area which they inclosed to fill quite rapidly to about 16 feet above standard low water before the autumn of 1882. Since that time the deposits have been raised by successive floods, but at the same time the river has shown a tendency to cut a way the outer edge. Although no rapid caving has occurred, the new bank has receded considerably. For the first 350 feet below the River Des Peres there has been no per-

ceptible change, but from that point to Dike No. 1 the cutting has taken place, increasing quite regularly from a width of a few feet at the upper part to a maximum of about 350 feet at the dike.

The object of the work carried on during the past season was to protect this new bank from further erosion, and the plan of revetment was similar to that used at Beard's and Foster's islands, except in the width of the mattress, which in this case was reduced to 100 feet.

LOW-WATER PROTECTION.

The work of moving the boarding outfit to the portable buildings below Ivory Station was commenced March 14; by the 19th all the preparatory work had been completed and the weaving of the mattress commenced.

Matress fabrication.—The construction of the low-water mattress was precisely similar to that used at Foster's Island last fall, except in width, which, in this case, was 100 feet instead of 120 feet.

The force engaged directly in mattress fabrication consisted of one suboverseer, one master laborer, and from 45 to 50 laborers. On March 19, a mooring barge was placed in position perpendicular to the bank just below the mouth of the River Des Peres. It was secured by lines leading to clumps of piles, which were driven on the upper side of this stream opposite the "Vulcan Steel Works." The head block of the mattress was fastened to the down-stream side of this barge by the usual bridle lines.

At Station 0 the new bank caused by the permeable works was about 70 feet outside the primary hurdle, but gradually approached and intersected it 350 feet below. This hurdle remained intact as far as secondary hurdle No. 1, 600 feet below the initial point of the mattress, and crossing the line of standard low water at a small angle extended 35 feet outside of it at secondary hurdle No. 1. It was found to be impracticable to remove this obstruction. When this point was reached the mattress was gradually narrowed from the inside edge, the inner stringer being turned outward till it was parallel to the primary hurdle, and each adjacent pole discontinued as the narrowing process reached it, until the obstruction was passed.

The normal width of mattress was resumed below this point, the oblique inner edge of the narrowest part fitting closely against the hurdle line, as shown in the sketch. The mattress presented the appearance of having had a piece in shape of a right-angled triangle cut from its inner edge, the altitude of the triangle, 250 feet, being parallel to its length, and the base, 35 feet, parallel to the width. At the point where the mattress was widened a strong cross stringer, like the head block of the mattress, was used, and the inner corner, which was on the line of standard low water, was secured by string lines leading up-stream to clumps of piles.

The construction was carried on continuously till May 17, with the exception of one day, in which the entire force was used in sinking the head of the mattress, and such days as were lost by unfavorable weather.

The high stage of the river during the entire spring season retarded progress in various ways. The guide piles were necessarily quite long, and, being unbraced, any pressure against the ways barge from easterly winds or cross-current sufficed to bend them inward. The barge at such times would be held by the guide piles below, and would require sparring out for almost every launch.

Another cause of delay was a scarcity of poles large enough for stringers, which could not be obtained while the river was so high. The poles used being small and short, almost double the usual amount of splicing was required, while the mattress constructed was necessarily weaker than usual.

Owing to these various disadvantages progress was somewhat slower than at Foster Island last fall. The largest day's work was the construction of 110 linear feet, with 410 hours' labor, an average of 2.55 linear feet for each ten hours' work. The average for the entire season was 1.83 linear feet for each ten hours of labor.

After the head of the mattress had been placed a rapid fall occurred along the inner edge and inside of the primary hurdle, where the mattress was narrowed, and the necessity of placing another mattress back of the hurdle line was removed.

The mattress was completed to Dike No. 1 Saturday, May 17, and was launched from the ways and placed the following Monday.

Securing mattress.—The method of securing and holding the mattress in place preparatory to sinking was almost identical with that described in the report for Foster's Island, the only change being in the manner of fastening the securing lines on shore. As no trees were available for the purpose, and "dead men" could not be used on a bank which was often covered with water, clumps of piles were driven as required a short distance inside the regular line of guide piles.

Matress sinking.—Soon after mattress construction was begun the river rose quite rapidly to a stage 21 feet above standard low water. As sinking would be difficult at this time, and there seemed a probability of an early decline in the river, the placing of the head was delayed from day to day. The water fell slowly during the first three days of April, and then began rising again.

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As the 300 linear feet then constructed was subjected to considerable strain, both from the increased current and the drift-wood which had accumulated at the head, it was decided to sink the upper portion April 10.

The usual preparations were made, and about 800 linear feet were successfully placed with the river 25 feet above standard low water. In the evening of the same day the large flow of drift-wood overturned a flat which buoyed up the outer edge below the new mooring barge, and made a small rent in the edge. During the night the mattress above this rent was doubled under somewhat by the force of the current so as to leave a small triangular break, which extends into the protection about 20 feet. About 150 linear feet of this portion was placed the following day.

From this time until the protection was nearly completed an extra barge was used to buoy up the outer edge and keep the drift-wood from striking the mattress, and sinking followed construction closely.

The accumulation of drift-wood, however, continued to cause trouble; it collected in large quantities above the mooring barge and under the mattress, causing great strains and severely testing the strength of both mattress and lines. Various means were tried to overcome the difficulty, but without material success.

On April 30 a barge was drawn in below the one which had been previously used as a mooring barge and used in sinking, while the latter was left in position to act as a boom. This resort was successful for the time being, but the accumulation above the boom became so large that it was plainly impossible to hold it much longer, and more was continually coming. The steamer General Gillmore attempted to pull the barge and accumulated drift out into the stream May 3, but during the process a large part of the drift came down against the mooring barges with great force, crowding them inward in such a manner as to break several weaving poles of the mattress. This portion was immediately placed, but in a damaged condition; a piece 25 feet wide by about 40 feet long was torn from the outer edge, and the mattress below the rent doubled under during the sinking process, leaving a considerable break in the outer edge of the protection, as shown in the accompanying sketch.

Upon the completion of the mattress construction, Saturday, May 17, 580 linear feet remained floating. This was placed the following Monday without difficulty, completing the low-water protection from the River Des Peres to Dike No. 1.

MEDIUM STAGE PROTECTION.

The medium stage protection, consisting of a layer of riprap, was commenced May 20, with a small force.

After the placing of the mattress a considerable diminution of current was noticed at the head of the works, and no tendency to impinge upon the bank above Station 8 was apparent.

The stone revetment was, therefore, begun at Station 8 and carried from this point to the end of the mattress and extended up the bank to a stage 6 feet above standard low water. Between secondary hurdle No. 7 and the dike a strong eddy was making serious inroads into the upper zone of the bank, and over this distance of 150 feet the protection was widened, and extends to 13 feet above standard low water.

Work was discontinued May 31.

The accompanying sketch shows the amount and location of the work done during the year, the soundings showing the relative depth of water November 28, 1883, and May 31, 1884.

Before closing, I desire to express my thanks to Mr. John L. Duffy, assistant engineer, and Mr. Gerald Bagnall, assistant engineer, for their able assistance in the prosecution of the work.

Very respectfully, your obedient servant,

J. E. SAVAGE,
Resident Engineer.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

5.

TWIN HOLLOWES, WEST BANK.

REPORTS OF MR. WILLIAM S. MITCHELL, ASSISTANT ENGINEER.

I.

SAINT LOUIS, MO., December 31, 1883.

MAJOR: I have the honor to submit the following report of the operations performed for the improvement of the Mississippi River at Twin Hollowes, west bank, during the half year ending December 31, 1883.

On the accompanying tracing is shown, in red, the work which was done during the season, and, in black, that which was standing when the high water which prevailed during the early part of July had passed.

The condition of the latter was as follows:

At the head of the works the crib work in the primary hurdle was in good condition for one-half its length from the shore, with a heavy deposit both above and below it.

In the remaining distance (250 feet) it had been almost completely destroyed. From Station 6, the point of junction of the hurdle with the cribs, to Station 11+17, from Station 13+50 to Station 15, and from Station 17+25 to 30 the hurdle was gone, only the tops of a few piles in each of these spaces remaining to mark the line of the former hurdle. Soundings, however, showed that a large bar existed inside of this line extending from Station 13+50 to secondary hurdle No. 1. Between Station 30 (secondary hurdle No. 1) and Station 70 (secondary hurdle No. 3) the hurdle was in good condition. On the outside the water, in an attempt to follow the lines of contraction, had eaten away the narrow sand-bar which formerly fringed that portion of the primary line nearly to the piling, while on the inside the dry bar stretched from the hurdle well towards the Missouri shore.

Between secondary hurdles Nos. 3 and 4 the hurdle was broken in a number of places, and although the current set in through them, it was with no force, and soon spread out over the shoal places without doing other damage than to augment the stream going down the shore.

Below secondary hurdle No. 4 the hurdle was unchanged, the bar extending on either side of and for 1,000 feet below it.

In secondary hurdle No. 1, between the primary hurdle and Station 6+50, there were no distinct breaks in the line, although the wattling throughout that distance was generally broken down by drift, which remained tangled among the piles. From Station 6+50 to the east end of the crib-work (Station 8) the hurdle was entirely gone. The crib-work, however, was intact and half buried in a deposit that reached nearly to the top of the wattling.

In secondary hurdle No. 2 there were distinct breaks between Stations 5+50, and 6+75, and 7+75, and 8+25.

The shore crib had been carried out by ice in the spring. The other crib-work was very much broken, although still in place.

In secondary hurdle No. 3 no change was observed. The hurdle was in good condition to Station 7, and between that point and Station 10+50 the wattling only remained to be placed.

A small gap existed between the end of the piling and the crib-work. This latter had created a deposit on each side of it and was not in need of repair.

In secondary hurdle No. 4, a gap existed between Station 10 and the east end of the crib (Station 12+60), and from the west end of the crib (Station 14) to the 16-foot contour. From this latter space a shore crib had been pushed out by the ice in the spring. To partly fill these gaps two cribs had been constructed and had been carried on flats and barges through the high water, awaiting a favorable opportunity for sinking.

Those portions of secondary hurdle No. 5 which had been constructed were intact, the bar on each side reaching to the top of the hurdle. Gaps still existed between Stations 11+25 and 13+60, and between Station 15+10 and the 16-foot contour.

In the general condition of the old work no great change was observed, neither had any damage been suffered by the work constructed since the spring, although such an immense field of drift lay above the new portion of secondary hurdle No. 3, throughout the high water, as to preclude the possibility of wattling it until a tolerably low stage of water was reached.

In regard to the bars the wash outside of the primary hurdle has already been noticed. There had also been eaten away a corner of the bar immediately below secondary hurdle No. 4.

Over the bars generally some deposit had been gained, and their edges had been pushed further west, narrowing the channel flowing down the shore.

Along the shore a deposit had also been gained; especially was this the case near the ends of the hurdles, thereby widening the beach and still further narrowing the shore channel in which the depths and speed of current were found less than had obtained during corresponding stages in the spring.

At the beginning of the season the plant was in harbor awaiting the passage of the high water.

During the first fortnight of July one pile-driver with its crew was engaged in loading on barges piles which had been delivered in rafts during June, and in clearing the cribs which were being carried through the high water and their lines from drift.

From this time until August 31 work was confined to the repair and reconstruction of secondary hurdles Nos. 3, 4, and 5.

These hurdles having been completed as far as was then possible, the quarter-boats,

pile-drivers, &c., were moved to the Missouri shore, above the head of the works, and the repair of the primary hurdle was begun.

This, together with the construction of a new secondary hurdle (No. 0), and the repair of secondary hurdle No. 1, occupied the time until November 16, when the plant was again taken to secondary hurdle No. 4, and those portions of lines Nos. 3 and 4, which in August remained unwattled, were completed.

Active operations in the field closed November 30. The quarter-boats, barges, &c., were then placed in winter harbor, all tools, lines, and mess and kitchen furniture being removed to the engineer depot, and the records and instruments to the main office.

The complete details of the season's work, showing the amounts of work done in the different hurdles and various classes of construction, the material expended, and the performance of each pile-driver employed, are given in the tables which accompany this report.*

* * * * *

In the numerical order of the hurdles the work done upon them was as follows:

Primary hurdle.—On September 1, pile-driving was begun on the hurdle at the head of the works to restore the line formerly occupied by the cribs which were broken down by the ice in February. The line chosen for the new work was a little above that occupied by the old hurdle, in order that the remains of the crib-work might not interfere with pile-driving and the sinking of mattresses.

The hurdle was restored with three rows of piles, 20 feet apart, and with the downstream or brace-row, 25 feet above the old line referred to. The piles in the brace and hurdle rows were spaced as usual, 12 and 6 feet apart, respectively, while those in the drift row were doubled in number, being only 6 feet between centers. The two latter rows were braced with diagonal braces. Stringers and cross-stringers were bolted to the tops of the piles in all three rows.

The piling was carried from the shore to a point 25 feet outside of the primary hurdle at station 6.

As the depths of sand found (only 5 to 8 feet overlying rock ledge) were insufficient to hold the piles, a mattress $3\frac{1}{2}$ feet thick, 45 feet wide, and 210 feet long, was constructed and sunk over the line, which, with the stone required to sink it, built up the bottom around the piles about 5 feet, effectually securing them from scour. The hurdle row was then wattled to a level 16 feet above standard low water.

The length of this portion of the work 250 feet. It was completed September 24.

Until October 15, no further work was attempted in the primary hurdle. Then, however, work was resumed at Station 6. From this point to a junction with what was standing of the old work at Station 11+17, the hurdle was re-established with three rows of piling, the two outer rows braced in the usual manner, and with stringers and cross-stringers. The rows are 18 feet apart, and the piles in the drift row are spaced 12 feet between centers.

As the old mattress was found in place at every point in this line, the piles were sharpened and driven through it without the use of the jet, and no other mattress was fabricated or thought necessary. The hurdle row was wattled to the 16-foot level, the average depth of wattling being 27 feet.

Five clumps of piles were driven around the angle in the line to protect it from running ice, and the clumps firmly braced to the piles in the hurdle. This work was completed November 15.

Secondary hurdle No. 0.—As the distance (2,350 feet) between the head of the work and secondary hurdle No. 1 was thought too great to lie between two hurdles, it was decided to construct another secondary hurdle midway between them.

This hurdle (No. 0) was begun September 11, at Station 17 in the primary hurdle, and was carried parallel to secondary hurdle No. 1, to the 16-foot contour on the Missouri shore. The piling, braced with diagonal braces and stringers in the usual manner, was driven to within 125 feet of the shore end of the hurdle. The remaining distance was filled in with crib-work built in place.

A mattress 45 feet wide, woven in one piece and extending from the primary hurdle, to within a flat's length (35 feet) of the crib-work, was fabricated and sunk. The remaining distance (160 feet) was covered with a mattress of the same width but $1\frac{1}{2}$ feet thick, to serve as a floor for the crib-work as well as a mattress for that portion of the hurdle. The piling was wattled throughout the entire length of the line for an average depth of 16.4 feet, and was completed October 16.

Secondary hurdle No. 1.—The gap which existed in secondary hurdle No. 1, between Stations 6 and 8+50, was closed during October, with another hurdle bending slightly up-stream to avoid in pile-driving the wreck of the old line. The repairs consisted of two rows of piles driven to the rock in about 6 feet of sand. In order to secure them from scour a mattress 3 feet thick by 30 feet by 238 feet, similar to the one placed at the head of the works, was fabricated and sunk, building up the bottom around the piles with brush and stone.

* Embodied in tables, Appendix 2.

The hurdle was wattled for a depth of $15\frac{1}{2}$ feet. These repairs were completed October 31.

Secondary hurdle No. 3.—In the repairs to this hurdle the three rows of piles which before the high water had been carried across the gap to Station 10+50 were continued, on the resumption of work in August, to a junction with the crib-work at Station 11+50. The new work was braced throughout, and between Stations 10+20 and 11+50 it was wattled for a depth of 15 feet. This was completed August 13, and from that time until November 16 no work was attempted in this line, although 400 feet of it between Stations 7 and 10+50 remained to be wattled. It was impossible to do it in the summer, on account of the drift which had then lodged against the hurdle. In November, however, the water and drift had fallen far enough to render it practicable, and the unfinished portion of the line was then wattled to the 16-foot level, with a depth of $14\frac{1}{2}$ feet.

Secondary hurdle No. 4.—On July 13, the water and current having reached conditions under which it was thought feasible to sink the two cribs which had been carried through the high water, the attempt was made, and the large crib was successfully placed in position between Station 11+20 and Station 12+60. After freeing it of lines and barges the smaller or shore crib was placed between Station 14+10 and Station 14+70.

The gap which existed in this line at the east end of crib-work, between Stations 9+80 and 11+70, was closed during August by carrying the hurdle up-stream from each side of the break to a point 100 feet above it. This increased the length of the line considerably, but the depths of water found were much less, and those of sand in which to drive were greater than on the original line for the hurdle. To the west branch of this new line a drift row was added, as it faced the deep water and strong current. The other side was protected by the sand-bar.

This work was completed throughout August 30.

During the latter part of November the front of the crib-work which had been left unfinished during August on account of drift was wattled.

On November 2, one of the brace-piles near Station 10+20 was observed to be working in the sand, showing that the current there was scouring under the mattress. To remedy this and to prevent further damage 100 cubic yards of stone were thrown in on the mattress in a space of 50 feet on either side of the loose pile to force the mattress firmly to the bottom, and 8 piles were driven, one on each side of the four brace-piles in the vicinity, and to which these piles were bolted. This completed the work in this line November 30.

Secondary hurdle No. 5.—On July 30 a crib was begun for the shore end of this hurdle. On August 12 it was completed and sunk in place between Station 15+30 and Station 16+20, and its front, 90 feet by 15 feet, was wattled. No other work was done on this line.

The high water, which July 1 had fallen to a stage 25.75 feet above standard low water, continued to recede until September 29, when it reached its lowest stage, 4.6 feet. The river then rose slowly to 11 feet, November 12, after which it fell steadily until the close of the season, when it stood at 7.64 feet.

When active operations were assumed during the latter part of July the force was increased to fifty men, which remained the average number employed throughout the season. During October sixty-five men were engaged, but on the approach of winter a large number left to go south, reducing the force to thirty at the end of November.

The men suffered somewhat from malarial fevers until the appearance of frost, but it was not so prevalent among them as in 1882, nor did it materially interfere with the work.

In the supervision of the works and in keeping the records, I have been very kindly assisted by Mr. J. L. Duffy, assistant engineer, and Mr. E. D. Frasier, clerk. The latter has been connected with the works throughout the season, and the former until November 5, after which time he was engaged under your orders in other work.

Very respectfully, your obedient servant,

WM. S. MITCHELL,
Resident Engineer.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

II.

SAINT LOUIS, MO., June 16, 1884.

SIR: I have the honor to report that no further work has been done at Twin Hollows, west bank, during the fiscal year ending June 30, 1884, than has been noted in my report for the half year ending December 31, 1883.

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The only changes observed in the general condition of the works since that report are:

1. The destruction by ice, in the spring, of the drift row of piles in the hurdle at the head of the works.

2. The loss of about 150 linear feet of hurdle at the outer end of secondary line No. 1, and similar losses in secondary No. 3, and in the primary hurdle below No. 1.

3. A small break in secondary hurdle No. 4, at the east end of the crib-work. The tops of the piles are gone, yet under water the obstruction seems to remain.

When these observations were made the water was within 2 feet of the tops of the hurdles, so that nothing further could be seen.

Soundings were also taken June 7, 1884, and are shown on the accompanying tracing.

They show a general fill behind the hurdles, in the channel following the shore, and especially at the head of the works. That this fill has not been greater is due to the broken condition of those portions of the hurdles built in previous years, and which has never since been repaired.

Very respectfully, your obedient servant,

WM. S. MITCHELL,
Assistant Engineer.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

6.

TWIN HOLLOWES, EAST BANK.

REPORT OF MR. B. E. JOHNSON, ASSISTANT ENGINEER.

SAINT LOUIS, MO., December 31, 1883.

SIR: I have the honor to submit the following report of the operations for the improvement of the Mississippi River at Twin Hollowes, east bank, during the half year ending December 31, 1883.

In accordance with your orders of October 22, 1883, directing me to take charge of this work, an immediate effort to procure the necessary plant, number of men, boarding facilities, &c., was commenced, and on October 25 I arrived on the ground with the following outfit transferred me by Mr. C. V. Mersereau, resident engineer at Chesley Island: 1 quarter-boat, 1 flat, 2 yawls, 2 skiffs, and 17 men.

An inspection of the work showed it to be in good condition from the upper point of the work to Station 49, and even as far as Station 61+25 it was in a good condition to a 12-foot stage—8 feet above standard low water. However, from Station 59 to Station 74+25 a considerable caving had taken place, and from Station 61+25 to Station 74+25, no stone between the mattress and shore could be found. Between Station 76 and Station 78 there had also occurred some caving of the bank; still stone was found along the edge of the mattress but not extending to the height of 8 feet above standard low water. Below the end of the mattress at Station 86 considerable erosion of the bank had taken place, and had a tendency to cut in behind the mattress.

In several places the old transit line had been cut away, and it was found necessary to make an off-set of 25 feet at Station 59, and at Station 65 a second off-set of an additional 25 feet. The new line runs east of and parallel to the old one to Station 75, where the old line was resumed. On this transit line are located the reference stations for the work, which are 100 feet apart; they begin with Station 0, at the extreme upper point of the work, and are numbered continuously down-stream. While this line represents the general direction of the shore-line, it is in reality shorter, as it does not contain the sinuosities of the shore-line, and in consequence of this more surface is absolutely protected than is reported.

At the commencement of the work my instructions were to carry the protection to a height of 8 feet above standard low water where no protection could be found already existing, and after this had been accomplished then to revet to a higher stage wherever it could be done without grading the bank. This revetment was made entirely of stone. It was commenced October 25, 1883, and continued without interruption until the 27th of November following, when work was suspended for the season.

The following statement shows the amount of the medium-stage protection completed during this time: From Station 63+75 to Station 70+25, from Station 76 to Station 78, and from Station 86 to Station 87+50, a distance of 1,000 feet, it was carried to a height of 8 feet above standard low water, and will average about 42.5 feet in width; from Station 70+25 to Station 72+25, a distance of 200 feet, it was carried to a height of 10 feet above standard low water and will average about 53 feet in width; from Station

72+25 to Station 74+25, a distance of 200 feet, it was carried to a height of 16 feet above standard low water and will average about 80 feet in width; from Station 49 to Station 53, a distance of 400 feet, it was carried from a height of 8 feet to a height of 16 feet above standard low water, and will average about 35 feet in width; from Station 53 to Station 55, and from Station 59 to Station 60, a distance of 300 feet, it was carried from a height of 8 feet to a height of 12 feet above standard low water, and will average about 13 feet in width; from Station 55 to Station 59 and from Station 61+25 to Station 63+75, a distance of 650 feet, it was carried from a height of 8 feet to a height of 14 feet above standard low water, and will average about 25 feet in width; from Station 74+25 to Station 75+75, a distance of 150 feet, it was carried from a height of 12 feet to a height of 16 feet above standard low water, and will average about 20 feet in width.

Thus a distance of 2,900 feet of bank has been protected with an average width of 36.6 feet.

There were expended during the half year 3,212.91 cubic yards of stone.

There were also expended during the first half of the year by Mr. John O. Holman, resident engineer, 528 cubic yards of stone to protect the bank between Station 59 and Station 61+25.

The tracing forwarded herewith shows the condition of the work at the close of the season.

Very respectfully, your obedient servant,

B. E. JOHNSON,
Resident Engineer.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

7.

PULLTIGHT.

REPORT OF MR. C. D. LAMB, ASSISTANT ENGINEER.

SAINT LOUIS, MO., June 11, 1884.

SIR: I have the honor to submit the following report of operations at Pulltight for the fiscal year ending June 30, 1884.

In accordance with your letter of instructions, dated August 15, 1883, the force which had been engaged in constructing and repairing the hurdles at Cahokia Chute, after completing that work, was removed to Pulltight, where operations were begun on the 16th of August. An inspection made at that time showed that the piling in the primary hurdle was in good condition except for a short distance near its lower end, but many of the diagonal braces were missing, while the wattling which had been placed for 1,100 linear feet at the upper end of the line was considerably injured, and the piles driven in June for the shore end of secondary line No. 1 had been overturned and covered by drift. Secondary hurdle line No. 3, built in 1882, was broken in the narrow channel next to the Illinois shore, and its outer end was covered by the bar which at that place rose to a height of 12 feet above standard low water. Soundings taken at this time showed a large fill near the head of the primary hurdle, deposited during the last high water, but a scour had taken place in the channel next the Illinois shore and also around the lower end of the primary line, caused by a considerable body of water passing in to join that running down next the shore. There had also been a scour in the narrow channels running into the chute just above Beard's Island, while the upper end and outside of the tow-head above had been eroded for about 150 feet.

Work was begun August 16 upon the primary line, on which the wattling was repaired from Station 0 to Station 11, and then constructed from that point to Station 25+40, which was as far as the piles in the hurdle row were serviceable. The braces missing were also replaced, completing the work upon this line early in October. Meanwhile secondary line No. 1 had been relocated about 50 feet below its former position, which was 2,000 feet below the upper end of the primary, and its construction from shore to the primary hurdle, a distance of 960 feet, completed early in October. Some of the piles driven in the spring for the shore end of the line were pulled with the aid of the jet and redriven in the new line.

Secondary hurdle line No. 2, located 2,000 feet below No. 1, was begun September 5 and completed from shore to its intersection with the proposed line of the primary, a distance of 1,560 feet, on the last of October, though work upon it was retarded by shoal water near the middle of the line.

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Line No. 5 was then located 6,000 feet below No. 2, or about 1,000 feet below the head of Beard's Island, and work upon it began October 30. Though delayed by severe weather and drift, which ran in considerable quantities for several days, the line was completed from shore to Beard's Island November 21. The fleet, however, had been towed into winter quarters at Twin Hollows on the 19th instant for security against floating ice.

The hurdles were but slightly injured during the winter; about 40 feet of the end of secondary line No. 2 was carried away, about 100 feet of secondary line No. 5 overturned next the island, and a breach about 200 feet wide was made near the middle of the line.

The work of repairing line No. 5 was begun with a small force March 21, but progress was at first very slow on account of bad weather and the rapid rise in the river, accompanied by heavy drift. This rise greatly increased the strength of the current running through the chute. The damaged portion of the hurdle next the island was carried away, the breach near the middle of the line was increased in size, another breach made between it and the Illinois shore, and a cut 15 feet deep and 50 feet wide was made around the east end of the line before the erosion could be checked. It was temporarily stopped by driving piles close to the perpendicular bank and filling the space behind them with brush, but the sand composing the bank at that place oozed out under the brush during the storm of March 26, and in a few hours the gap was 100 feet wide and 22 feet deep. Further cutting was prevented by a mattress 40 feet wide, woven with the brush perpendicular to the shore-line, the bank being graded just ahead of the flats, which were dropped down as the mattress was completed. The gap was then closed by three rows of piles driven from shore to the east end of the hurdling, and the bottom protected against scour by a foundation mattress 60 feet wide. The water in the middle breach at this time was 30 feet deep, and as the piles on hand were not long enough to drive in this depth, repairs were begun upon the island end of the line. The piles were driven in three rows with the brace-piles about 20 feet above the old hurdle row, allowing the new foundation mattress to lap about 10 feet over the old one, which soundings showed to be in good condition. The new line was to be deflected down-stream to join the old work when extended beyond the break, but before the point of deflection had been reached the remaining portion of the old line was so broken by the heavy drift and strong current that no part of it could be utilized, and the new work was continued on in a straight line parallel to the old hurdle. The piling had been extended a distance of 650 feet when work was interrupted, May 6, by heavy drift brought down from the hurdles above by a sudden rise in the river. This drift overturned seven unbraced drift-piles, about 450 feet from the island, and carried away 80 linear feet of the unbraced piling near the end of the line. Work was then begun at the Illinois shore and the hurdle built out to the point where work was suspended on the 6th of May. The missing piles were replaced, a foundation mattress built and sunk upon them, and the drift and hurdle rows stiffened with braces and stringers throughout, but no wattling was done on any part of the line. The reconstruction of the line was completed on May 21, when the force was discharged and the equipment transferred to the supply clerk.

The secondaries built during the fall were not protected by a drift-row, but when line No. 5 was reconstructed in the spring it was built with three rows of piles driven 18 feet apart, except in deep water, where the distance between the lines was made about equal to the depth. The hurdle-row of each line and the drift-row of line No. 5, built in the spring, were stiffened with braces and stringers. The stringers used during the fall were placed at an elevation of 16 feet above standard low water, but those placed in the spring were from 4 to 6 feet higher. The foundation mattress built during the year was all woven on small flats, except about 400 linear feet on line No. 2, which was built across the bar near the middle of the line. The mattress extended about 10 feet above the upper row and 20 feet below the brace piles.

The change in the regimen of the river in the locality of the work was very small during the year, though the crossing at the head of the work was pushed a considerable distance down-stream by the moving down of the bar outside the work at Twin Hollows, and the current running down next the primary hurdle was greatly increased, causing a considerable scour near the line, which carried away its lower end as far up as Station No. 17, and overturned most of the drift-piles above that point. About 100 feet of the outer end of secondary line No. 1 was also carried away, but the large bar inside the primary shuts off most of the current from the chute at low stages. During the high water of April, however, a large body of water ran over the upper hurdles and caused a head of over a foot at line No. 5. The upper end of Beard's Island was cut away for a distance of 350 feet, and the tow-head above was eroded on three sides. The bar protected by the hurdles received a large deposit during the spring, being raised to a height of 20 feet above standard low water between the head of the primary and secondary hurdle No. 2, and was 3 feet higher below that line,

but the portion just under the hurdle was cut away by the current running in toward the Illinois shore. These changes, as well as the location and extent of the work done during the year, are shown on the accompanying tracing made from the survey of June 2.

Very respectfully, your obedient servant,

C. D. LAMB,
Resident Engineer.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

8.

CHESLEY ISLAND.

REPORT OF MR. C. V. MERSEREAU, ASSISTANT ENGINEER.

SAINT LOUIS, MO., *December 31, 1883.*

SIR: I have the honor to submit the following report of operations at Chesley Island for the half year ending December 31, 1883:

There were constructed during the half year 4,500 linear feet, or 132,000 square feet, of medium stage protection, averaging about 29 feet wide; 305 piles driven, 172 braces placed, 121 stringers placed, 465 linear feet, or 18,000 square feet, of foundation mattress, averaging about 38 feet wide; 435 linear feet, or about 5,700 square feet, of wattling, about 13 feet deep.

During the first part of July a force of nine men were employed at Chesley Island taking care of the property and material put in harbor at that place during the high water.

On July 13 a crew was placed on pile-driver No. 11, and work was resumed on the hurdle line on the following day.

On July 18 pile-driver No. 7 was received from the depot and also put at work on the line.

On resuming work the hurdle line was found to be in the following condition: Commencing at the east or island end of the line as Station 0 for 90 feet the three rows of piles were erect and in good condition; from that point the drift-row crowded over towards the second row and met it at about Station 1 + 40. The second row was erect to about Station 1 + 80, where it crowds over to the third row. From Station 3 to Station 4 + 50 the three rows crowded over, leaving a break of about 150 feet. From Station 4 + 50 to Station 5 the second and third rows were standing. From Station 5 to Station 6 was a gap, the larger part of which had never been driven. From Station 6 to Station 8 + 50 the three rows of piles, braced with large poles, were in good condition.

A section of foundation mattress was begun on July 17 at Station 7. On July 19 it had been extended to Station 5 + 70, making a section 130 feet long and 38 feet wide, when it had to be dropped from the flats and placed, as about twenty piles at its end were washed out and twelve more crowded over and had to be pulled. On account of the large amount of drift-wood above the line, the foundation mattress was only built up to the drift-row instead of above it.

On July 23 the wattling was begun at Station 8 + 50 and extended to Station 5 + 75. It varied from 4 to 18 feet deep and averaged about 14 feet.

On July 26 a new section of foundation mattress was begun, and up to August 1 120 feet had been constructed.

On August 1 all of the piles of the line had been driven and stringers placed on all of the drift-row and part of the second row. On that evening the rising river carried so much drift-wood against the line that a break of about 200 feet occurred, taking out all of the piling, two flats, and about 100 feet of foundation mattress that had been dropped from the flats on that day. The break extended from Station 3 + 50 to Station 5 + 50. The drivers immediately moved into the break and commenced re-driving the line in from 20 to 36 feet of water.

On August 8 a section of foundation mattress about 40 feet wide was commenced at Station 4 + 20. It was extended to Station 4 + 75, when it had to be placed, on account of the drift-wood accumulating under it.

On August 14 about 100 feet of foundation mattress about 30 feet wide was placed in about 25 feet of water. In sinking, the upper edge of the mattress caught on the drift projecting below the drift-row, and considerable difficulty was experienced in getting it to the bottom. This section completed the mattress required on the line.

After completing the work in the break the drivers put extra piles in the third row from Station 1 + 80 to Station 4, drove a brace row behind them, and placed braces and stringers on that portion of the line.

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The braces and stringers placed at a higher stage of water on the west end of the line were lowered to about 16 feet above standard low water.

The short incline at the east end of the line and from Station 0 to Station 1 of the main line was wattled. The wattling varied from 7 to 18 feet deep and averaged about 12 feet. The remainder of the line could not be wattled on account of the large amount of drift projecting through the second row of piles.

On August 28 the driver crews were discharged and the drivers sent back to the depot.

On August 18 about 50 feet of the drift row crowded down against the second row, but still remained in an upright position.

On August 25 about 50 feet more of the drift row, including two clumps of three piles each, moved bodily down against the second row.

On October 21 a break of about 125 feet occurred in the line. It extended from Station 4 + 75 to Station 6. Driver No. 17 arrived from Horsetail Bar on the 22d, and commenced repairing the line. It was repaired by building up around the break instead of directly across it, as the driver would have considerable shoaler water to work in. About 75 feet of the drift-row on the east side of the break had been crowded down against the second row, which was also moving bodily down-stream. The new work was extended over far enough to protect that portion of the line. The total length of the new work was about 240 feet, although the ends were located at about Station 4 and Station 6.

On November 13 all of the piles had been driven, stringers and cross-stringers placed, and all but two braces bolted into place, when 200 feet of the new work gave way, taking with it about 60 feet of foundation mattress about 50 feet wide, that had been constructed on that day. For several days previous to the break the line was moving bodily down-stream. The mud brought up on the jet-pipe of the driver indicated that the bottom was of a soft blue mud.

As it was too late in the season to repair the line, two barge loads of stone were thrown in and around the break to prevent further scouring.

During the half year the following work was done on the hurdle line: 305 piles driven, 172 braces placed, 121 stringers placed, 465 linear feet, 18,000 square feet, of foundation mattress averaging about 38 feet wide.

Four hundred and thirty-five linear feet, about 5,700 square feet, of wattling averaging about 13 feet deep.

Before suspending work in June the medium stage protection had been extended up to 16 feet above standard low water from Station 0 to Station 28 + 90, and up to the 6-foot stage from Station 28 + 90 to Station 39.

As the banks of the island were of a sandy soil the high water graded them back from the riprap with a very flat slope.

Work was resumed on the medium stage protection about the 15th of August and continued during the months of September and October. The riprap was extended up to the foot of the small bluff bank, on the east side of the island, from Station 0 to Station 43, also from Station 0 to Station 2 on the west side of the head of the island. The averaged width of the portion placed was about 30 feet.

A large part of the stone placed between Station 0 and Station 20, also between Station 2 and Station 5 + 40 on the west side of the island, during the high water was leveled off and the surplus stone used to extend the riprap up to the foot of the bluff bank.

The following table gives the total width of the riprap, and the height to which it is carried above standard low water:

Station.	Width.	Height.	Station.	Width.	Height.	Station.	Width.	Height.	Station.	Width.	Height.	Station.	Width.	Height.
0	80	21	11	78	20	22	65	17	33	85	20	20	80	23
1	115	21	12	74	21	23	68	18	34	80	21	* 50	80	23
2	100	21	13	77	19	24	80	20	35	90	21	* 1	80	21
3	100	21	14	73	21	25	65	20	36	75	20	* 2	40	19
4	98	20	15	70	20	26	65	21	37	67	20	* 3	43	21
5	95	20	16	68	20	27	63	20	38	60	16	* 4	48	22
6	105	20	17	60	20	28	60	21	39	68	16	* 5	30	20
7	105	20	18	70	20	29	60	16	40	75	18	* 40	25	16
8	90	20	19	68	18	30	65	10	41	68	13			
9	90	21	20	65	19	31	60	17	42	52	14			
10	83	21	21	48	17	32	70	18	43	40	18			

* On the west side of the head of the island.

The high water in June left from 6 to 18 inches of mud on the floors of the portable shanties. They were cleaned out as soon as practicable, and the floors raised off of the mud. In September they were taken down and sent to the depot.

During the first part of November about ninety cords of brush were cut from the lower end of the island and loaded on barge No. 19.

The tracing forwarded herewith shows the condition of the work on December 3, 1883. The portion in red indicates the work done the half year. The soundings in black were taken December 3, 1883; stage of water 6 feet on the standard gauge. Soundings in red were taken June 30, 1883, but are reduced to the same stage as those in black.

The tables appended show the service of plant, material expended, and the distribution of labor.

In closing, I desire to express my thanks to Mr. B. E. Johnson, resident engineer, for valuable assistance rendered.

Very respectfully, your obedient servant,

C. V. MERSEREAU,
Resident Engineer.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

9.

JIM SMITH'S.

REPORT OF MR. JOHN O. HOLMAN, ASSISTANT ENGINEER.

SAINT LOUIS, MO., December 31, 1883.

SIR: I have the honor to submit herewith, the report of the operations at Jim Smith's, for the half year ending December 31, 1883.

The damage to the works by the ice of last winter was increased by the high water of June and July. The inclined primary from the shore to Station 11, which was in good condition before the rise, was washed out, as also all that remained of hurdle No. 1, and the high sandbar which had formed between the primary and hurdle No. 2. Very little change occurred in the lower hurdles.

An outfit for the repair of the inclined primary was moved to Jim Smith's, August 1, locating the quarter barges on the Illinois shore just at the foot of Beard's Island.

Driving began on the 3d at the shore end. Three rows, the drift, hurdle, and brace-rows were entirely redriven to Station 17½, with exception of about 50 feet at Station 10, where 12 piles of the old line remained in position. In this distance 552 piles were driven in 411 hours, a rate of 13½ piles per day, varying from a weekly rate of twenty piles per day to one of eight per day.

From the shore end to Station 9½, the shoal water with moderate current, and the absence of the old piling and foundation mattress rendered the driving easier than from Stations 9½ to 17½, where the piles remaining from the old line, and the strong current passing through them, made the driving very difficult. From Station 17½ to Station 34, 139 piles were driven, of which about 40 were driven in the drift-row to Station 18½, and the brace row to Station 22, and 99 in the hurdle row. The hurdle row was repaired between Stations 17½ and 27, redriven in the break, which extended from Station 27 to 30, and repaired from Station 30 to 34. The driving reached Station 17½ September 24, and Station 34 October 13. Station 18½ was made the end of the drift-row and Station 22 the end of the brace-row, it also being the end of the stringing, bracing, and wattling.

A scour of several feet occurred the last of October at Stations 27 and 28, washing out about 24 of the newly-driven piles, which were redriven November 1 to 7, and stringers placed along the length of the new work from Station 27 to Station 30.

Stringers were placed on the drift, and hurdle rows from the shore end to Station 22 by October 10. To Station 17½ the hurdle-stringer was placed at a 16-foot stage, the drift-row at a 17-foot stage, but below Station 17½ to Station 22 the stringer was lowered to a 14-foot stage, which was about the height of the piling of the old line.

Bracing of the line began August 20, and was finished October 15. The braces were placed against every other hurdle-pile, and against the piles in the drift-row upon which the drift-stringer lapped. To Station 10½, which is the end of the new foot mattress, the braces were lowered to the bottom, but below Station 10½ the braces were held above the bottom by wire, giving them a heel against the brace-pile. To do this the round or down-stream end of the clevis, which is placed over the brace-pile was held by a double strand of No. 9 wire, when lowered nearly to the bottom and the brace would receive a solid footing against the brace pile. The braces from Stations 10½ to 22 were placed in this way, and but two of them dropped from place.

The mattress was begun August 4 on the shore 200 feet above the piling. It was built 50 feet wide, and to Station 4½ was built in the old form, a frame-work of poles

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with two layers of brush wired to it. The brush used was out before the high water and had become too stiff for weaving. From Station 4½ to Station 10½ the mattress was woven on three flats, the ways of which were high enough for weaving over the tops of the piles. Station 10½ was made the end of the mattress, because the old mattress was found to be in good condition below Station 10.

The wattling was not begun until the line to Station 18 had been driven and braced. October 6 and November 8 were the dates of the wattling from Station 0 to Station 22. The work was started at Station 8, working down-stream to a 1-foot stage to Station 18, and then from Station 22 full height up-stream to the shore end. The work was slow, owing to the extra work required in moving the flats in the strong current and in raising the flats sunk by the steamboats.

Secondary No. 1 was entirely rebuilt from the shore to the primary, a distance of 950 feet, between October 13 and November 19. The driving and stringing was finished November 8, the mattress, 30 feet in width, was woven on two flats and finished on the 10th, the bracing on the 16th, and the wattling on the morning of the 19th. The braces were lowered to the mattress for a footing.

The pile-drivers at Jim Smith's were Nos. 5, 10, and 21. No. 10 drove all the piles in the primary until the beginning of the secondary, October 12, when it was exchanged for No. 5; No. 21 doing all of the stringing and bracing. No. 21 was fitted with a boom during the first part of August, by which the stringers of the hurdle and drift rows, and the drift-row braces could be placed with the driver below the brace-row of piling. From October 13 to 19, drivers 5 and 21 drove most of the piles in secondary No. 1, when No. 5 was laid up, No. 21 finishing the secondary and repairing the break in the primary at Stations 27 and 28.

The tracing of the progress map accompanying this report shows the changes from August 2 to December 3. The bar-lines and soundings of August 2 are in red, those of December 3 are in black. Below No. 2 the survey of November 1 is used, as none was made of that portion of the work for the November report. The work constructed on the primary and No. 1 secondary is shown by red lines.

Appended are tables showing the service of the plant, and the material used.

Postscript.—June 19, 1884.

I have the honor to submit herewith a sketch, showing the condition of the works at Jim Smith's, June 12, 1884.

The inclined primary line below Station 20, and the end piece of No. 2 hurdle, most of which was built the previous year, has been carried away by the spring rise.

Secondary No. 1, and the primary above No. 1, which were built this year, remain intact.

The high water of March and April caved the bank at the head of the primary, but so far no damage has been done to the hurdles. The deposit has been very heavy at the upper end of the work, and also along the primary between secondaries Nos. 5 and 7. The current passing along the shore coming from the point F has scoured a deep channel clear down to hurdle No. 7.

Very respectfully, your obedient servant,

JOHN O. HOLMAN,
Resident Engineer.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

10.

FOSTER'S ISLAND.

REPORT OF MR. J. E. SAVAGE, ASSISTANT ENGINEER.

SAINT LOUIS, MO., December 31, 1883.

SIR: I have the honor to transmit herewith a report of the operations carried on at Foster's Island, Illinois, with a view to improving the Mississippi River, for the half year ending December 31, 1883.

I assumed charge of this work as resident engineer in accordance with your orders of September 28, 1883, relieving First Lieut. F. V. Abbot, Corps of Engineers.

SEMI-ANNUAL REPORT OF OPERATIONS AT FOSTER'S ISLAND, ILLINOIS.

The work of protecting the banks of Foster's Island, which was commenced November 9, 1882, and continued until the closing of navigation that year, was resumed August 23, 1883, and carried on until December 13.

During the season of 1882 580 linear feet of low-water mattress 100 feet in width had been constructed, and part of a large load of stone placed for medium stage protection. In the season of 1883, 5,284 linear feet of low-water mattress was constructed and placed, 5,030 linear feet of medium stage protection carried 9 feet above standard low water, and 254 linear feet carried 7 feet above that stage were placed.

A small force was organized, and, with the necessary plant, conveyed to the island August 23, by steamer General Gillmore.

All the preparatory work was completed and the fabrication of the mattress commenced August 27, and by September 1 a force of 60 laborers, and the allotted proportion of foremen, was complete.

No point of last season's survey could be found, as all the hubs had either been lost by the caving of the bank, or had been covered with a deposit of sediment; consequently it became necessary to make a new triangulation survey.

A transit line running north and south, having a zero station opposite the determined location of the head of the new mattress, was established. This survey showed considerable change in the outline of the bank. The large high bar which, last season, was opposite the head of the island, had extended down-stream over 3,000 feet, rendering it impossible to connect with the former protection works. Measured on the new transit line, the lower extremity of that work is 2,360 feet above Station 0.

The high bank below this bar was caving quite rapidly, and showed a maximum cut of about 600 feet since the survey of 1881.

Soon after the construction of the mattress was commenced, a rapid shoaling of the water, caused by a deposit of sediment, was noticed under the upper part of it. This unexpected result rendered it necessary to drop the mattress 270 feet down-stream, where sufficient depth of water was found, and the protection as completed extends from this point—Station 2 + 70—to Station 55 + 54.

Under the headings of low-water protection, medium stage protection, and surveys a detailed description of each class of work is given.

LOW-WATER PROTECTION.

Mattress fabrication.—The work of fabricating was commenced August 27, and progressed continuously until November 27, with the exception of a few days lost on account of bad weather.

The mattress was constructed according to the design adopted in 1881, being 120 feet wide, woven on a framework of willow poles, and secured to a line of guide piles, in such a manner as to place the inner edge at standard low water. It was strengthened laterally by cross-stringers of the same size as the weaving poles, which were woven with the brush at intervals of 100 feet, and which also afforded a reliable hold for the securing lines.

The force engaged at this class of work consisted of one suboverseer, one master laborer, and an average of about 48 laborers.

Slow progress was made at the outset, as the force of laborers was small and unaccustomed to this kind of work, but later in the season quite rapid progress was made, the average per 10 hours' labor increasing from .91 linear feet in the month of August to 1.97 linear feet for November.

The largest amount and largest average attained in any one day was 120 linear feet, with 480 hours labor, or 2.5 linear feet per 10 hours' work. This average is believed to be the best that has been made on this class of work.

On November 27 the construction had been carried to Station 55 + 54, or a length of 5,284 linear feet, the longest continuous mattress in the world. The lower portion was launched from the ways the next morning and the sinking process successfully completed.

The following statistics show the hours labor, linear feet fabricated, linear feet per 10 hours, and the cost of the labor of fabricating for each month, together with the totals and average for the season.

They are carefully compiled from measurements which were taken each day.

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Date.	Labor.	Fabricated.	Fabricated per 10 hours labor.	Laborers.	Foremen.	Total.
	<i>Hours.</i>	<i>Feet.</i>	<i>Feet.</i>			
August.....	1,078	99	0.91	\$97 02	\$43 15	\$140 17
September.....	10,541	1,600	1.53	948 69	165 20	1,113 89
October.....	10,939	1,691	1.54	984 51	195 75	1,180 26
November.....	9,597	1,894	1.97	863 73	170 50	1,034 23
Totals.....	32,155	5,284	1.64	2,893 95	574 00	3,468 56

Total cost for labor per linear foot, 65.67 cents.

Securing mattress.—The mattress was secured and held in place in about the same manner as in last season. A line of guide piles were driven 15 feet apart, following the shore-line, and 15 feet nearer shore than the line of standard low water. The mattress was attached to these piles by extending two willow poles from the mattress to the upper and lower side of each pile, spiking and wiring cross-pieces inside and outside the pile in the form of a yoke, and securing the other ends with wire to the first and second weaving poles of the mattress. No. 9 wire was used on the yokes instead of sisal rope, and in not a single case did a yoke break or become detached from the mattress.

To hold the head of the mattress in place, the usual mooring barge was swung out at right angles to the stream, its prow being placed against a clump of piles, while the outer end is held by 5-inch and 6-inch manila lines secured on the bank.

The head block of the mattress was secured to the lower side of this barge and two 5-inch lines were attached to the mattress (with the usual toggle and buoy), which, leading up the bank, were secured to trees or "dead men." As weaving progressed, other lines were similarly placed at distances of about 100 feet apart, and as sinking progressed the upper lines would be drawn out and used further down-stream.

The following table gives the hours, labor and cost of securing for each month, and includes preparing and driving piles for the same:

Date.	Labor.	Laborers.	Monthly men.	Total.
	<i>Hours.</i>			
August.....	283	\$23 67	\$30 80	\$54 47
September.....	1,730	155 70	118 20	273 90
October.....	1,686	152 64	122 00	274 64
November.....	1,551	139 59	101 25	240 84
Totals.....	5,240	471 00	372 25	843 85

Cost of securing per linear foot, 15.97 cents.

Sinking mattress.—After about 250 linear feet of the head of the mattress had been placed, September 8, sinking progressed continuously with fabrication; from 150 to 200 linear feet being placed every second or third day.

To sink the head of the mattress another mooring barge partly loaded with stone was drawn across it, 250 feet below, sinking it to a sufficient depth to allow the barge to pass over. The barge was then secured and the mattress attached to its lower side in about the same manner as to the first.

The section between the two barges was then sunk in a manner similar to that adopted last season. A barge partly loaded with stone—the balance having been transferred to the upper mooring barge—was drawn up over the mattress to its head, this being accomplished by partly sinking the mattress as it progressed, and then stone was thrown from both barges, the mooring lines slackened, and the head placed. The barge was then swung down over the mattress again and sufficient stone thrown on to sink it securely on the river bed.

For the continuous sinking, a barge-load of stone was kept on the up-stream side of the mooring barge, and, as the fabrication progressed, sufficient mattress was placed to leave only about 200 linear feet floating above the ways barge.

This plan necessitated sinking a section every second or third day, and for this purpose eight laborers were usually employed from three to four hours. Eight stage plank were used as "runs" for stone barrows, and enough stone wheeled from the upper barge and dumped from the lower side of the mooring barge to allow both to pass over the mattress, the sinking process being completed by throwing stone from the upper barge to sink it to its place as the lines were gradually slackened and the barges dropped.

This process was repeated until the required length had been placed, when the mattress was again secured to the mooring barge until enough more had been fabricated for another sinking.

The appended table shows the hours labor sinking, amount sunk, linear feet sunk per 10 hours labor, and the cost of labor, for each month:

Date.	Sinking.	Sunk.	Ten hours' labor.	Laborers.	Foremen.	Total.
	<i>Hours.</i>	<i>Lin. feet.</i>	<i>Lin. feet.</i>			
September.....	592	1,310	22.1	\$53 28	\$29 90	\$83 18
October.....	252	1,750	69.5	22 68	15 60	38 28
November.....	268	2,224	83.0	24 12	13 85	37 97
Totals.....	1,112	5,284	47.5	100 08	59 35	159 43

Cost of sinking per linear foot, .302 cents.

MEDIUM STAGE PROTECTION.

Placing riprap.—Medium stage protection, to consist of the usual layer of riprap stone, was begun October 20, with an additional force of one master laborer and twelve laborers.

No grading of the bank was done, as it was designed to carry this protection only from the inner edge of the low-water mattress to 6 feet above that stage during the present season.

With the small force employed and the necessity of taking men from it at times in order to keep the mattress gang complete, the work progressed very slowly until the 16th of November. On that date, another quarter-boat having been received, two more gangs were organized, and the work pushed forward rapidly.

A rise in the river about this time effected a grading of the bank to about 9 feet above standard low water, and as the weather continued favorable after the completion of the mattress, it was decided to carry this protection to the foot of the perpendicular bank.

Work was continued until December 12, the bank having been protected from Station 2+70 to Station 53, 9 feet above standard low water, and to a height of 7 feet above that plane from Station 53 to Station 55+54.

The average width of the stone protection is a little over 43 feet, and the number of square feet is 228,660.

The process of placing riprap was so irregular, the same section being carried to a different stage at a later date, that any statistics to show progress and cost for each month would be impracticable; therefore only the total hours, labor, and cost are given:

Laborers, 8,735 hours, at 9 cents.....	\$786 15
Foremen.....	215 90

Total labor	1,002 05
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Linear feet revetted per 10 hours' work.....	6.05
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Cost of labor per linear foot	17.77
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SURVEYS.

Triangulation.—As no point of previous surveys could be found on the island, triangulation survey was made early in September to locate the shore-line and establish a transit-line. Stations 27 and 29 of McGregor's survey, on the Missouri shore, were used, and angles taken to re-establish Station 31 of the same survey.

The triangulation was made from these points to two stations, A and B, on the large bar mentioned above, and Station C, on the island. The angles were all read to a third repetition on both verniers of the transit, each vernier being read independently by different persons. By this means, although the distances were from 1 to 2 miles, all the triangles closed very accurately, the greatest variation being about 30 seconds, while nearly all closed within 6 or 7 seconds.

The continuation of the line between B and C was made the upper part of the transit-line for locating the work constructed, the zero station being 300 feet south of Station C.

Measurements were taken from the upper continuation of the transit-line to the piles driven at the head of the previous protection-work, in order to check its location. When plotted on the progress map these measurements checked the location of that work as nearly as could be ascertained by scaling it.

Transit-line.—In order to make the transit-line to which the construction work is

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referred as permanent as practicable on ground subject to a heavy deposit of sediment, it was located from 100 to 200 feet from the bank, and large hubs 4 feet long and 6 inches in diameter were driven at Station 0, at each 400-foot station below this point, and at Station 2+70, the head of the protection. These hubs project 2 feet above the ground and are suitably and permanently numbered.

Soundings.—Soundings have been taken at the end of every month opposite each 400-foot station of the line. A new method was adopted to locate the soundings, as follows: A light cod line was divided by tags into 25-foot spaces; one end of this was held on the bank opposite the station, the other in a skiff. The oarsmen kept the skiff in range with 2 signals at right angles to the transit-line, while the leadsman cast the lead opposite each tag. It was found that for short lines of soundings this method is more accurate and takes less time than the method of locating each sounding with the transit.

The entire work progressed very smoothly throughout the season, no break, accident, or loss having occurred either in constructing or sinking the mattress.

The total cost of all labor, including engineering and subsistence for the season, was \$7,565.34, which shows the cost of labor per linear foot of bank protected to be about \$1.43.

The appended tables show in detail the application of labor and the service of equipment, and the accompanying sketch shows the location and progress of the work.

I desire to express my thanks, before closing, to Mr. Gerald Bagnall, assistant engineer, for his intelligent assistance, and the interest he has manifested in the work.

Very respectfully, your obedient servant,

J. E. SAVAGE,
Assistant Engineer.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

11.

SUPPLY DEPOT.

REPORT OF MR. C. L. STEVENSON, SUPPLY CLERK.

UNITED STATES ENGINEER DEPOT,
Saint Louis, June 30, 1884.

SIR: I have the honor, respectfully, to submit a report of the operations at this depot for the fiscal year ending June 30, 1884.

The work done by the mechanics was confined chiefly to repairs to equipment, which are described as follows, viz:

Steamer General Gillmore.—A new boom for the electric light was placed, new kevels made and fixed, a surface blower for the boiler prepared, and slight repairs made to the boat at different times during the last half year.

Steamer A. A. Humphreys.—Slight repairs were made to the machinery in the latter part of the year.

Launch Florence.—A new wheel was added, the hull repaired, the machinery overhauled and put in good working order. Later in the season a new bed-plate was made for the pump, new stanchions for the cabin, the braces to the pilot-house re-fastened, and slight repairs made to the hull.

Launch Hornet.—The hull having been condemned as worn-out and unserviceable, the machinery was removed from it, greasy-leaded, and put away for further use.

Pile-driver No. 3.—The fire-front was patched and slight repairs made to the machinery.

Pile-driver No. 4.—The cabin was straightened, two stanchions—extending to the bottom of the hull—put in to stiffen it, and the doors were repaired.

Pile-driver No. 7.—One timber-head, one side-brace to the leads, three rails to the platform, four kevels, and one toggle-iron were renewed, her rakes calked, and machinery repaired. Later she was raised from the water and a break in the bottom closed with new plank.

Pile-driver No. 9.—The friction and caps to the drum renewed.

Pile-driver No. 13.—A side brace to the ladder was renewed.

Pile-driver No. 15.—A new air chamber and pipe connections were furnished.

Pile-driver No. 16.—A side brace to the leads was renewed.

Pile-driver No. 17.—One side rail and two braces to the leads made.

Pile-driver No. 21.—A new side brace made for the leads and the machinery repaired.

Machine-shop.—The hull of it being worn out and unserviceable the cabin was transferred to that of pile-driver No. 14, was properly repaired and fitted up with conveniences suitable for the work of the master machinist. The deck, outside of the cabin, was calked, seams payed, and timber-heads added.

Quarter-boat No. 4.—The main deck closet and guards were repaired, sliding windows put in, the hull calked, and closet painted.

Quarter-boat No. 5.—Parts of the deck and a hatch-cover were renewed, slight repairs were made to the after quarter, and the rakes calked.

Quarter-boat No. 6.—The water-closet was rebuilt, two new hatch-covers added, the locks and pumps repaired, glass renewed in some of the windows, and rakes calked.

Mattress-barge No. 2.—The platform and ways repaired and hull calked.

Barge No. 12.—Braces were added to the top sides extending from the floor to the clamp streaks.

Barge No. 14.—A survey was made and extensive repairs put on her hull. The old deck, deck beams, and top streaks on the sides were replaced by new materials; all the top streaks, 69 deck beams, 117 short top timbers, the plank-sheers, center streak, two pieces of the center streak, under the beams, two capstan beds, three hog chain posts, and two pairs of bitts were renewed. Two hundred and thirty new stanchions were put under the beams, the futtock head streak in the hold repaired, a piece of the main keelson removed, and new timber placed. Her deck was relaid with new plank, it and the hull calked, and the whole painted.

Barge No. 15.—The side dock was used to repair below the water-line; an engraven piece was put in the knuckle plank amidships, and two planks, one 16 the other 8 feet at the water-line, were renewed, defective planks on both sides of the hull were replaced by new, a broken capstan replaced, the hog-chain braces (four) were renewed, deck patched in several places, and hull calked where needed.

Barge No. 18.—The top sides were calked all around, deck calked all over, and the hull painted.

Barge No. 21.—New kevels were added, deck patched, hull repaired, and top sides calked.

Barge No. 23.—Three pieces of new plank were put in on one side of the hull, two on the other side, the patches and top sides were calked.

Barge No. 24.—Seven short hoods on the bow at one end, five on the other, and one piece in the side were renewed, the deck patched, and top sides calked.

Barge No. 25.—A pair of bitts was added, the pump repaired, top sides calked, and hull painted.

Barge No. 27.—The top sides were calked all around, pumps put in order, and the hull painted.

Barge No. 29.—The rakes were repaired and hull calked.

Barge No. 31.—A bulkhead was built across one end, pumps repaired, and rakes calked.

Barge No. 34.—Three new planks were put in the rakes, other repairs made, and rakes calked.

Barge No. 38.—Slight repairs made to her hull and rakes calked.

Barge No. 39.—Pumps repaired and rakes calked.

Barge No. 40.—Pumps repaired, rakes and top sides calked.

Barges Nos. 41, 46, 54, which had been in service as mattress barges, had their platforms and ways removed to be used for carrying materials. No. 46 had two new timber heads and the rakes calked; No. 54, four planks in her rakes, two in the gunwales, and two timber heads were renewed and her rakes calked.

Barges Nos. 43, 44.—Their pumps were repaired, sides and rakes calked.

Barge No. 45.—One end was raised from the water with side dock, rake timbers, planks on the rakes, and end of the gunwales were renewed and rakes calked. Later in the season she was put in the sectional docks and received general repairs.

Barge No. 49.—One plank-shear renewed, pumps repaired, and top sides calked.

Barge No. 51.—The top sides were calked.

Barge No. 53.—Slight repairs were made to her hull, top sides calked, and pumps repaired.

Barge No. 55.—Five new planks were put in her rakes and the rakes calked.

Barge No. 56.—Six planks on one side and five on the other were renewed and top sides calked.

Barge No. 42.—Was docked by the Missouri Dock Company and received general repairs. One long and one short plank were put in the rake forward, one short piece in that aft, six pieces, engraven, in the gunwales on the larboard and five on the starboard side. All the bottom, two of the scarps on one side, and the rake seams as high as the second gunwales were calked. Again, in the second half-year, she was placed in the sectional docks, overhauled, two engraven pieces put in the bottom, the bottom, sides, and rake seams recalked, the latter to 4 feet from the bottom.

Barges Nos. 41, 46, and 54 were placed in the sectional docks and received general repairs.

Barge-flats Nos. 28, 30, 32, 33, and 38, having been condemned as worn out and unserviceable, the shanties thereon, which had been used as quarters for working parties, were transferred to and put up on Nos. 40, 51, 41, 49, and 55, respectively, to be applied to similar service. The former, with barge-flats Nos. 31, 36, 37, 44, 45, and

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50, which had also been condemned as worthless, were wrecked, and the materials taken therefrom put away at the depot for further use.

The small barge-flat pertaining to the Osage River appropriation received new deck-beams, a new deck of grub-plank, four new timber heads, and her rakes and sides were calked. Two sections (10 by 12 feet) of portable shanties were put up on it to be used as a telephone office for the works at Chesley Island.

Three sections of portable shanties were put up on the hull of pile-driver No. 14, to be used as quarters at Foster's Island. This hull was subsequently used for a floating machine-shop, as stated heretofore.

Slight repairs were made from time to time, during the year, to the machinery of pile-drivers Nos. 1, 2, 6, 8, 9, 10, 11, 12, 18, 19, and 20.

Ways were constructed on five large flats to be used for weaving mattresses.

Five large flats were decked over, calked, and ways built on them for constructing mattresses.

Small boats.—The flats, yawls, and skiffs were repaired, from time to time, during the year, as needed for service.

Eight clumps of piles, three to each, were driven along the channel bank at the depot, to be used as moorings for the fleet.

Among the smaller fabrications furnished to the works during the year were 7,144 bolts, assorted sizes, and 2,218 pile clevises.

The implements, tools, and appliances in use at the works were repaired here, from time to time, as needed.

The materials, supplies, boarding outfit, and the plant of the department, which were in use in the field, were transferred to the depot about the 1st of June—the former stored, and the vessels moored in harbor.

I submit herewith a statement in detail of the distribution of materials and supplies expended on equipment in the last half-year, and also one of that on hand at the depot at the close of the fiscal year, June 30, 1884.

With much respect, your obedient servant,

C. L. STEVENSON,
Supply Clerk.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

12.

SUBSISTENCE.

REPORT OF MR. S. S. VAN NORMAN, SUBSISTENCE CLERK.

UNITED STATES ENGINEER DEPOT,
(SUBSISTENCE DEPARTMENT),
Saint Louis, June 30, 1884.

MAJOR: I have the honor to submit my report of operations in the subsistence department connected with works of improvement under your charge for the fiscal year ending June 30, 1884.

COST OF SUBSISTENCE.

The average cost of the ration with the average number of men subsisted are given in the following table, and includes the cost of service of all persons employed in the department:

Months.	Average number of men subsisted daily.	Average cost of the ration for each month.
July, 1883	168	Cents. 47
August, 1883	354	40
September, 1883	382	41
October, 1883	431	40
November, 1883	442	42
December, 1883	44	42
March, 1884	205	47
April, 1884	312	38
May, 1884	364	40
June, 1884	82	40

Or 42 cents per ration for the year.

During the first four months of 1882, when the present system of providing for employes was adopted, 736 men were subsisted at a cost of 47 cents per ration. For the same time in 1883 the cost of the ration, with 329 men, was 44 cents, and in 1884, with only 276 men, the cost of the ration was reduced to 42 cents, while the variety, quantity, quality, and service of the food were such that I have heard of but one complaint from the men during the year, which originated with a few disorderly persons in the brush force, and proved to be groundless.

The showing for 1884 is especially gratifying when we consider the fact that the number of men has been the smallest yet subsisted and the principal articles of provisions higher than before, and is no doubt due to the weeding-out process which has been going on in the department for the past two years, resulting in retention only of the most zealous and efficient employes, who have been educated to appreciate the necessity for rigid economy and strict accountability.

The manner of procuring and distributing supplies; variety and quantity of same; bill of fare, allowance, &c., are given in detail in my report for 1883, which may be found in Appendix T, page 1244, Report of the Chief of Engineers for 1883.

Very respectfully, your obedient servant,

S. S. VAN NORMAN,
Subsistence Clerk.

Maj. O. H. ERNST,
United States Engineers.

13.

PILE-DRIVING.

REPORT OF LIEUTENANT FREDERIC V. ABBOT, CORPS OF ENGINEERS.

SAINT LOUIS, MO., July 1, 1884.

SIR: I have the honor to transmit herewith a report showing in detail the manner in which the pile-drivers under your orders have been employed during the past fiscal year; and also the results deduced from the records kept during the last eighteen months by the master pile-drivers.

PART I.—SERVICE OF PILE-DRIVERS DURING THE FISCAL YEAR ENDING JUNE 30, 1884.

The object of the following report is to show the various ways in which the pile-drivers, at work under your orders, have been employed, and the proportionate time and expense devoted to each class of work they have done during the fiscal year ending June 30, 1884, and also to give the results of certain records which have been kept for the last eighteen months for each pile which has been driven.

The following table shows the number of hours the pile-drivers have been employed at each of the different localities for each kind of work, the corresponding money expenditures for labor, for wear and tear, and pile timber. In other words, it gives a reliable basis on which to estimate the probable expense and time required for similar work in the future:

TABLE I.—Service of pile-drivers for the fiscal year ending June 30, 1884.
CAHOKIA CHUTE.

Period.	Hours.	Labor.	Driver.	Piles expended.						Coal.	Coal.	Miscellaneous.	Total cost.		
				30 to 35 feet.		36 to 45 feet.		46 to 60 feet.						Total.	Total cost pile timber.
				No.	Feet.	No.	Feet.	No.	Feet.						
First six months:															
Driving.....	258	\$365 96	\$209 84	164	5,385	48	1,816			212	7,201	\$686 10	\$1,255 90		
Bracing.....	83	239 48	67 50	72	2,265	5	191			77	2,456	227 19	631 82		
Total.....	341	605 44	277 34	236	7,650	53	2,007			289	9,657	893 29	1,887 72		
Second six months:															
Driving.....	428	1,113 62	365 94	83	2,902	290	11,561	36	1,744	409	16,207	1,341 69	2,903 33		
Bracing.....	150	353 18	128 25	44	1,365	81	3,174	9	427	134	4,966	405 29	1,067 45		
Stringing.....	201	370 41	171 86	21	678	33	1,327	16	766	70	2,771	232 25	1,844 30		
Removing drift.....	46	101 75	39 33										141 08		
Raising driver No. 7.....	35	163 99	29 92										193 91		
Total.....	860	2,102 95	735 30	148	4,945	404	16,062	61	2,937	613	23,944	1,979 23	5,150 07		
Total for year.....	1,201	2,708 39	1,012 64	384	12,595	457	18,069	61	2,937	902	33,601	2,872 52	7,037 79		
HORSETAIL, EAST SIDE.															
First six months:															
Driving.....	1,045	\$1,378 71	\$849 94	407	12,255	442	17,598	56	2,780	905	32,633	\$3,019 56	\$5,446 28		
Bracing.....	204	798 72	239 12	265	9,209	142	5,435	16	827	443	15,471	1,431 07	2,877 90		
Stringing.....	146	737 90	118 74	194	6,735	132	4,873	58	2,827	384	14,431	1,334 87	2,667 49		
Removing obstacles.....	158	210 12	128 50										338 62		
Total.....	1,643	3,125 54	1,336 30	866	28,189	716	27,911	130	6,435	1,732	62,535	5,784 50	11,330 29		
Second six months:															
Driving.....	1,431	2,519 14	1,266 26	275	9,032	1,019	40,310	281	13,982	1,575	63,324	5,337 50	9,769 90		
Bracing.....	659	811 23	563 44	224	6,989	282	11,194	107	5,201	613	23,384	1,934 71	4,130 17		
Stringing.....	584	1,097 18	499 32	51	1,628	121	5,044	93	4,635	265	11,307	974 10	2,894 88		
Removing obstacles.....	278	364 12	237 68										635 08		
Miscellaneous service.....	103		86 07										88 07		
Total.....	3,105	4,791 67	2,654 77	550	17,649	1,422	57,548	481	23,818	2,453	98,015	8,246 31	17,518 11		
Total for year.....	4,748	7,917 21	3,991 07	1,436	45,838	2,138	85,459	611	30,253	4,185	161,550	14,030 81	28,848 40		

TWIN HOLLOW, WEST SIDE.

First six months:	555	\$914 48	\$451 40	258	9,070	258	10,643	63	3,042	609	22,755	\$2,104 94	640	\$44 80	\$9 92	\$3,525 54
Driving.....	431	452 25	350 55	121	4,042	81	3,106	12	592	214	7,830	734 29	455	31 85	12 25	1,571 19
Bracing.....	374	677 78	304 19	122	3,846	41	1,565	32	1,613	195	7,024	649 74	405	34 65	1 35	1,657 71
Stringing.....	289	664 05	235 05	31	948	17	671	1	51	49	1,570	154 48	220	15 40	108 41	1,177 39
Crib.....																
Total.....	1,649	2,708 56	1,341 19	562	17,906	397	16,075	108	5,298	1,067	38,279	3,633 45	1,810	126 70	131 93	7,941 83

PULLTIGHT.

First six months:	590	\$914 48	\$479 87	236	7,842	488	19,403	65	3,159	789	30,404	\$2,812 38	839	\$58 73	\$10 10	\$4,275 57
Driving.....	292	948 59	237 50	240	7,535	108	4,183	10	480	358	12,198	1,128 15	385	28 95	345 08	2,688 27
Bracing.....	171	235 26	139 08	3	1,103	42	1,723	29	1,403	74	3,229	298 69	295	20 65	110 16	803 84
Stringing.....																
Total.....	1,053	2,098 33	856 45	479	15,480	638	25,309	104	5,042	1,221	45,831	4,239 23	1,519	106 33	465 34	7,765 68
Second six months:	550	\$791 41	\$471 69	10	344	249	10,261	118	5,872	377	16,477	\$1,430 38	1,120	\$73 11	\$503 60	\$3,270 19
Driving.....	197	243 06	168 44	44	1,489	102	3,890	7	46	147	5,425	428 55	235	15 41	159 44	1,014 90
Bracing.....	104	184 42	88 92	37	1,174	23	905	7	362	67	2,441	209 97	100	6 56	44 05	533 92
Stringing.....																
Total.....	851	1,218 89	729 05	91	3,007	374	15,056	126	6,280	591	24,343	2,068 90	1,455	95 08	707 09	4,819 01
Total for year.....	1,904	3,317 22	1,585 50	570	18,487	1,012	40,365	230	11,322	1,812	70,174	6,308 13	2,974	201 41	1,172 43	12,584 69

JIM SMITH'S.

First six months:	747	\$1,307 00	\$608 13	336	8,748	414	15,236	159	8,240	909	32,224	\$3,172 71	1,398	\$96 23	\$64 76	\$5,250 82
Driving.....	290	532 88	235 86	90	2,840	111	4,418	77	3,960	278	11,248	1,040 45	449	31 43	262 32	2,102 94
Bracing.....	344	444 20	279 78	32	1,052	61	2,405	40	2,217	133	5,674	524 85	571	39 97	211 22	1,500 02
Stringing.....	55	87 45	44 74													132 19
Waiting.....																
Total.....	1,436	2,371 53	1,168 51	458	12,640	586	22,059	276	14,447	1,320	49,146	4,738 01	2,416	169 62	538 30	8,985 97

CHESLEY ISLAND.

First six months:	400	\$603 24	\$326 88	71	1,809	179	7,316	72	3,754	322	12,879	\$1,191 31	320	\$22 40	\$10 10	\$2,153 93
Driving.....	192	235 53	156 16	92	3,015	67	2,610	13	653	172	6,377	580 63	133	9 31	145 69	1,127 38
Bracing.....	197	342 42	160 23	47	1,523	49	1,894	24	1,270	120	4,657	433 55	100	7 00	115 40	1,058 00
Stringing.....	28	44 52	22 77													67 29
Removing obstacles.....																
Total.....	817	1,235 77	666 04	210	6,347	295	11,820	109	5,676	614	23,843	2,305 40	553	38 71	271 19	4,407 20

TABLE I.—Service of pile-drivers for the fiscal year ending June 30, 1884.—Continued.

HORSETAIL BAR, WEST SIDE.

Period.	Hours.	Labor.	Driver.	Piles expended.								Coal.	Miscel- laneous.	Total cost.	
				30 to 35 feet.		36 to 45 feet.		46 to 60 feet.		Total.	Total cost pile timber.				
				No.	Feet.	No.	Feet.	No.	Feet.						
Second six months:															
Driving.....	221	\$322 31	\$188 95	31	1,056	153	6,242	103	5,200	287	12,498	\$1,065 03		\$29 52	\$1,644 23
Removing obstacles.....	19		16 25												16 25
Total	240	322 31	205 20	31	1,056	153	6,242	103	5,200	287	12,498	1,065 03		29 52	1,660 47

FOSTER'S ISLAND.

[illegible]

GRAND TOTALS.

[illegible]

MEANS.

1 pile	0.982	1.591	0.814	1	41.603	3.493	1.401	0.095	0.193	6.188
1 brace	1.063	1.894	0.881	1	36.640	3.243	1.245	0.087	0.958	7.065
1 stringer	1.622	3.127	1.379	1	39.422	3.561	2.248	0.153	0.964	9.152

Loading piles on barges, &c., 200 hours. Money expended for this work was carried to cost of pile timber.

PART II.

Since the opening of the working season of 1883 each master driver has been required to record for each pile the depth of water, length of pile, and depth driven, as well as the time at which he began and finished driving it, at which he began to move to drive the next pile and stopped moving, and in another column all the time during the days on which any piles were driven that his crew or driver devoted to other work than that which was directly connected with driving piles. While these records were, of course, not kept with any great degree of accuracy, it is thought that the averages obtained from all these records, kept by twenty-three different men, covering a period of eighteen months, during which time 9,519 piles were driven, are more reliable than any similar figures which have as yet been published in connection with jet-driving in sandy soils where drift-wood and strong currents are to be overcome.

No discussion of the records beyond the simple summing and taking of means has been attempted, as the driving done in any single season is of such a varied character, and there is so little chance that the next season's work will be done under even approximately similar circumstances, that anything more precise than a general statement of what will be true if a large number of piles are driven, would be liable to lead to error.

The first three items are of great aid to the resident engineer in keeping his records for the weekly and monthly reports. The main value of the time records is their immediate effect upon the master driver; he is forced to put on paper an account of the way in which his day has been spent, and he knows that this account will pass that very night through the hands of his immediate superior, the resident engineer, who can at once detect any falsifying, and whose attention will be called to any attempt to shirk duty. The time to make the record is practically nothing, and it is believed by all who have seen the system applied practically that the effect is to keep the drivers almost constantly at work.

Table II shows for each locality the total number of piles driven by each master driver on each pile-driver hull during the last eighteen months, together with the totals of all the other quantities recorded for each pile.

TABLE II.—Condensed record of pile-drivers.

CAHOKIA CHUTE.

Names of master drivers.	On pile-drivers.	Number of piles.	Depth of water. Feet.	Length of piles. Feet.	Depth driven. Feet.	Time driving. Min.	Time moving. Min.	Time incidental to driving. Min.	Driving time. Min.	Time other than driving.		
										Removing obstructions.	Equipment.	Idle.
Charles Years.....	2	161	1,896	5,133	2,393	2,363	2,737	2,460	.....	Min.	Min.	Min.
George Crane.....	4	6	87	145	62	175	455	570	.....	.....	1,500	780
Joseph Schneider.....	12	393	3,363	11,128	5,622	5,765	5,998	4,050	.....	.....	2,186	1,800
George Cannon.....	14	366	3,715	11,221	5,453	6,557	6,219	3,453	.....	.....	2,671	2,100
Charles Years.....	18	96	1,249	3,286	1,474	2,348	2,360	1,832	.....	.....	.....	1,260
James Nichols.....	19	77	1,074	2,493	1,987	1,493	1,151	1,936	.....	.....	120	1,480
Charles Years.....	13	120	1,813	4,717	1,799	2,925	1,750	4,685	.....	.....	9,840	1,980
Frank Schneider.....	7	108	1,943	4,525	1,562	3,181	1,444	4,075	.....	1,620	2,940	3,540
George Crane.....	10	60	1,741	2,187	1,868	1,445	1,760	4,495	.....	1,620	300	.....
D. T. Dent.....	11	121	1,157	4,513	2,039	2,550	1,490	850	.....	.....	810	300
Total.....	.....	1,508	17,018	49,348	22,279	28,802	24,364	23,427	76,593	3,600	20,367	12,240

HORSETAIL, EAST SIDE.

W. E. Jones.....	17	723	9,026	25,057	10,075	18,273	7,923	13,435	.....	2,701	5,908	2,760
C. W. Moore.....	16	629	6,200	20,968	8,327	12,483	7,172	15,284	.....	1,873	2,968	2,820
L. G. Johnson.....	7	122	1,498	4,430	1,596	3,620	2,540	3,164	.....	484	332	660
F. Schneider.....	11	175	1,654	5,415	2,651	3,083	2,389	2,767	.....	180	41	1,740
W. P. Bates.....	7	123	2,159	5,117	1,681	3,215	1,950	3,025	.....	2,370	1,550	1,090
H. Eichelberger.....	8	139	2,748	5,972	1,849	2,290	3,655	4,980	.....	780	875	1,210
Charles Years.....	9	103	1,700	4,215	1,561	2,915	3,140	2,150	.....	185	610	300
Frederick Frey.....	13	135	2,512	5,526	2,152	2,800	2,645	2,325	.....	960	570	900
W. E. Jones.....	16	303	5,338	11,481	4,302	6,593	6,917	6,235	.....	2,295	1,640	660
W. P. Bates.....	17	331	4,690	12,494	4,902	8,605	3,805	6,025	.....	2,070	1,635	420
L. G. Johnson.....	18	138	3,246	6,295	1,907	2,145	2,680	3,410	.....	970	1,775	120
C. W. Moore.....	20	138	1,929	5,264	2,187	2,700	2,545	3,315	.....	130	1,190	965
Total.....	21	165	3,051	6,741	2,463	2,715	4,319	3,068	.....	1,250	1,583	.....
.....	3,224	45,751	118,675	45,655	71,437	51,690	69,203	192,330	16,248	19,677	13,545

HORSETAIL, WEST SIDE.

D. T. Dent	11	281	4, 115	12, 154	4, 251	2, 402	5, 324	5, 474
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TWIN HOLLOW, WEST SIDE.

G. L. Paine	8	90	1, 650	3, 250	836	1, 890	1, 665	980	1, 045	1, 020
W. F. Bates	9	259	4, 015	9, 644	2, 741	6, 335	4, 980	3, 690	2, 645	840
George Cannon	13	163	3, 723	6, 670	1, 693	6, 361	3, 384	3, 155	.....	2, 650	1, 060
W. F. Bates	13	29	2, 526	1, 036	.....	1, 190	500	185	.....	1, 405	300
George L. Paine	13	183	2, 168	6, 229	1, 532	2, 553	2, 740	2, 819	.....	1, 728	960
Total .....	.....	724	12, 082	26, 851	7, 081	18, 529	13, 269	10, 739	42, 537	2, 770	9, 803
											4, 200

PULLTIGHT.

F. Schneider	21	700	10, 012	25, 204	8, 749	17, 013	6, 272	9, 295	.....	1, 920	2, 100
Thomas Richards	10	325	4, 011	11, 923	3, 764	6, 222	2, 587	5, 011	.....	5, 650	90
Charles Seifert	12	94	1, 448	2, 927	1, 456	2, 458	1, 077	355	.....	70	840
W. Dalton	12	257	1, 112	9, 223	4, 159	4, 456	4, 084	1, 635	.....	50	540
James Nichols	18	188	927	5, 894	2, 823	2, 985	3, 041	1, 429	.....	45	900
George Crane	10	189	3, 812	8, 191	2, 983	5, 458	5, 412	2, 950	.....	2, 040	2, 720
Peter Kehoe	5	89	2, 118	4, 312	1, 461	4, 765	1, 202	3, 020	.....	900	2, 413
Peter Kehoe	12	92	1, 896	4, 060	1, 478	2, 968	647	570	.....	390	115
Total .....	.....	1, 944	24, 336	71, 739	26, 873	46, 345	24, 322	24, 265	94, 932	3, 650	9, 718

JIM SMITH'S.

F. Schneider	10	663	6, 041	25, 303	8, 506	17, 513	6, 704	6, 183	.....	2, 540	600
F. Schneider	5	71	987	2, 679	887	1, 805	485	1, 010	.....	60	240
F. Schneider	21	66	801	2, 424	787	1, 735	460	1, 285	.....	.....	.....
Joseph Schneider	21	104	900	3, 754	1, 256	1, 321	1, 911	368	.....	3, 120	.....
Total .....	.....	904	8, 709	34, 135	11, 416	22, 374	9, 560	8, 846	40, 780	2, 600	840

TABLE II.—Condensed record of pile-drivers—Continued.
CHESLEY ISLAND.

Names of master drivers.	On pile-driver.	Number of piles.	Depth of water. Feet.	Length of piles. Feet.	Depth driven. Feet.	Time driving. Min.	Time moving. Min.	Time incidental to driving. Min.	Driving time. Min.	Time other than driving.		
										Obstructions.	Equipment.	Idle.
L. G. Johnson	11	16	98	483	359	191	278	431				300
W. Smith	11	204	3,285	7,321	2,608	4,216	2,573	4,538				
Julius Herr	11	118	2,630	5,257	1,513	3,020	1,590	2,335		1,873		1,020
Ed. Kelly	20	66	1,178	2,746	1,185	1,185	1,935	1,545		1,580	65	1,120
Charles Godst.	11	94	2,038	4,013	1,204	3,585	1,265	1,735		1,615		
Ed. Kelly	7	13	2,391	565	142	415	515	420		30	3,830	300
George Bauer	7	52	1,307	2,315	638	2,322	940	917		1561		240
L. G. Johnson	7	29	256	945	421	910	425	375		185		
W. E. Jones	17	58	988	2,381	749	1,620	510	800			3,310	360
Total		650	12,070	26,026	8,449	17,464	9,031	13,086	39,581	5,668	10,011	2,340

FOSTER'S ISLAND.

D. T. Dent	15	284	1,605	9,230	3,530	1,937	3,018	5,245				
Grand totals		9,519	125,686	348,188	120,534	209,290	140,578	160,285	510,153	34,536	89,228	42,883

MEAN VALUES.

Cabokia Chute	1	11,285	32,724	14,774	19,100	16,156	15,535	50,791	2,387	13,506	6,447
Horseshall, east side	1	14,172	36,810	14,159	22,158	16,033	21,465	59,856	5,040	6,103	4,261
Horseshall, west side	1	14,644	34,357	15,128	8,549	18,953	19,483	46,975			
Twin Hollows, west side	1	16,686	37,087	9,780	25,592	18,327	15,833	58,752	3,826	13,664	6,097
Pulltight	1	12,518	36,903	13,834	23,840	12,511	12,482	48,833	1,878	13,117	4,909
Jim Smith's	1	9,624	37,793	12,628	24,750	10,575	9,785	45,110	2,876	4,181	0,015
Chesley Island	1	18,568	40,040	12,598	26,868	13,894	20,132	60,894	8,720	15,402	0,060
Foster's Island	1	5,651	32,500	12,429	6,820	10,627	18,468	33,915			
Grand mean	1	13,204	36,578	13,607	21,987	14,768	16,839	53,594	3,638	9,374	4,505

Examining the above table, the large totals at the bottom of the three right-hand columns of figures show how much the time of the drivers was devoted to other purposes than driving, even on the days nominally devoted to this kind of work. This must continue to be the case where so much drift is constantly accumulating, and where the currents are so strong as to require a pile to be braced immediately after it is driven. The continual change from one class of work to another is, however, most unfavorable to rapid progress, and may, it is thought, be somewhat reduced by care on the part of the resident engineer in local charge.

The tabular exhibit at the end of Table II gives the averages of the several quantities for each locality, and the grand average for all the places for eighteen months. The locality averages are very instructive, as they afford the best obtainable criterion by which to compare the difficulty of driving piles at these places. To make this comparison more definite the following facts should be considered:

At Cahokia Chute and Pulltight the work was on new ground, the current was for a great part of the time far from severe, and the depth of water was not so great as to add much to the difficulty of handling the piles after they were in the leads; in other words these places represent about as favorable conditions as can reasonably be hoped for in future work.

At Horsetail, east side, the current was very strong and large quantities of drift-wood were almost constantly collecting against the piles. Large pile rafts could not be brought to the place where work was in progress, and the crews had to tow their own piles, a few at a time, for an average distance of one mile.

As this time appears in the column headed work incidental to driving piles, it accounts to a large degree for the relatively small number of piles driven per ten hours' work driving.

At Twin Hollows, west side, the work was almost exclusively repairing old lines, where piles driven in former years were continually in the way; the water was very deep and the current correspondingly strong. Next to Chesley Island this was the most difficult driving done during the period under consideration.

At Jim Smith's the work was of about average difficulty, and is a fair indication of what may usually be expected.

At Horsetail, west side, and Foster's Island the piles were driven as guide piles for bank protection mattress. They were all near the shore, where good facilities for fastening the mooring lines of the pile-drivers were to be found, and there was little or no difficulty in handling either flats or piles. It is thought that the average at Foster's Island could have been made 20 piles a day easily; but this was undesirable, as the piles would then get too far ahead of the mattress work. For this reason fifteen was regarded as the maximum to be desired. There was but one day on which less than this number was driven. High water rendered the work at Horsetail, west side, more difficult, but it was much easier than the driving to be done in ordinary contraction works.

The original records from which Table II is derived show plainly that fifteen piles is none too much to require for a day's work in a reasonably easy position, but while more than this number was frequently driven, none of the master drivers averaged fifteen per ten hours' driving for any length of time. In this connection it is important to consider the difference between a day's work and ten hours' work "driving."

Table II shows the total "driving" time at each place which was required to drive the total number of piles there driven, also the average number of piles per ten hours' driving. Table III shows the actual number of days on which 1, 2, 3, &c., piles were driven.

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TABLE III.—Number of days in which the number of piles shown in Column I were driven.

Piles.	Cahokia.	Horse tail, east side.	Horse tail, west side.	Twin Hol- lows.	Pulltight.	Jim Smith's.	Chesley Isl- and.	Foster's Isl- and.	Total.
1	6	13	0	0	8	2	2	0	31
2	15	29	0	14	4	2	5	0	69
3	15	30	0	7	11	3	11	0	77
4	9	29	3	8	12	1	15	0	77
5	9	23	3	9	15	2	11	0	72
6	13	32	4	11	13	3	9	0	85
7	9	23	1	10	6	5	7	0	61
8	13	30	3	8	10	11	8	0	83
9	11	29	1	6	7	1	8	0	62
10	13	30	2	4	6	4	6	0	71
11	6	28	2	4	9	6	1	0	58
12	7	31	1	6	12	6	5	1	69
13	12	30	1	2	14	5	2	0	66
14	4	11	0	3	15	5	2	0	40
15	36	18	6	2	16	7	3	5	93
16	18	17	1	2	15	3	1	2	59
17	4	7	1	0	14	6	.....	4	36
18	3	3	.....	1	2	2	.....	0	11
19	1	4	.....	0	2	3	.....	3	13
20	4	3	.....	0	0	1	.....	2	10
21	.....	.....	.....	0	0	1	.....	.....	1
22	.....	.....	.....	0	1	0	.....	.....	1
23	.....	.....	.....	1	.....	1	.....	.....	2
24	.....	.....	.....	0	.....	.....	.....	.....	0
25	.....	.....	.....	0	.....	.....	.....	.....	0
26	.....	.....	.....	1	.....	.....	.....	.....	1

The total number of piles shown in this table somewhat exceeds the total number shown in Tables II and V because Table III shows every pile that was driven, while Tables II and V include only those of which a complete record was kept.

The difference between Tables II and III is instructive. While the average number of piles per ten hours' "driving" time is shown to be but little less than ten anywhere, a glance at Table III shows that on many days not more than one pile was driven, the rest of the time in that case being, of course, devoted to other work.

It is best to study Table III in the graphical form, as shown in Plate I. The horizontal axis represents the number of days on which the number of piles shown on the vertical axis were driven. This plate really tells the pile-driving history of each place as much in detail as publishing all the day records would, and from it much more can be learned than by trying to study them. The character of work done shows at a glance. Those places where the greater number of days correspond to a large number of piles per day are seen to be Cahokia, Pulltight, and Foster's Island, where the work was, as shown on pages 16, 17, and 18, to be of the easiest character, and where full days could consequently be devoted exclusively to driving. The opposite is the characteristic of the curves of Horsetail, east side, Twin Hollows, west side, and Chesley Island, where the difficulties were so great that it was seldom possible to allow a crew to drive a whole day, but where first a pile was driven, then braced, then drift pulled out of the way to allow the next to be placed. Jim Smith's and Horsetail, west side, have curves which show that there were some full days' driving and some days on which several kinds of work were done; in other words, as stated on page 17, the work was there of average difficulty.

The way in which the "incidental" time was spent is shown for two drivers in Table IV:

TABLE IV.—*Distribution of incidental time.*

Name of master driver.	Time of service.		Sharpening piles.	Cutting off piles to proper length.	Repairs of cordage and machinery.	Towing piles.	Raising and putting out anchors.	Coaling driver and cleaning out boilers.
	From—	To—						
	1883.	1883.	<i>Min.</i>	<i>Min.</i>	<i>Min.</i>	<i>Min.</i>	<i>Min.</i>	<i>Min.</i>
C. W. Moore	Mar. 28	Nov. 11	3,244	2,202	2,282	10,022	314	1,978
W. E. Jones	Mar. 27	Oct. 19	0	81	1,125	5,960	435	840

PART III.

In order to compare the efficiency of the several master drivers who have been employed during the last eighteen months the record made by each man has been made up and shown in Table V. If all had worked at the same place and under identical conditions a very sharp comparison of their merits could be made, but as it is nothing more than a very general idea can be formed. It is necessary to look at the right-hand column and see where a man did his work before awarding him credit for having attained an unusually high average or condemning him for a poor one. It is thought that all did a fair amount of work, but there is no doubt felt that each man could have done more, and that in the coming year they should be made to do so.

Table V is capable also of another and more useful interpretation. Assuming for purposes of discussion that the master drivers were all equally skillful, an assumption in most cases not far from the truth, the table shows how much time was required to drive a pile in depths of water varying from 4 to 25 feet.

TABLE V.—Condensed record of piles driven.

Master drivers.	Locality.	On pile-driver.	Number of piles.	Depth of water.	Length of piles.	Depth driven.	Time driving.	Time moving.	Time incidental to driving.	Driving time.	Time other than driving.		
											Removing obstructions.	Equipment.	
William P. Bates	Horsetail, east side.....	No.		Feet.	Feet.	Feet.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
	Do.....	8	139	2,748	5,972	1,849	2,280	3,665	4,980	.....	780	875	1,210
	Twin Hollows, west side.....	18	138	3,246	6,295	1,907	2,145	2,680	3,410	.....	970	1,775	420
	Do.....	9	250	4,015	9,644	2,741	6,335	4,980	3,600	.....	1,580	2,465	840
	Total.....	13	20	526	1,058	279	1,190	500	185	.....	20	1,405	300
George Bauer	Cheesley Island.....	7	505	10,535	22,969	6,776	11,960	11,825	12,175	35,960	3,350	6,520	2,770
	Cahokia Chute.....		52	1,307	2,315	638	2,322	940	917	4,179	.....	1,581	240
	Twin Hollows, west side.....	14	366	3,715	11,221	5,453	6,557	6,219	3,453	.....	.....	2,671	2,100
	Total.....	13	163	3,723	6,670	1,693	6,561	3,384	3,155	.....	1,170	2,650	1,080
	Cahokia Chute.....	529	7,438	17,891	7,146	13,118	9,603	6,608	29,229	1,170	5,321	3,180	
George Crane	Do.....	4	6	67	145	62	175	455	570	.....	.....	300	.....
	Pulltight.....	10	60	741	2,187	868	1,445	760	495	.....	.....	9,620	2,720
	Total.....	10	189	3,812	8,191	2,983	5,458	5,412	2,950	.....	2,040	.....	.....
	Pulltight.....	12	255	4,620	10,523	3,913	7,078	6,627	4,015	17,720	2,040	9,920	2,720
	Total.....	12	257	1,112	9,223	4,159	4,456	4,084	1,635	10,175	35	50	540
D. T. Dent	Cahokia Chute.....	11	121	1,157	4,513	2,039	2,550	1,490	850	.....	.....	810	300
	Horsetail, west side.....	11	281	4,115	12,154	4,251	2,402	5,324	5,474	.....	.....	.....	.....
	Foster's Island.....	15	284	1,605	9,236	3,530	1,937	3,018	5,245	.....	.....	.....	.....
	Total.....		686	6,877	25,897	9,820	6,889	9,832	11,569	28,290	.....	810	300
	Horsetail, east side.....	9	103	1,700	4,215	1,561	2,915	3,140	2,150	8,205	185	610	.....
Fred. Frey	Horsetail, east side.....	16	303	5,336	11,481	4,302	6,593	6,917	6,255	19,765	2,295	1,640	900
	Cheesley Island.....	11	94	2,039	4,013	1,704	3,585	1,265	1,735	6,585	385	3,830	.....

		11	118	2,630	5,257	1,513	3,020	1,590	2,325	6,935	1,580	65	1,020
Julius Herr.....	do.....												
Louis G. Johnson.....	Horsetail, east side.....	11	175	1,654	5,415	2,651	3,083	2,389	2,767	.....	180	41	174
	Do.....	20	138	1,929	5,284	2,187	2,700	2,545	3,315	.....	130	190	120
	Cheasley Island.....	11	16	96	463	239	191	278	431	.....	.....	.....	300
	Do.....	7	29	256	945	421	910	425	375	.....	185	1,105	.....
	Total.....		358	3,935	12,107	5,518	6,884	5,637	6,888	19,409	495	1,836	2,100
William E. Jones.....	Horsetail, east side.....	17	723	9,026	25,057	10,075	18,273	7,928	13,435	.....	2,701	5,908	2,760
	Do.....	17	331	4,690	12,484	4,902	8,605	3,805	6,025	.....	2,070	1,635	660
	Cheasley Island.....	17	58	988	2,381	749	1,620	510	800	.....	.....	3,310	360
	Total.....		1,112	14,704	39,932	15,726	28,498	12,238	20,260	60,896	4,771	10,853	3,780
Peter Kehoe.....	Pulltight.....	5	99	2,118	4,312	1,461	4,765	1,202	3,020	.....	900	5,100	2,413
	Do.....	12	92	1,886	4,060	1,478	2,988	647	570	.....	390	3,080	1,115
	Total.....		191	4,014	8,372	2,939	7,753	1,849	3,590	13,192	1,290	8,190	2,528
Edward Kelly.....	Cheasley Island.....	7	13	291	595	142	415	515	420	.....	30	120	300
	Do.....	20	66	1,178	2,746	915	1,185	935	1,545	.....	1,615	.....	120
	Total.....		79	1,469	3,311	1,057	1,600	1,450	1,965	5,015	1,645	120	420
Charles W. Moore.....	Horsetail, east side.....	16	629	6,200	20,688	8,327	12,483	7,172	15,284	.....	1,873	2,968	2,820
	Do.....	7	122	1,498	4,430	1,598	3,620	2,540	3,164	.....	484	332	660
	Do.....	21	165	3,051	6,741	2,463	2,715	4,319	3,068	.....	1,250	1,583	865
	Total.....		916	10,749	31,839	12,388	18,818	14,031	21,516	54,865	3,607	4,883	4,345
James Nichols.....	Cahokia Chute.....	19	77	1,074	2,493	987	1,493	1,151	956	.....	.....	120	490
	Pulltight.....	18	188	927	5,894	2,823	2,985	3,041	1,429	.....	45	.....	900
	Total.....		265	2,001	8,387	3,810	4,478	4,192	2,385	11,055	45	120	1,380
George L. Paine.....	Twin Hollows, west side.....	8	90	1,650	3,250	836	1,897	1,665	980	.....	.....	1,645	1,020
	Do.....	13	183	2,168	6,229	1,532	2,553	2,740	2,819	.....	.....	1,728	960
	Total.....		273	3,818	9,479	2,368	4,451	4,405	3,799	12,647	.....	3,373	1,980
Thomas Richards.....	Pulltight.....	10	325	4,011	11,925	3,764	6,222	2,587	5,011	13,820	240	5,650	90
Frank Schneider.....	Cahokia Chute.....	7	108	1,943	4,525	1,582	3,181	1,444	4,075	.....	1,620	2,940	3,540
	Horsetail, east side.....	7	123	2,159	5,117	1,681	3,215	1,950	3,025	.....	2,370	1,550	1,080
	Pulltight.....	21	700	10,012	25,204	8,749	17,013	6,272	9,295	.....	.....	1,920	2,100
	Jim Smith's.....	10	663	6,041	25,308	8,506	17,513	6,704	6,183	.....	2,540	660	600
	Do.....	5	71	967	2,679	867	1,805	485	1,010	.....	60	.....	240
	Do.....	21	66	801	2,424	787	1,735	460	1,285	3,120
	Total.....		1,731	21,923	65,257	22,172	44,462	17,315	24,873	96,650	6,590	10,190	7,570

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TABLE V.—Condensed record of piles driven—Continued.

Master drivers.	Locality.	On pile-driver.	Number of piles.	Depth of water.	Length of piles.	Depth driven.	Time driving.	Time moving.	Time incidental to driving.	Driving time.	Time other than driving.		
											Removing obstructions.	Equipment.	Idle.
Jos. Schneider	Cahokia Chute	No.		Feet.	Feet.	Feet.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
		12	393	3,363	11,128	5,622	5,765	5,998	4,051				
		21	104	900	3,754	1,256	1,321	1,911	368				1,800
	Total		497	4,263	14,882	6,878	7,086	7,909	4,419	19,414		2,186	1,800
Charles Seifert	Pulltight	12	94	442	2,927	1,456	2,458	1,077	355	3,890		70	840
William Smith	Chesley Island	11	204	3,285	7,321	2,008	4,216	2,573	4,538	11,327			
Charles Years	Cahokia Chute	2	161	1,896	5,133	2,392	2,363	2,737	2,460				
	Do.	96	1,219	3,286	1,474	2,348	2,360	2,832	1,832		300	1,500	780
	Do.	18	120	1,813	4,717	1,793	2,925	1,750	4,685				1,280
	Horsetail, east side	13	135	2,512	5,536	2,152	2,800	2,645	2,325		1,620	9,840	1,860
	Total		512	7,470	18,662	7,818	10,436	9,492	11,302	31,230	2,940	11,910	4,320
	Grand total		9,519	125,686	348,186	120,534	209,290	140,578	160,285	510,153	34,536	89,228	42,883

Total time accounted for, 676,800 minutes, equal to 1,128 full working days.

TABLE V.—Condensed record of piles driven—totals—Continued.

MEAN VALUES.

Master drivers.	Number of piles.	Depth of water.	Length of piles.	Depth driven.	Time driving.	Time moving.	Time incidental to driving.	Total driving time.	Time other than driving.			Idle.
									Removing obstructions.	Equipment.	Idle.	
William P. Bates	1	Feet.	Feet.	Feet.	Min.	Min.	Min.	63.646	Min.	Min.	Min.	4.903
George Bauer	1	18.646	40.653	11.933	21.168	20.929	21.549	80.366	5.929	11.540	11.540	0.977
George Cannon	1	25.135	44.519	12.269	44.654	18.077	17.635	55.442	2.212	30.404	30.404	0.100
George Crane	1	14.060	33.820	13.508	24.784	18.153	12.491	69.490	8.006	10.059	10.059	10.867
W. Dalton	1	18.118	41.967	15.347	27.757	25.988	15.745	39.593	0.136	38.902	38.902	0.035
D. T. Dent	1	4.327	35.887	16.169	17.339	15.891	6.362	41.239	1.796	1.181	1.181	0.437
H. Eichelberger	1	16.025	37.751	14.315	10.042	14.333	16.864	79.860	7.574	5.222	5.222	2.970
Fred. Frey	1	16.505	41.273	15.155	28.301	30.485	20.644	65.231	4.096	40.245	40.245	0.144
Charles Godat	1	17.617	37.801	14.198	21.759	22.828	18.457	70.053	13.390	0.551	0.551	6.034
Julius Herr	1	21.691	42.692	12.808	28.138	13.458	19.704	54.772	4.291	9.760	9.760	3.899
Louis Johnson	1	22.288	44.551	12.822	25.393	13.475	18.219	69.069	6.754	42.880	42.880	13.236
W. E. Jones	1	10.992	33.819	15.413	19.229	15.746	18.796	63.480	20.823	1.519	1.519	0.089
Peter Kehoe	1	13.223	35.910	14.142	25.628	11.005	23.489	59.351	3.938	5.331	5.331	4.744
Ed. Kelly	1	21.016	43.822	15.387	40.592	9.681	24.873	69.069	0.170	0.454	0.454	0.087
C. W. Moore	1	18.595	41.910	13.380	20.253	18.354	15.419	46.327	0.738	12.355	12.355	0.121
James Nichols	1	11.654	34.739	13.524	20.544	15.318	14.891	42.523	3.807	17.885	17.885	0.005
George L. Paine	1	7.551	31.649	14.376	16.898	15.819	15.419	50.056	.....	4.398	4.398	0.060
Thomas Richards	1	13.985	34.722	8.674	16.275	16.136	3.776	55.325	.....	0.745	0.745	0.149
Frank Schneider	1	12.342	36.701	11.582	19.144	7.960	22.074	60.986	.....	23.244	23.244	8.438
Jos. Schneider	1	12.655	37.689	14.281	23.686	10.003	16.839	53.594	.....	9.374	9.374	4.505
Charles Seiffert	1	8.578	29.944	13.839	14.258	15.914	8.891	.....	.....	.....	.....	.....
William Smith	1	4.768	31.138	15.489	26.149	11.457	22.245	.....	.....	.....	.....	.....
Charles Years	1	16.103	35.887	12.784	20.667	12.613	22.074	.....	.....	.....	.....	.....
Grand mean	1	13.204	36.578	13.607	21.987	14.768	16.839	53.594	3.628	9.374	9.374	4.505

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The exact agreement between the grand totals, whether obtained from the locality subtotals or from the master driver's subtotals, shows, since both were obtained direct from the original records, that no numerical errors have crept in during the long and tedious computation required to derive these values from the pile records. There is no better place than this to express my obligations to Mr. John O. Holman, who voluntarily assisted me in the first and most discouraging part of the work, which was deciphering the almost illegible pencil records kept in the field by the master drivers. Without his aid the labor would have been more than I could have attempted in the limited time I had to prepare this report.

PART IV.

It is not possible to make any definite statement of the exact effect of the system inaugurated eighteen months ago. That the result of the change of organization then adopted has been to largely increase the efficiency of the pile-driving force over what it was in the preceding eighteen months no one acquainted with the facts doubts, but before the change was made there were no records kept which were at all comparable with those which are discussed in the present report. There has been an increase in the number of piles driven in ten hours' "driving" time, as reported by the resident engineers, from 8.2 in the eighteen months ending January 1, 1883, to 11.2 in the eighteen months ending June 30, 1884; but the records in the first period were of such a character that the comparison must not be regarded as an accurate statement of the actual facts.

In the months of September, October, and November, 1880, before the application of jets to the drivers, there were 1,692 piles driven in 1,607 hours—that is, the average number of piles for ten hours' work "driving" was 10.5, somewhat less than the present rate. The jet was then applied to the drivers, and 306 piles were driven in 220 hours, averaging 14 piles per ten hours' work. This result was obtained in quite hard bottom, with a strong current and moderate depth of water; and, while the number of piles driven was too small to give a reliable average, it shows what can be expected with good masters and crews. There were but five drivers. The masters were all very good, and their crews were thoroughly well trained. Early in the year 1882 the full present force of twenty-one drivers was put at work. Many men who were formerly laborers on the pile-drivers were of necessity made masters, and the average from June, 1881, to January, 1883, was very poor. The system applied in January, 1883, was devised to raise the standard, and it has done so to a considerable extent, but the first average made by a few good masters with well-trained crews is not yet equalled. While considering the question of the averages made in different years, it is curious to see how closely the figures obtained from the last 9,519 piles driven agree with those deduced last year from 72 piles accurately recorded and carefully selected. For instance, the time to move was last year reported from the small number of piles as 15.8 minutes; from 10,000 piles it is now found to be 16.8 minutes. In the master driver's records there is nothing exactly corresponding to my driving time, but the sum of their driving time and time incidental to driving is 38.8 minutes, corresponding to 26.4 minutes, reported last year with the remark, "I frequently noticed that the drivers on which I was not present had to wait for piles to be brought to them, while those where I was located were generally kept well supplied."

There has been an improvement over the past; it is now necessary to consider how a still further improvement can be made in the future. Referring to Plate I it is seen that 15 piles or more were driven on 227 days. As this was so often done it should be possible to make this number compulsory. The average insisted on last year was 12; the average made, 11.2; in other words, the men were not held up to the requirements. For the coming year I would suggest the following:

1. As the master driver alone is not able to do the work, but to get the best results must have a good crew, I would suggest that the pay of pile-driver men be increased 25 cents a day, so that really good men could be induced to come and remain at work for the season. To make the master select the best men a severe penalty should follow his failure to drive 15 piles per ten hours' driving time. For this purpose I would suggest the following: Let the rate of pay of a master driver be \$75 and board for every month in which he maintains the required average; in any month that he fails to make this average, \$45 and board; a second failure to involve dismissal. His rate should be determined from the time roll, on which the number of piles driven and the number of hours' driving time should be invariably stated. If the work the master has been doing has been of such a nature that the requirements are really too severe, and he has been unable to meet them, the resident engineer should state on the time roll that in his judgment the penalty should not be applied in that special case; when this statement is not made the rate of pay should depend solely on the driving record he has made. The fact that there will be a great temptation under this system to do incomplete driving is fully appreciated, and this should be met by the special detail of one resident engineer to see that the drivers do their work as required. As shown last year, the increase in the number of piles driven would much more than cover the additional expense this involved.

2. As far as possible the piles should be supplied to the drivers by a force specially organized for that purpose. When the crew of the driver tows its own piles, there are really two men, both at a salary of \$2 a day, in charge of six men, doing work which could be equally well superintended by one man at \$1.25 a day. With a very small force one driver can more than keep up with the mattress work, and in this case it is in the interest of economy to keep the crew busy at any work rather than to have them idle, or to allow the piles to preceede the mattress too far, and thus be exposed to loss by scour of the bottom; but where the mattress force is sufficiently great to keep up with the drivers, it is certainly more economical to have a special pile rafting and preparing force, who supply each pile-driver with piles of lengths suited to its work.

3. That in the time part of the record the masters be required to record only the time at which they begin to drive each pile, the time at which they begin on other work than that directly connected with driving, the time at which they return to driving, as well as the time of beginning, ending, and cause of any unusual delay. This change will greatly diminish the work of the engineers in examining and preparing the records for discussion, and will, it is thought, serve the purpose of keeping the masters from shirking work as well as the present system.

An additional advantage is that under the new system the time record will be at once available to the resident engineer for distributing all his pile-driver time, so that every item recorded by the master pile-driver will serve the double purpose of keeping him busy at his proper work and of supplying the engineer with data which he must have for every report which he submits.

In the past season the same blanks have been used to record the work done in bracing and placing stringers. I would suggest that this be continued so that the masters' records should afford complete data for making up the entire service of drivers.

FREDERIC V. ABBOT,
First Lieutenant of Engineers.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

14.

Record of gauge at Grafton, Ill., for the fiscal year ending June 30, 1884.

[Height of water above plane 200 feet below the Saint Louis City directrix.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.
	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>
1	210.85	202.65	196.00	194.54	196.55	197.66	194.92	197.40	198.85	210.50	204.18	201.80
2	209.20	203.20	196.00	194.82	196.31	197.75	194.73	198.02	198.92	210.89	204.84	201.54
3	209.10	203.50	196.05	194.90	196.15	197.76	194.73	198.32	199.10	211.40	204.35	201.44
4	208.15	203.55	196.10	195.01	196.10	197.70	197.10	198.64	198.35	211.81	204.55	201.53
5	207.50	203.86	196.05	195.25	196.00	197.60	197.10	200.12	199.30	212.25	205.07	201.54
6	206.85	204.13	196.00	195.82	196.15	197.40	197.20	199.65	199.15	212.45	206.25	201.50
7	206.10	204.35	195.80	196.40	196.83	197.25	197.82	198.80	198.00	212.45	206.46	201.40
8	204.75	203.85	195.75	196.40	196.70	197.00	198.46	197.64	198.50	212.35	206.30	201.40
9	204.35	203.40	195.64	196.22	196.63	196.90	198.76	197.82	198.05	212.16	206.10	202.30
10	203.85	203.00	195.50	196.00	196.62	196.80	198.86	197.06	197.86	211.90	205.90	203.04
11	203.68	202.60	195.26	195.86	196.29	196.70	199.80	196.68	197.82	211.52	205.75	203.10
12	203.50	202.10	195.00	195.82	196.92	196.64	199.30	197.00	197.88	211.16	205.54	203.18
13	203.65	201.70	194.85	195.70	196.65	196.67	199.35	198.84	197.79	210.75	205.30	202.95
14	203.75	201.37	194.76	195.54	196.68	196.80	199.39	198.05	197.75	210.19	204.95	202.50
15	203.80	200.85	194.69	195.50	196.56	196.85	199.39	198.86	197.68	209.53	204.60	201.95
16	203.80	200.42	194.63	195.78	196.48	196.00	199.12	198.21	197.82	209.25	204.30	201.65
17	203.20	199.78	194.60	195.60	196.04	196.60	198.92	198.45	198.10	208.68	204.04	201.38
18	203.20	199.35	194.52	195.92	197.44	196.11	198.79	198.11	198.82	208.16	203.95	201.17
19	203.43	198.91	194.51	196.10	197.10	195.50	198.40	199.75	201.05	207.65	204.08	201.05
20	203.00	198.75	194.50	197.28	197.00	195.12	198.18	199.44	201.65	207.30	204.06	201.09
21	202.20	198.57	194.45	197.78	197.00	194.62	197.86	199.40	201.85	206.90	203.85	201.35
22	201.85	198.31	194.36	197.08	197.65	194.60	197.65	199.36	202.24	206.50	203.78	201.20
23	201.45	198.10	194.32	196.50	197.50	194.60	197.45	199.24	202.91	206.43	203.50	201.20
24	201.15	198.00	194.30	196.22	197.50	194.18	197.30	199.30	204.00	206.40	203.30	201.21
25	201.00	197.70	194.30	196.22	197.58	194.01	196.94	199.10	205.00	206.18	203.21	201.28
26	200.75	197.12	194.29	196.20	197.54	194.00	196.80	199.14	206.25	205.85	203.05	201.35
27	200.45	196.83	194.27	196.38	197.27	193.80	196.62	199.16	207.50	205.45	202.85	201.48
28	200.60	196.53	194.24	196.64	197.38	193.92	196.48	198.90	208.45	205.05	202.66	201.34
29	200.55	196.41	194.26	196.71	197.56	194.30	196.40	198.50	208.76	204.50	202.50	201.16
30	201.70	196.25	194.38	196.80	197.71	194.66	196.45	.....	209.00	204.20	202.30	201.04
31	202.35	196.15	.....	196.75	.....	194.80	196.70	.....	209.38	.....	202.04	.....

Navigation suspended on account of ice, — January 4 to —.

1522 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

15.—Record of gauge at Gray's Point, Missouri, for the fiscal year ending June 30, 1884.

[Height of water above a plane 200 feet below the Saint Louis City directrix.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.
	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>
1	120.66	105.51	99.31	94.81	100.01	100.66	95.21	98.31	107.51	114.51	109.91	105.21
2	120.21	105.91	99.01	94.91	100.21	100.51	95.41	97.41	106.91	114.31	110.41	105.01
3	119.41	107.66	98.81	95.00	100.21	100.11	95.61	98.66	100.11	114.36	110.01	104.66
4	118.66	108.51	98.51	95.21	99.81	99.01	95.11	98.91	105.41	115.21	111.11	104.91
5	117.21	107.91	98.51	95.41	99.31	99.51	96.01	99.76	101.61	115.01	112.21	105.51
6	116.21	107.16	98.41	95.51	98.91	99.16	96.66	104.01	103.61	115.01	113.16	106.01
7	114.60	106.61	98.21	95.01	98.51	98.66	95.51	106.51	102.51	115.21	114.11	100.21
8	113.41	106.21	97.91	96.11	98.31	98.31	95.01	106.01	101.41	115.21	114.41	106.41
9	112.11	105.91	97.60	96.61	98.41	97.81	95.31	107.01	100.51	115.01	114.21	106.66
10	111.11	105.61	97.51	96.81	100.21	97.31	96.41	106.76	99.66	115.91	113.81	107.61
11	110.61	105.41	97.21	96.91	101.61	97.11	96.06	106.66	99.31	116.01	113.31	108.66
12	110.41	104.91	97.01	97.01	102.11	97.11	98.21	106.51	99.51	116.01	112.66	109.31
13	110.31	104.31	96.66	96.81	102.41	97.31	98.66	106.31	99.81	115.66	112.51	109.66
14	110.21	103.91	96.51	97.01	102.21	97.41	99.21	107.31	100.76	115.31	111.91	109.66
15	110.41	103.41	96.31	97.01	101.81	97.31	99.91	109.16	101.01	114.91	111.11	109.31
16	110.76	103.11	96.11	96.81	101.41	97.21	99.41	108.91	101.21	114.21	110.21	108.91
17	111.91	102.66	95.91	96.21	100.66	97.21	99.21	110.21	102.01	113.01	109.11	108.51
18	111.91	102.41	95.66	96.01	100.21	97.21	99.11	110.51	102.41	113.11	108.61	108.11
19	111.61	102.31	95.61	97.11	99.66	97.01	99.41	110.56	103.31	112.41	108.31	107.81
20	111.21	102.46	95.51	97.31	99.21	96.11	99.66	110.91	104.91	111.66	108.01	107.66
21	110.81	102.21	95.41	97.51	99.21	95.66	99.51	110.66	107.01	111.41	107.81	107.91
22	110.11	101.41	95.31	98.31	102.31	95.01	99.41	110.51	108.11	111.21	107.81	108.51
23	109.66	101.21	95.21	99.11	102.41	93.81	99.31	110.41	108.61	110.91	107.41	109.01
24	109.01	101.21	95.11	99.21	101.61	94.91	99.31	110.21	108.81	111.21	107.01	109.11
25	108.01	101.20	95.01	98.66	102.01	94.81	99.11	110.21	108.41	112.11	106.41	109.11
26	107.21	101.51	94.91	98.31	102.01	94.66	99.01	109.91	110.01	112.51	106.01	109.21
27	106.61	101.26	94.91	98.31	101.01	94.61	99.01	109.41	111.81	112.51	105.61	109.31
28	106.01	101.31	94.91	98.21	101.61	94.41	99.21	108.86	113.51	112.21	105.41	109.51
29	106.11	100.66	94.91	99.66	101.11	94.41	99.51	108.61	115.31	111.61	105.11	109.41
30	105.61	100.21	94.81	99.31	100.81	94.61	99.66	115.51	110.66	105.11	105.11	109.11
31	105.41	99.66	.....	99.21	.....	94.91	99.91	.....	114.91	.....	105.31	.....

Navigation suspended on account of ice December 25, and from January 2 to January 30.

16.—Depth of water upon the bars between Saint Louis and Cairo, as reported by pilots.

[In feet.]

Date.	Stage above standard low water by Saint Louis gauge.	Name of steamer furnishing report.	Arsenal Island.	Horsetail.	Carroll's Island.	Twin Hollows.	Beard's Island (head).	Beard's Island (foot).	Jim Smith's.	Sulphur Springs.	Foster's Island.	Herculeanum Swashin.	Cornice Island.	Selma.	Forest Home.	Perry's T. H.	Fish Bend.
1883.	<i>Feet.</i>																
Aug. 16	11.00	City of Saint Louis.....	.....	.....	.....	12	9	10	.....	13	.....	.....	12	.....	.....	.....	.....
16	11.00	Gillmore.....	18	15	18	14	9	16	.....	17	13	20	14	.....	.....	.....	.....
17	10.70	.....do.....	18	15	18	14	9	16	.....	17	13	20	14	.....	.....	.....	.....
18	11.00	.....do.....	18	15	19	13	10	16	.....	10	14	21	.....	.....	.....	.....	.....
20	10.10	.....do.....	18	13	18	13	9	16	.....	10	13	.....	.....	.....	.....	.....	.....
21	9.60	.....do.....	17	13	18	13	9	16	.....	15	12	21	12	.....	13	12	15
22	9.20	Arkansas City.....	.....	.....	15	12	9	.....	13	.....	15	.....	.....	.....	12	.....	.....
22	9.20	City of Baton Rouge.....	.....	16	.....	10	8	13	12	10	12	.....	.....	.....	10	.....	.....
22	9.20	Gillmore.....	18	13	16	13	9	16	15	12	.....	.....	.....	.....	.....	.....	.....
23	9.40	.....do.....	.....	18	13	.....	8	16	14	10	.....	.....	.....	.....	.....	.....	.....
24	10.00	.....do.....	17	12	17	13	8	16	13	10	21	13	.....	.....	.....	.....	.....
24	10.00	City of Helena.....	.....	10	.....	9	9	.....	9	10	12	.....	9	.....	.....	.....	.....
25	9.90	Gillmore.....	17	12	18	13	10	16	13	10	.....	.....	.....	.....	.....	.....	.....
27	9.10	.....do.....	17	13	16	13	9	16	15	10	20	10	.....	.....	.....	.....	.....
28	8.70	.....do.....	.....	18	13	.....	8	16	14	10	.....	.....	.....	.....	.....	.....	.....
29	8.00	City of Providence.....	.....	16	12	16	13	9	16	15	10	20	10	13	.....	12	13
29	8.00	John A. Scudder.....	.....	.....	.....	13	9	.....	13	9	15	.....	16	.....	16	.....	.....
30	7.60	Gillmore.....	14	12	15	12	9	15	12	9	19	.....	.....	.....	.....	.....	.....
30	7.60	City of New Orleans.....	.....	8	.....	9	8	9	.....	9	12	.....	.....	.....	.....	.....	.....

16.—Depth of water upon the bars between Saint Louis and Cairo, &c.—Continued.

[In feet.]

Date.	Stage above standard low water by Saint Louis gauge.	Name of steamer furnishing report.	Arsenal Island.	Horsetail.	Carroll's Island.	Twin Hollows.	Beard's Island (head).	Beard's Island (foot).	Jim Smith's.	Sulphur Springs.	Foster's Island.	Herculaneum Swashin.	Cornice Island.	Selma.	Forest Home.	Perry's T. H.	Fish Bend.
1883.	Feet.																
Aug. 30	7.60	City of Cairo.....	10½	10½	10½	9	10½	10½	8	13½	12	12	12	12	12	13½	10½
Sept. 3	7.80	Gillmore.....	14	10½	10½	12	9	14	12	9½	10	9½	10½	10½	10½	10½	10½
4	6.60	do.....	13½	10½	13½	10½	9	10½	12	9½	18	10½	10½	10½	10½	10½	10½
5	6.50	do.....	14	10½	15	10½	8½	10½	10½	9½	18	10½	12	12	12	10½	10½
6	6.50	Arkansas City.....	12	10½	10½	10½	9	10½	10½	9½	18	10½	12	12	12	10½	10½
7	6.30	Gillmore.....	13½	10½	15	10½	9	10½	12	9½	18	10½	12	12	12	10½	10½
8	6.30	City of Saint Louis.....	10½	9	12	7½	7½	9	7	7	9	9	9	9	9	10½	10½
9	6.20	Gillmore.....	12	10½	16	12	8½	10½	11	8½	18	10½	12	12	12	10½	10½
10	6.00	City of Helena.....	12	9½	10½	12	8½	10½	10½	8½	18	10½	12	12	12	10½	10½
11	5.70	Gillmore.....	12	9½	10½	12	8½	10½	10½	8½	18	10½	12	12	12	10½	10½
12	5.70	City of Vicksburg.....	15	9½	10½	10½	8	9½	9½	7½	16½	10½	10½	10½	10½	10½	10½
13	5.30	Gillmore.....	6½	8	9	9	7	9	8	6	9	9	9	9	9	10½	10½
14	5.00	Annie P. Silver.....	12	9½	14	10½	7½	9½	9½	7½	10½	9½	9	10½	10½	10½	10½
15	5.00	Gillmore.....	9	9	10½	10½	9	9	9	6½	10½	9½	9	9	9	10½	10½
16	4.50	Sidney Dillon.....	10½	8	12	9½	7	9½	9	7	15	7	7	7	7	10½	10½
17	4.50	Gillmore.....	10½	8	12	9½	7	9½	9	7	15	7	7	7	7	10½	10½
18	4.50	City of Cairo.....	10½	8	12	9½	7	9½	9	7	15	7	7	7	7	10½	10½
19	4.50	City of Providence.....	9½	8½	13½	9½	6½	9½	6½	6	15	8	8	8	8	10½	10½
20	4.30	Gillmore.....	9	7	10½	10½	6½	9½	6½	6	15	8	8	8	8	10½	10½
21	4.10	do.....	9	7	10½	10½	6½	9½	6½	6	15	8	8	8	8	10½	10½
22	3.90	Gillmore.....	9½	7	10½	10½	6½	9½	6½	6	15	8	8	8	8	10½	10½
23	3.75	Arkansas City.....	6	7	10½	10½	6½	9½	6½	6	15	8	8	8	8	10½	10½
24	3.75	Gillmore.....	9½	7	10½	10½	6½	9½	6½	6	15	8	8	8	8	10½	10½
25	3.40	Centennial.....	9	7	10½	10½	6½	9½	6½	6	15	8	8	8	8	10½	10½
26	3.40	Gillmore.....	9½	7	10½	10½	6½	9½	6½	6	15	8	8	8	8	10½	10½
27	3.40	do.....	9	7	10½	10½	6½	9½	6½	6	15	8	8	8	8	10½	10½
28	3.40	Gillmore.....	9	7	10½	10½	6½	9½	6½	6	15	8	8	8	8	10½	10½
29	3.30	do.....	9	7	10½	10½	6½	9½	6½	6	15	8	8	8	8	10½	10½
30	3.10	City of Providence.....	8	6	13½	7	7	9	9	5	13½	8½	10½	8	8	9½	8½
31	3.10	Gillmore.....	9½	8	13½	7	7	9	9	5	13½	8½	10½	8	8	9½	8½
Oct. 1	3.00	do.....	9½	7½	10½	12	6	9½	8	5	13½	8	8	8	8	7	12
2	3.00	David R. Powell.....	6	7	10½	12	7	10½	9	5½	13½	8½	8	8	8	7	12
3	3.10	Montana.....	9½	7	10½	12	7	10½	9	5½	13½	8½	8	8	8	7	12
4	3.10	Gillmore.....	9½	7	10½	12	7	10½	9	5½	13½	8½	8	8	8	7	12
5	3.60	Annie P. Silver.....	6½	6½	10½	12	7	10½	9	5½	13½	8½	8	8	8	7	12
6	3.70	Gillmore.....	10½	7½	10½	12	7	10½	9	5½	13½	8½	8	8	8	7	12
7	3.70	City of Helena.....	8	6½	10½	12	7	10½	9	5½	13½	8½	8	8	8	7	12
8	3.00	Gillmore.....	10½	8	10½	12	7½	10½	9½	6	13½	8½	12	12	12	10½	10½
9	4.20	do.....	10½	8½	11	12	8	10½	10½	6½	14	9	10½	10½	10½	10½	10½
10	5.00	C. P. Chouteau.....	10½	8	10½	12	8	10½	9½	6	14	9	10½	10½	10½	10½	10½
11	5.00	Gillmore.....	10½	8	10½	12	8	10½	9½	6	14	9	10½	10½	10½	10½	10½
12	5.00	do.....	10½	8½	10½	12	8	10½	9½	6	14	9	10½	10½	10½	10½	10½
13	5.00	City of Cairo.....	8	8	10½	12	9	10½	10½	6	14	9	10½	10½	10½	10½	10½
14	5.00	Gillmore.....	11	8½	12	12	8	10½	10½	6	14	9	10½	10½	10½	10½	10½
15	4.90	City of New Orleans.....	9	8	10½	12	8	10½	10½	6	14	9	10½	10½	10½	10½	10½
16	4.50	Gillmore.....	9½	9½	12	12	8½	10½	12	6	14	9	10½	10½	10½	10½	10½
17	4.40	do.....	10½	8½	12	12	8½	10½	12	6	14	9	10½	10½	10½	10½	10½
18	4.40	do.....	10½	9	12	12	8½	10½	12	6	14	9	10½	10½	10½	10½	10½
19	5.80	do.....	12	9	12	12	9	10½	12	8½	15	10½	10½	10½	10½	10½	10½
20	7.00	City of Vicksburg.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
21	6.80	John A. Soudder.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
22	6.80	Gillmore.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
23	6.40	Future City.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
24	6.40	City of Providence.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
25	6.40	Gillmore.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
26	6.50	City of Baton Rouge.....	12	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
27	6.50	Gillmore.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
28	6.30	do.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
29	6.50	do.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
30	7.80	do.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
31	7.60	Arkansas City.....	12	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
Nov. 1	7.60	Gillmore.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½
	7.60	do.....	13½	9½	12	12	10½	12	9½	8½	15	10½	10½	10½	10½	10½	10½

1524 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

16.—Depth of water upon the bars between Saint Louis and Cairo, Mo.—Continued.

[In feet.]

Date.	Stage above standard low water by Saint Louis gauge.	Name of steamer furnishing report.	Arsenal Island.	Horsetail.	Carroll's Island.	Twin Hollows.	Beard's Island (lead.)	Beard's Island (foot.)	Jim Smith's.	Sulphur Springs.	Foster's Island.	Herculeanum Swashin.	Cornice Island.	Selma.	Forest Home.	Perry's T. H.	Fish Bend.
1883.	Feet.																
Nov. 3	6.90	David R. Powell								9						8	
5	6.90	City of Vicksburg								8						12	
8	6.35	Gillmore	13	9	14	12	10	10	9	8	15	10					
7	6.05	City of Saint Louis	10				12	9		7	12	10				15	
9	8.70	Gillmore	14	10	15	14	12	12	12	10	16	12					
12	10.35	do	15	12	16	15	12	13	13	10	16	13					
14	9.50	Arkansas City					15			12							
16	8.30	Gillmore	13	10	14	12	12	10	10	8	15	10					
17	7.75	City of Vicksburg	13				13			9							
17	7.75	Gillmore	12	9	14	12	12	10	9	8	14	10					
19	6.55	do	12	9	13	12	11	9	9	8	14	10					
20	6.20	Future City		12		12	9	10	12	7	12				15	9	
22	6.70	Gillmore	13	10	14	12	10	10	10	9	15	10					
24	7.10	Annie P. Silver														10	
24	7.10	Gillmore	14	10	15	13	12	10	10	9	15	10					
27	6.05	do	13	10	15	13	10	10	10	9	15	10					
30	6.50	do	13	10	13	12	10	9	9	8	14						
Dec. 1	6.40	Gillmore	12	9	13	12	9	9	9	7	14						
1	6.40	City of Vicksburg					12	8		8	15				15		
1	6.40	Centennial	15			12	10	9		7						10	
3	6.20	Gillmore	12	9	12	10	9	8	8	7	13	10					
5	5.85		12	9	12	12	10		8	7	12					10	
7	5.35	Gillmore	12	9	12	12	9	9	8	7	13						
8	5.10	John A. Scudder					12	9	9	6	9						
10	4.95	Gillmore	10	9	10	12	10	7	8	8	13	10			12		
12	5.20	Arkansas City					10	9	10	9							
12	5.20	City of New Orleans	10	12		13	8	10	9	9	10				9	10	
13	5.25	Gillmore	10	9	10	12	9	7	8	8	13						
16	5.35	W. P. Haliday					8	9	7	9	10					10	
18	4.40	Future City					8	8	7							8	
19	3.70	City of St. Louis						7	7								

Date.	Stage above standard low water by Saint Louis gauge.	Name of steamer furnishing report.	Fort Chartres.	Cambria Hollow.	Turkey Island.	Saint Genevieve Bend.	Kaskaskia Island, Fairy Island.	Saline Creek.	Pratt's Bend.	Mary River.	Liberty Island.	Jones's Point.	Wilkinson's, Ryan's.	76 Crossing.	Grand Tower Island.	Crawford's.	Moccasin Springs.
1883.	Feet.																
Aug. 16	11.00	City of Saint Louis	16	10	15	10	16	9	12	13	10					9	
21	9.60	Gillmore	16	10	15	10	16	9	12	12	10	8					
22	9.20	Arkansas City						9	12	9	8	8				8	
22	9.20	City of Baton Rouge	12			10		9	12	9	10	8				8	
24	10.00	City of Helena		9		10		7	13	10	9	8			10		
28	8.70	Gillmore	12	9	13	10	15	7	12	13	10	8					
29	8.00	City of Providence		9				10	12	9	8	9				7	
29	8.00	John A. Scudder				12		8	13	12	10	10				7	
29	7.60	City of New Orleans	13		12	7		9	10	9	9	7			13	15	
30	7.60	City of Cairo						7	9	9	8	7			15	8	
Sept. 4	6.50	Gillmore	16	9	12	9	12	7	10	9	10	7				8	
4	6.50	Arkansas City	9							9	6	6				8	10

16.—Depth of water upon the bars between Saint Louis and Cairo, &c.—Continued.

[In feet.]

Date.	Stage above standard low water by Saint Louis gauge.	Name of steamer furnishing report.	Fort Chartres.	Cambria Hollow.	Turkey Island.	Saint Genevieve Bend.	Kaskaskia Island, Fairy Island.	Saline Creek.	Pratt's Bend.	Mary River.	Liberty Island.	Jones's Point.	Wilkinson's, Ryan's.	76 Crossing.	Grand Tower Island.	Crawford's.	Moccasin Springs.
1883.	Feet.																
Sept. 5	6.30	City of Saint Louis			9	8		7	10½		6½	6½				8	
7	6.00	City of Helena	10½			8	21	6	9	8	6½	6½	6	12		8	9
8	5.70	City of Vicksburg						7			7½		6½			8	
10	5.30	Annie P. Silver	10½	9		8		5½		0½	5½		5	9		8	9
11	5.00	Sidney Dillon					6½		7½	7½	7½		5½			8½	10½
13	4.50	City of Cairo		8	7	8		6½	10½	6½	6½					7	7
13	4.50	City of Providence						7				5½				6½	10½
15	4.10		9			9		6½	9	7½	0		5½	8	10½	8½	8½
18	3.75	Arkansas City		10½				6	8	6	0		4½	8			
18	3.75	Gillmore	9½	8	8½	8½	12	6	9	8½	6½		5				
20	3.40	Centennial				9	7	8	7	7½	7	6				7	
20	3.40	Arkansas City														8	
21	3.40		9		8	9	6	9	9	6½		5		9		8½	
25	3.20	Gillmore	10½	8½	7	8	10½	5½	8	6½	6	5½					
26	3.10	City of Providence			8	8½		7		7½							
29	3.00	David R. Powell		9		8		5½		5½	5½					5	8
29	3.00	Montana				8		5½	8	6	5½					5	
Oct. 3	3.60	Annie P. Silver	12	9½	6½	8	6	7½	8½	6½	5½	6		7		7	7
4	3.70	City of Helena		10½	6	6½		8½		6½	6½	6					
8	5.00	C. P. Chouteau			10½			8	10½							8	
8	5.00	Gillmore	10½	9	8	8½	10½	6½	9	8½	6	6					
12	5.00	City of Cairo				9		6½		8	6½			8		8	
14	4.90	City of New Orleans			8			8		8½	8					8	
21	7.00	City of Vicksburg									8						
23	6.80	John A. Scudder								8½	9					9	
24	6.40	Future City	12	13½				7		8						8	
24	6.40	City of Providence			13½			8		9						10½	
25	6.50	City of Baton Rouge						8½		8	8					9	
26	6.30	Gillmore	12	8½	10½	10½	12	8	10½	9½	8	8½	9½	9	8½		
31	7.60	Arkansas City						9		8½	8½						
Nov. 3	6.90	David R. Powell		10½						6½	9			9	7	10½	
3	6.90	City of Vicksburg								6½	9					9	
7	6.05	City of Saint Louis			15			7½	10½	6	6		10½	12	7½	9	
17	7.75	City of Vicksburg				9				9	12				12		
20	6.20	Future City	10½	10½				9½	12	10½	13½				12		
24	7.10	Annie P. Silver	12	8½				8½		6½	10½				12		
Dec. 1	6.40	City of Vicksburg				9	10½		9						10½		
1	6.40	Centennial			9½				15	8	9½					9	12
5	5.85				9			9	9	7½			13½		2½	10½	
8	5.10	John A. Scudder		8	12			8	10½	7					8		
12	5.20	Arkansas City						9	12	9		8			8	12	
12	5.20	City of New Orleans		9	13½			9	9	8½	7	8			8		
16	5.35	W. P. Haliday		8				7½	9½	7½	6½	9			7	8½	
18	4.40	Future City						7		5	8				7		
19	3.70	City of Saint Louis						6½		7	5½	6		9	8		

REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

16.—*Depth of water upon the bars between Saint Louis and Cairo, &c.*—Continued.




[In feet.]

Date.	Stage above standard low water by Saint Louis gauge.	Name of steamer furnishing report.	Hamburg, Bainbridge.	Devil's Island.	Beaver Dam Rock.	Jacket Pattern.	Atherton's.	Goose Island.	Buffalo Island.	Saladin T. H.	Greenleaf's.	Abel's T. H.	Pond Lily.	Eliza Point.	Greenfield's.	Cairo Point.
1883.	Feet.															
Aug. 16	11.00	City of Saint Louis	10½	8½	13½	...	12	8½	13½	15	...	...	...	...	...	...
22	9.20	Arkansas City	12	8	10½	...	13½	9	10½	9	...	...	...	...	...	...
22	8.20	City of Baton Rouge	12	8	12	12	13½	9	12	...	...	...	...	...	...	...
24	10.00	City of Helena	10½	8	10½	9	12	8	...	...	...	...	...	...	...	...
29	8.00	City of Providence	10½	10½	10½	9	9	...	10½	8½	...	...	...	...	...	12
29	8.00	John A. Scudder	13½	8½	12	10½	10½	8	9	9	9	...	...	...	...	...
30	7.60	City of New Orleans	9	7½	12	10½	9	8	9	9	9	...	...	...	...	9
30	7.60	City of Cairo	9	6	10½	9	10½	8	12	9	8	...	...	...	...	8
Sept. 4	6.50	Arkansas City	10½	7	9	8	10½	7	...	8	7	...	...	...	10½	10½
5	6.30	City of Saint Louis	10½	7½	7½	7½	8	7½	...	6	6	...	...	...	...	9
7	6.00	City of Helena	7½	6	10½	8	9	...	9	6	6	...	...	...	...	7½
8	5.70	City of Vicksburg	8½	6½	9	6½	8½	6½	10½	8½	...	...	...	...	...	...
10	5.30	Annie P. Silver	7	5½	9	6	7	...	9½	8½	...	...	...	...	...	...
11	5.00	Sidney Dillon	7	5½	9	6	7	...	8½	7½	...	...	...	...	...	...
13	4.50	City of Cairo	7	5½	9	6	7	...	10½	9	...	...	...	...	...	...
13	4.50	City of Providence	7½	6	9	6½	8	6½	12	7	...	...	...	...	...	...
15	4.10	Centennial	6½	5½	5	5	6	...	9	8	...	...	...	...	...	...
20	3.40	Arkansas City	7	6	9	5½	7	...	9	8½	...	...	...	...	...	...
20	3.40	City of Providence	7	5½	6½	5	6	...	12	12	...	...	...	...	...	...
20	3.00	David R. Powell	6	5	4	4	6½	6	9	7½	...	...	...	...	...	...
29	3.00	Montana	6	4	4	4	6½	6	10½	8½	9	8	...	...	...	...
Oct. 3	3.60	Annie P. Silver	6	4½	7½	5½	6	6	12	8	...	...	...	...	...	...
4	3.70	City of Helena	8	5½	10½	9	6	9	10½	...	...	...	...	...	...	...
8	5.00	C. P. Chouteau	6	5	7½	7½	6	9	10½	...	...	...	...	...	...	...
12	5.00	City of Cairo	8	7	...	...	8½	12	...	10½	...	...	...	...	...	...
14	4.90	City of New Orleans	8	6½	8	...	8½	12	...	10½	...	...	...	...	...	...
21	7.00	City of Vicksburg	9	8½	10½	8½	12	12	...	12	...	...	...	...	...	...
23	6.80	John A. Scudder	8	9	10½	8	12	12	...	12	12	...	...	...	...	...
24	6.40	City of Providence	8	8	8	8	9	12	...	13½	...	...	...	...	...	...
24	6.50	City of Baton Rouge	9	8	10½	9	12	12	...	12	...	...	...	...	...	...
26	6.30	Gillmore	9½	8½	...	...	...	...	...	...	...	...	...	...	...	...
31	7.60	Arkansas City	9½	9	...	...	...	...	...	...	...	...	...	...	...	...
Nov. 3	6.90	D. R. Powell	9½	9½	...	...	9	...	...	...	...	...	...	...	...	...
3	6.90	City of Vicksburg	9½	9	...	...	12	12	...	12	15	...	...	...	...	...
7	6.05	City of Saint Louis	8½	8	9	...	10½	12	...	12	15	...	...	...	...	...
17	7.75	City of Vicksburg .....	...	9	...	...	...	...	...	...	...	...	...	...	...	...
20	6.20	Future City	10½	12	12	...	...	...	16½	15	18	18	...	...	...	...
24	7.10	Annie P. Silver	12	12	12	13½	...	...	...	...	...	...	...	...	...	...
Dec. 1	6.40	City of Vicksburg .....	...	9½	12	...	...	...	...	...	...	...	...	...	...	...
1	6.40	Centennial .....	...	9½	13½	...	...	16½	...	...	...	...	...	...	...	...
5	5.85	...	9½	9½	...	...	...	...	...	...	...	...	...	...	...	...
8	5.10	John A. Scudder	7	7	10½	...	8	12	...	...	...	...	...	...	...	...
12	5.20	Arkansas City	8	8	9	10½	9	12	...	15	12	...	...	...	...	...
12	5.20	City of New Orleans	9	9	12	12	10½	12	...	8½	12	...	12	...	...	...
16	5.35	W. P. Haliday	7½	6½	9	10½	8	12	...	9	9
18	4.40	Future City	6½	7	7	...	8	9½	10½	...	10½
19	3.70	City of Saint Louis	8	8	...	8	6	...	10½	12

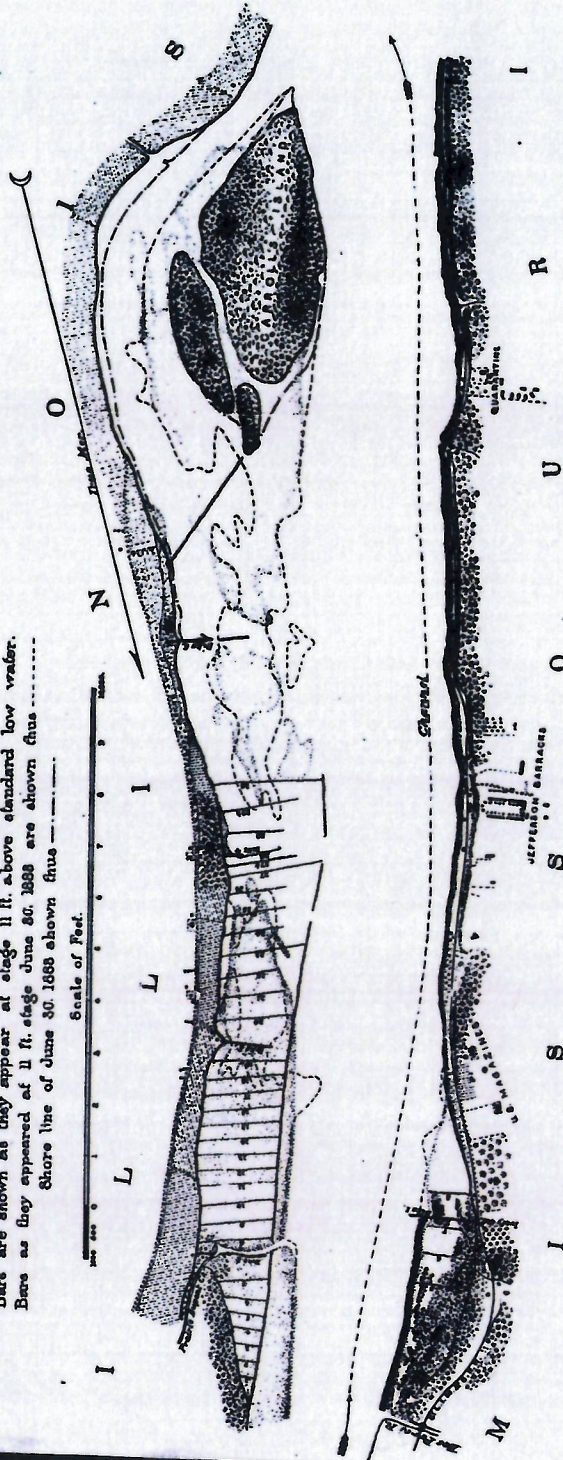
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MISSISSIPPI RIVER.
HORSETAIL BAR.

Map showing location of works June 2^d 1884.

Bank protection, west side, represented thus 
Bars are shown as they appear at stage 11 ft. above standard low water.
Bars as they appeared at 11 ft. stage June 80, 1888 are shown thus 
Shore line of June 30, 1888 shown thus 

Scale of Feet.

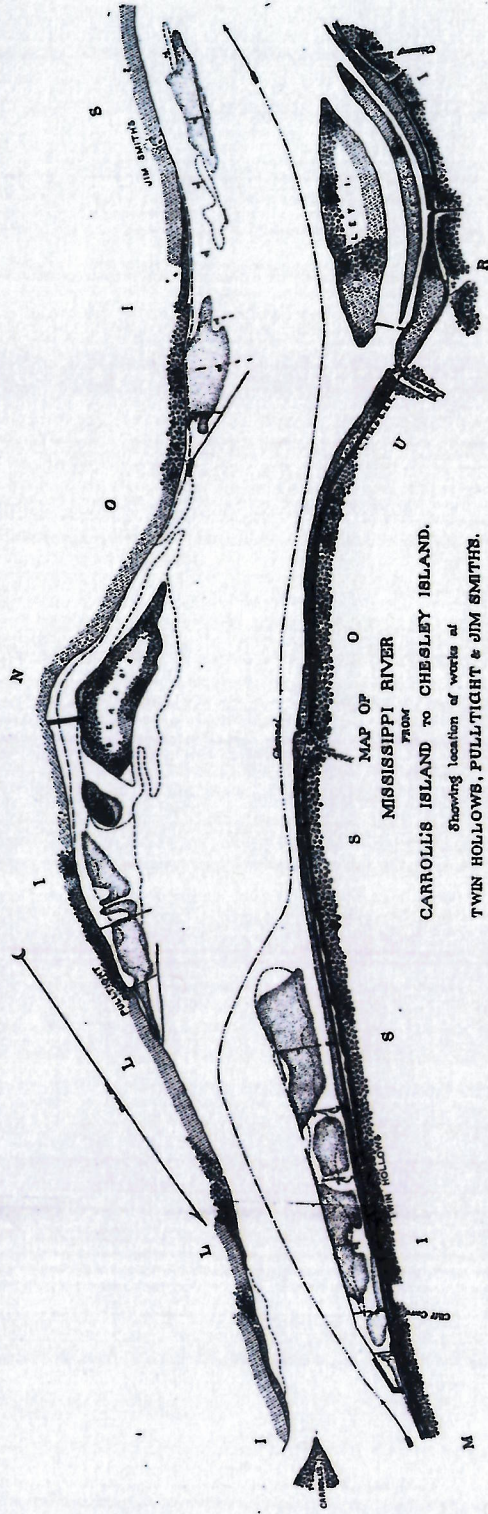


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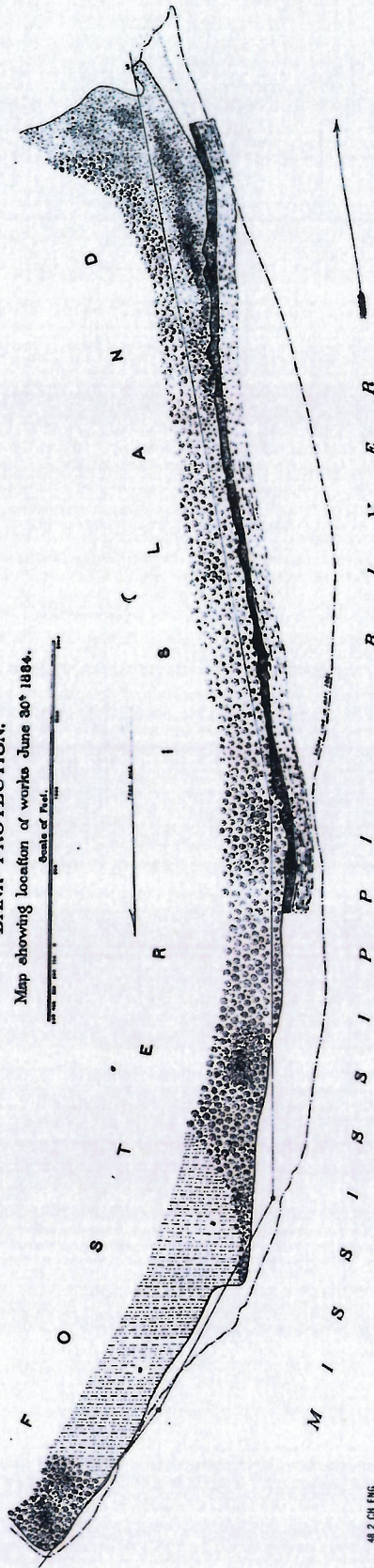


Improvement of Mississippi between Illinois and Ohio Rivers. Annual Report of Major O. H. ERNST, Corps of Engineers. 1884.

PLATE III.

FOSTER ISLAND.
BANK PROTECTION.

Map showing location of works June 30th 1884.



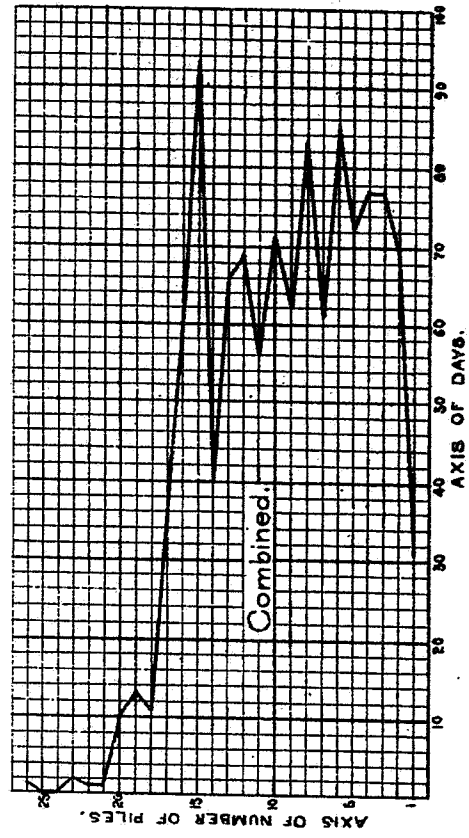
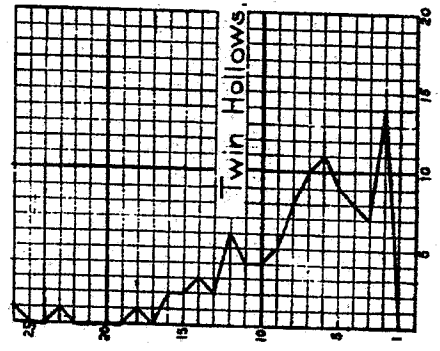
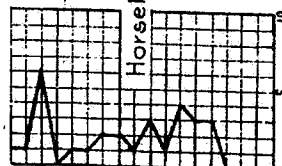
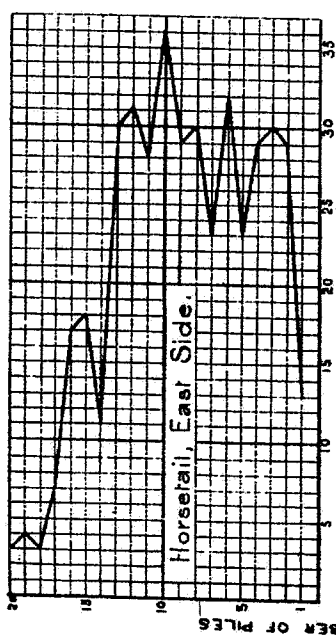
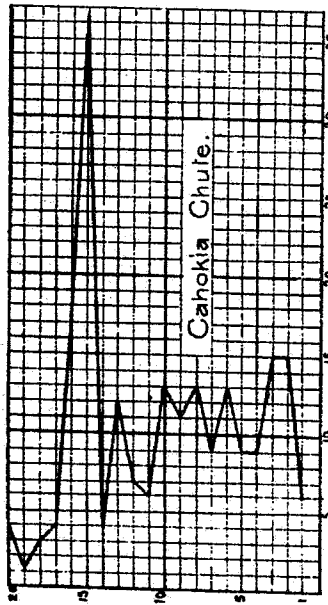
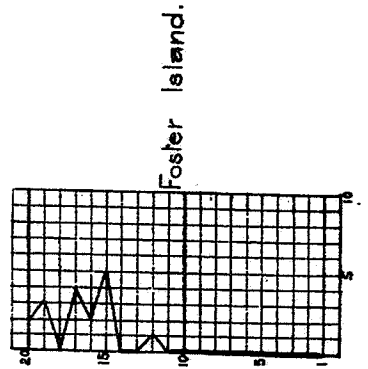
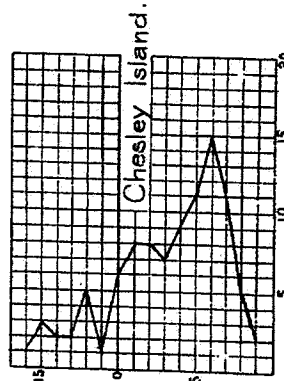
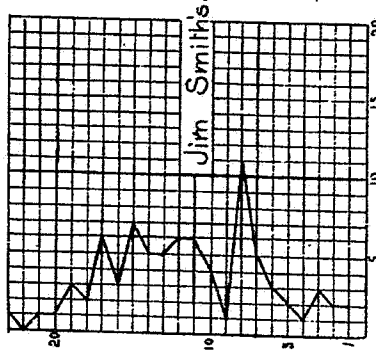
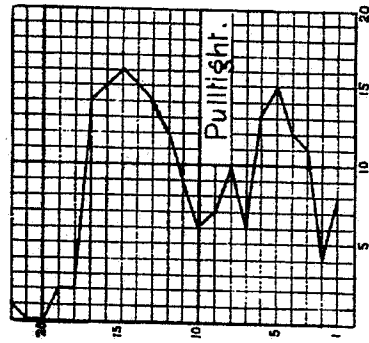
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TABLE III PLOTTED.

Relative frequency of driving 1,2,3,4 &c. piles in single civil days by single pile driver crews, shown for several localities separately, and for them all combined.

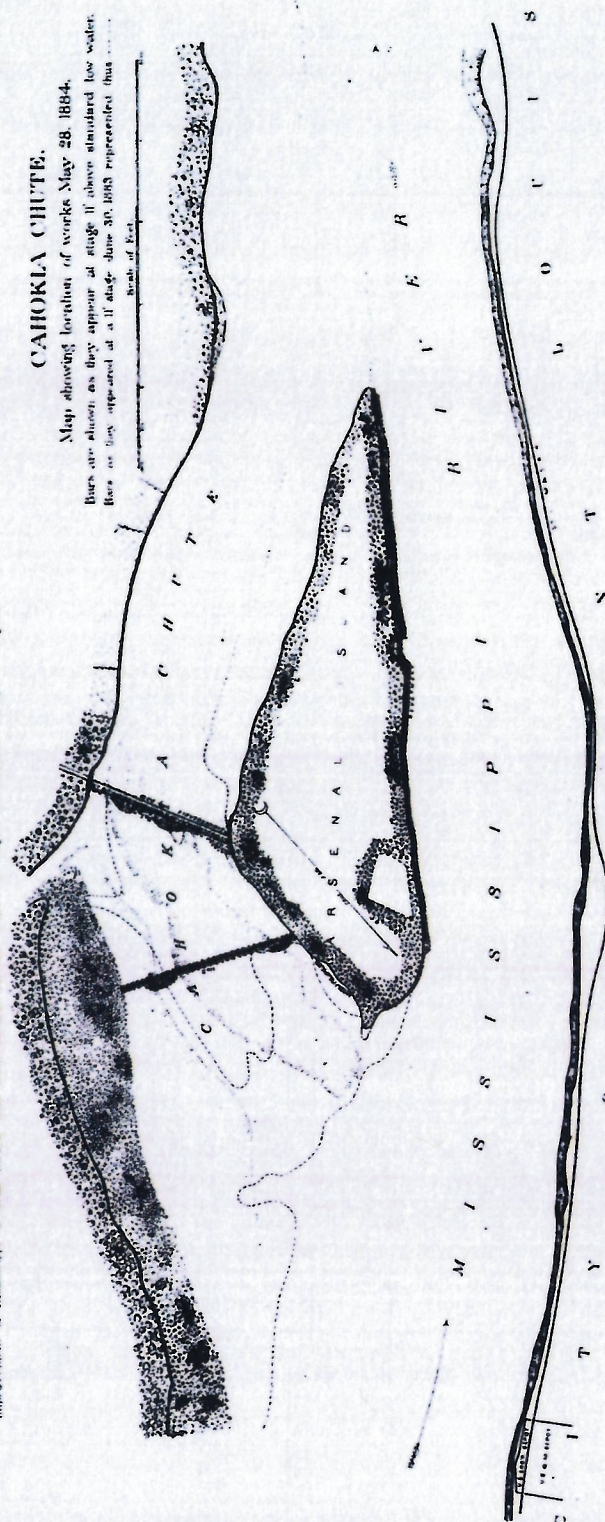


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Improvement of Mississippi between Illinois and Ohio Rivers. Annual Report of Major O. H. ENNST, Corps of Engineers, 1884.

CAHOOKA CHUTE.

Map showing location of works May 28, 1884.
Bars are shown as they appear at stage of above standard low water.
Bars not shown as they appeared at a 14 stage above 30, 1883 represented thus



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U 2.

IMPROVEMENT OF THE HARBOR AND MISSISSIPPI RIVER AT ALTON,
ILLINOIS.

Nothing was done here during the year. The dike previously constructed has continued to exert its beneficial action upon the Alton landing. The shoal formerly existing there has been entirely removed, and the deep water near shore has extended down-stream farther than the wharf has been improved. No further improvement of the landing, so far as the river is concerned, is at present required. There has been some settling of the dike, amounting upon an average to 2 feet, with a maximum at one point of 7 feet. To preserve the efficiency of the dike it is proposed to fill up all depressions and to raise the general level of its crest to what it was before. Funds for this purpose are provided in the river and harbor act of July 5, 1884. No further appropriations for this place are needed.

The original estimated cost of this work was	\$120,000 00
Aggregate amount appropriated	68,354 70
Amount expended to July 1, 1884	68,354 70

U 3.

IMPROVEMENT OF MISSISSIPPI RIVER OPPOSITE THE CITY OF SAINT
LOUIS, MISSOURI.

At the date of my last annual report two hurdles in Cahokia Chute had been begun and were nearly completed. These were finished as soon after the beginning of the fiscal year as the stage of the river would permit work to be carried on. They suffered some damages in the early spring rise, which were promptly repaired. For details attention is invited to the report of the resident engineer, Mr. John O. Holman, hereto appended, marked 17.

The condition of the chute is shown upon Plate V. Very large additions have been made to the deposits formerly secured, and the process of silting up the chute has progressed in a satisfactory manner. It is probable that repairs will be required to the hurdles in the future. If required, they will be made from the general appropriation for the improvement of the Mississippi between the Illinois and Ohio. No further special appropriation for this work is recommended.

The original estimated cost of the work was	\$60,000
Total amount appropriated	60,000
Amount actually expended	60,000

Money statement.

July 1, 1883, amount available	\$26,096 06
July 1, 1884, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1883	26,096 06

17.

REPORT OF MR. JOHN O. HOLMAN, ASSISTANT ENGINEER.

ENGINEER DEPOT, June 14, 1884.

SIR: I have the honor to submit the following report of the operations at Cahokia Chute for the fiscal year ending June 30, 1884.

1528 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Construction work was in progress from July 14 to August 16 under the direction of Mr. C. D. Lamb, assistant engineer, and from April 18 to May 31 under my charge.

The high water which caused the suspension of work June 8 did not allow of its resumption until July 14, when the river had fallen to a stage of 19 feet above standard low water at Saint Louis.

An examination made at that time showed that a breach about 150 feet wide had been made near the middle of line No. 1, and most of the piles driven out from shore a distance of 200 feet to repair its island end had been washed away. A narrow channel had been cut around the Illinois end of line No. 2 and about 30 feet of the wattling near the island was partly overturned. The first work done during the year was the repairing of line No. 1.

Two rows of piles were driven above and around each gap, a foundation mattress built and sunk, and the hurdle-row braced and wattled. Wattling was also placed upon the piles driven the previous year across the breach near the Illinois shore. About 200 linear feet of hurdles were required to repair this breach, about the same next the island, and about 250 feet to close the breach near the middle of the line. No drift-row was driven above these gaps, this line being lower than the piles in No. 2.

Work was then begun on hurdle No. 2, the cut 40 feet wide made around the Illinois end of the line was closed, piles were driven to prevent further injury to the wattling near the island, and the bracing left the previous season was placed as far as practicable, about 300 linear feet of the uncompleted part of the line being covered with sand and drift. About 200 linear feet of these obstructions were next the Illinois shore, and the remaining 100 feet at the outer end of the line completed during the spring of 1883, or about 1,400 feet from the island.

These repairs were completed the 16th of August, when Mr. Lamb was given charge of the works at Pulltight.

Work was resumed April 18 to repair the breaches which appeared in both lines after the rise which occurred during the first of the month.

Not until the 1st of May, when the breach at the island end of No. 2 was redriven, did the river decline to a stage low enough for their accurate measurement, which were found to be as follows: Near the island end of No. 2, 190 feet; near the shore end of No. 2, 300 feet; near the shore end of No. 1, 75 feet; near the middle of No. 1, 325 feet; damaged at the island end of No. 1, 450 feet.

Two drivers completed the driving of the breaks in No. 2 May 19; a mattress 540 feet long by 80 feet in width, containing 43,200 square feet, was constructed by the 14th; the stringers, 32 in number, and the braces, 71 in number, were placed by May 28.

Two extra drivers were transferred to the works May 21, working on the driving of No. 1 line, and, with the help of those from No. 2 line after May 23, succeeded in finishing line No. 1 May 31, driving 199 piles, placing 53 braces, and 33 stringers.

A mattress was constructed only in the middle gap of No. 1. It was 325 feet long by 80 feet wide, and was completed May 29.

In repairing No. 2 hurdle and the middle break of No. 1 three rows of piles were driven, with the stringers and braces placed in the usual manner. The mattress in these breaks was made 80 feet in width. It was woven on five-way flats, one placed above the drift-row of piles, one above the hurdle-row, one above the brace-row, and two below the brace-row, bringing about 10 feet of the mattress above the hurdle-row and from 30 to 40 feet below the brace-row.

In hurdle No. 1, 170 feet in the repair at the island end was driven in three rows, with the usual braces and stringers; 230 feet, the extreme island end, and the shore break were repaired with a double drift-row, the piles in each row being 12 feet apart, those in the lower row just 6 feet below those in the upper row. The tops of the piles were pulled together and bolted to a stringer which passed between the rows.

No wattling was placed on either hurdle-line.

The work done during the year was distributed as follows: *

The deposition of sediment in the chute was very rapid during the early part of the year. At a 7-foot stage the bar at the head of the chute was dry from the Illinois shore to the island. The fill has also been very heavy below the hurdles, especially below No. 1, at the shore end. Protection work is needed on the head of the island from the revertment nearly to No. 2, to prevent the erosion which has occurred along that portion of the bank from extending around the end of the hurdle.

The location and extent of the work done during the year is shown on the accompanying tracing, which was made from the survey of May 28.

I remain, very respectfully, your obedient servant,

JOHN O. HOLMAN,
Resident Engineer.

Maj. O. H. ERNST,
Corps of Engineers, U. S. A.

U 4.

IMPROVEMENT OF THE MISSISSIPPI RIVER AT OR NEAR CAPE GIRARDEAU, MISSOURI, AND MINTON POINT, ILLINOIS.

The good results of the works at this place previously reported have been maintained throughout the year, the main steamboat channel flowing without obstruction from one end of the Cape Girardeau landing to the other. No funds were available, and nothing was done during the year. The hurdle built opposite Cape Girardeau as a preservative, and which was reported last year as having been damaged, has since been practically destroyed. The work of preservation, if undertaken, would therefore have to begin at the beginning. Its estimated cost would be about the same as the amount asked for last year for the protection of the banks. As there is no heavy caving of banks going on in this vicinity at present, it would seem proper to defer work of that kind until this point is reached in the general improvement of the river. The estimate of last year is therefore retained, but it is proposed to change the application of the sum asked for in accordance with the above.

The original estimated cost of the work was.....	\$90,170 16
Total amount appropriated and allotted	65,366 55
Total amount actually expended.....	65,366 55

Money statement.

Amount (estimated) required for completion of existing project.....	\$41,820 04
Amount that can be profitably expended in fiscal year ending June 30, 1886.	41,820 04

U 5.

IMPROVEMENT OF OSAGE RIVER IN KANSAS AND MISSOURI.

No work of improvement was done during the year.

The gauge at Tuscumbia was read daily throughout the year, and that at Warsaw daily until September 30, when it was discontinued. Their records are appended, marked 18 and 19.

The only work that can be done to advantage upon this stream at the present time is the removal of snags and overhanging trees. The number of such obstructions and the cost of their removal is uncertain. An appropriation of \$5,000 would probably accomplish all that will be required during the coming year.

Money statement.

July 1, 1883, amount available.....	\$1,660 65
Miscellaneous receipts	31 66
	<hr/> 1,692 31
July 1, 1884, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1883.....	\$1,493 45
July 1, 1884, outstanding liabilities	55 12
	<hr/> 1,548 57
July 1, 1884, amount available	143 74
	<hr/> <hr/> 5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1886.	5,000 00