

1892

RIVER AND HARBOR IMPROVEMENTS.

249

Amount drawn under section 7, act of August 11, 1888.....	\$98,250
June 30, 1892, amount expended during fiscal year.....	98,250
	-----
July 1, 1892, amount available for fiscal year ending June 30, 1893.....	100,000

(See Appendix X 1.)

2. *Mississippi River between the Ohio and Illinois rivers.*—The original condition of the navigable channel of this portion of the Mississippi River, before the work of improvement was begun, was such that the natural depth at low water was in many places from 3½ to 4 feet, and the water was scattered by islands, which formed sloughs behind them, thus wasting the water available for low-water navigation.

The project adopted for improvement consists in closing these sloughs, and, by contraction works, the concentration of the water between banks 2,500 feet apart, the object being thereby to obtain a depth of 8 feet in the channel between St. Louis and Cairo, and 6 feet between Grafton and St. Louis at standard low water, or at a stage corresponding to a reading of 4 feet on the St. Louis gauge.

The amount expended up to the close of the fiscal year ending June 30, 1891, was \$4,129,014.16 and the condition of the improvement at that time was such that but little trouble was experienced between St. Louis and Lucas Crossing, a distance of 30 miles, as far as the work of improvement had been carried on June 30, 1891, and then only at extreme low water. For stages of water above 4 feet on the St. Louis gauge there was generally a depth of at least 6 feet in the channel.

The amount expended during the fiscal year ending June 30, 1892, was \$276,168.99, and was applied to repairing plant, and carrying on works at the following localities:

*Alton.*—This work consisted in building an extension of 2,400 feet to the stone dike erected in 1882 and 1884, also in raising the crest of old dike 3 feet for a distance of 800 feet at its lower end. The object of the work was to prevent the further formation of a bar in front of the Alton landing and to wash away what had already formed. The work was commenced on August 10, 1891, and completed May 3, 1892. The effect of this work can not be determined until the next low-water season, as during the time of construction and since then, the Missouri River was higher than the Mississippi River, and in consequence back-water from the former so deadened the current that the work had but little effect on the deposit in the harbor. At least one high water from the Mississippi, when the Missouri is at a lower stage, is required before any material change can be expected. The amount expended on this work during the fiscal year was \$49,948.78.

*Rush Tower.*—Work at this locality consisted in an extension of the general plan of improvement, so as to include this section of the river. Work was commenced just prior to the close of the previous fiscal year and was continued during the present one. A series of four hurdles, of an aggregate length of 5,920 feet, was built on the east side of the river at James Landing; another series of three hurdles, having an aggregate length of 3,790 feet, was built on the west side near Wilcox Landing, and the bank at Calico Island was protected for a distance of 4,600 feet.

The object of this work was to concentrate the water into one channel at low water, it being scattered through three or four. At the close of the fiscal year a high stage of water still prevailed, and the full effect of the work will not be apparent until next low-water season. The amount expended at this locality during the fiscal year was \$181,006.

*Ste. Genevieve.*—The project for the improvement of the river at this

point had for its object the retention of the channel at Little Rock, the landing for Ste. Genevieve. To do this a series of three hurdles was built on the opposite side of the river, and they have been successful in obtaining the desired results. Work was in progress on these hurdles at the close of the last fiscal year and they were completed July 17. To induce a further fill, the wattling on the hurdles was raised to the 20-foot stage during the month of March. The amount expended during the fiscal year was \$31,422.71.

*Surveys.*—A resurvey of the river, from the head of Carrolls Island to the foot of the Rush Tower work and at Ste. Genevieve, was made for the purpose of determining changes in the banks and channel of the river.

The original estimated cost of this work, as revised in 1883, was \$16,997,100, of which amount \$4,529,600 has been appropriated.

July 1, 1891, balance unexpended.....	\$400,365.84
June 30, 1892, amount expended during fiscal year .....	276,168.99
July 1, 1892, balance unexpended.....	124,196.85
July 1, 1892, outstanding liabilities.....	3,827.58
July 1, 1892, balance available .....	120,369.27
Amount appropriated by act approved July 13, 1892 *.....	525,000.00
Amount available for fiscal year ending June 30, 1893.....	645,369.27

{ Amount (estimated) required for completion of existing project....	11,942,500.00
{ Amount that can be profitably expended in fiscal year ending June 30, 1894 †.....	758,333.33
{ Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

(See Appendix X 2.)

3. *Harbor at St. Louis, Missouri.*—The St. Louis Harbor may be divided into two parts, the upper and the lower, the line of division being the Eads Bridge. The upper portion, included between the bridge and the northern limits of the city, is about 10 miles in length, of which the only part to be considered as at present included in the practical harbor is the reach between the Eads Bridge and the Merchants Bridge, 3 miles in extent. This reach was obstructed by middle bars and by shoals near the Illinois shore, which interfered with landings on that side and rendered navigation difficult. The lower portion, included between the bridge and River des Peres, is 8 miles long, and the channel is good at all stages of water, the landings being easily accessible at all points.

The project adopted for the improvement of the harbor consisted in contracting the width of the river between the Merchants and Eads bridges to an average width of about 2,000 feet by constructing a series of hurdles extending out from the Illinois shore, which would cause a new bank to be built up between them.

The amount expended in building these hurdles, up to the close of the fiscal year ending June 30, 1891, was \$109,303.77, and at that time the effect of the work was quite appreciable, a considerable fill having taken place between the hurdles.

During the fiscal year ending June 30, 1892, \$41,226.44 was expended in building hurdle No. 5 of this system, which had previously been omitted on account of a ferry landing; in the extension of No. 8 to the

\* This appropriation was made for improving Mississippi River between mouths of the Ohio and Missouri rivers.

† For continuing work between mouths of the Ohio and Missouri rivers.

## X 2.

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

## PROJECT.

The object of the improvement is to obtain a minimum depth at low water of 6 feet from the mouth of the Illinois River to St. Louis, a distance of 41 miles, and 8 feet from St. Louis to the mouth of the Ohio River, a distance of 191 miles, the natural depth being in many cases from  $3\frac{1}{2}$  to 4 feet. The initial point of the work for the lower portion is St. Louis, the programme being to make the work continuous, working down stream from that city. Work at detached points has also been carried on under allotments specially made by law for the improvement of landings and the protection of local interests.

The plan of general improvement contemplates a reduction of the river to an approximate width of 2,500 feet below St. Louis, the natural width being in many cases from 1 to  $1\frac{1}{2}$  miles, and the protection of the alluvial banks from erosion. The methods employed are to build up new banks with the solid matter caught from the river itself by means of hurdles and revetment of the banks, both new and old, when necessary.

## ORGANIZATION.

The organization of the engineering staff during the season was as follows:

A supervising engineer was assigned to the general supervision of all the works and of the supply depot. His office was in St. Louis, and his duties were to advise and direct the resident engineers and to have especial charge of the supply of brush, stone, and piles, and of the tow-boat and barges engaged on the work.

The resident engineer was provided with quarters and an office at the work. His duties were to have immediate direction of the work of construction; to make such surveys and observations as might be required; to keep the progress map, upon which all work was to be located as fast as constructed; to keep the journal and other records of the work; to prepare pay rolls; to render quarterly property returns, semi-annual and annual reports to the officer in charge, forwarding them through the superintending engineer.

The superintending engineer was Mr. D. M. Currie. Resident engineers, at Alton, Ill., Mr. William S. Mitchell; at Rush Tower, Mr. C. D. Lamb during the fall season and Mr. John O. Holman during the spring season; at Ste. Genevieve, Mr. William S. Mitchell during the fall and Mr. John O. Holman during the spring season. The procurement of brush was in charge of Mr. C. D. Lamb.

## WORK ACCOMPLISHED.

Work was carried on during the year at Alton, Ill., Rush Tower, and Ste. Genevieve. Repairs to plant were made whenever necessary, and the new plant contracted for during the last fiscal year was completed and delivered. Eight gauges were established at short intervals between Jefferson Barracks and Jones Point and readings were made daily.

## ALTON.

The work at Alton consisted in the extension of the present submergeable stone dike, for a distance of 2,400 feet, and in raising the crest of old dike 3 feet, for a distance of 800 feet at the lower line.

The object of the work is to prevent the formation of a bar in front of the landing at Alton by directing the flow of water at low stages along the river front at that place. A contract was entered into for this work with Mr. H. S. Brown, of Quincy, Ill., under date of January 28, 1891, and operations were commenced on August 10, 1891, and completed, as far as the present appropriation would permit, on May 3, 1892. One hundred and ten piles, 45,400 cubic yards brush, and 17,422 cubic yards of stone were used in the work. The details are given in the report of Mr. William S. Mitchell, assistant engineer, which is forwarded herewith.

During the prosecution of the work and since then the Missouri River has been at a higher stage than the Mississippi River, causing backwater from the former, which so deadened the current that the work has as yet had but little effect on the bar in front of the landing. It requires a high water in the Mississippi, with a low water in the Missouri, before there is sufficient current to wash away the bar. The amount expended was \$49,948.78.

## RUSH TOWER.

Operations at this locality consisted in the construction of hurdles on the east side near James Landing, also hurdles on the west side near Wilcox, and in the protection of the bank at Calico Island.

At the close of the previous fiscal year work was in progress on hurdles Nos. 4 and 5, east side. These, as well as Nos. 2 and 3, were completed, and the bank between Nos. 4 and 5, which was rapidly caving, was revetted.

A large portion of the river flowed down the west side, spread out into three channels. To close these and force the water over to the east side of the river, three hurdles, Nos. 3, 4, and 5, were built. Owing to bed rock it was not possible to build the full length of these hurdles in the usual manner. They were extended as far out on the bar as was practicable at the stage of water and were then connected with the Missouri bluff shore by solid stone and brush dikes. During the winter and spring the hurdles were seriously damaged by ice and high water, those on the west side being nearly swept away, with the exception of the stone dikes. This work was all repaired, as well as the high and rapidly fluctuating stages of the river would permit.

The hurdles built aggregate 9,710 linear feet, of which 5,920 feet were on the east and 3,790 on the west side.

The protection of a portion of Calico Island became necessary, as the change in the direction of the current caused it to cave rapidly. A mattress 4,000 feet long by 120 feet wide was constructed and sunk so as to cover the eroded portion, and stone revetment was placed on 1,350 feet of the bank above the upstream end. The details of the work are shown in the reports of Mr. D. M. Currie, assistant engineer, and Mr. John Holman, superintendent, forwarded herewith.

The effect of this work can not be observed until low water, at which time it is expected that the water will be found confined in one channel. The amount expended was \$181,066.

## STE. GENEVIEVE.

This work was nearly completed at the close of the last fiscal year, and it only remained to finish it by sinking drift on hurdle No. 2, wattling and placing curtains on hurdles Nos. 3 and 4, and driving the lower row of piles on hurdle No. 4, all of which was accomplished by July 17. During the month of March the wattling on the hurdles was raised to the 20-foot stage to induce a further fill. The reports of Mr. D. M. Currie, assistant engineer, and Mr. John O. Holman, superintendent, forwarded herewith, show the details of the work.

This work has accomplished the object aimed at, namely, the retention of the channel at Little Rock, which is the landing for Ste. Genevieve. The amount expended was \$31,223.82.

## PLATES.

Plate 1 is a general map of the river from the Merchants Bridge to Brickeys Mill, and shows the location of the works, with the exception of the Alton Dam, which is shown on Plate 2. The work accomplished during the year at Calico Island and Rush Tower reach is shown on a larger scale on Plate 3.

## MATERIAL.

Brush and poles were obtained by hired labor, a royalty of 5 or 10 cents per cord being paid to owners of land where brush was cut.

Stone was obtained by contract from the Grafton Quarry Company at 45 cents per cubic yard, with the exception of a small quantity purchased in open market during the season of low water, the delivery in either case being upon Government barges at the quarries.

Piles were obtained by contract, during the first half of the year, from Mr. John Cleary, at prices varying from 6 to 8 cents per linear foot, according to length, delivered, and by purchase in open market during the last half of the year, at prices varying from  $4\frac{3}{4}$  to  $6\frac{3}{4}$  cents per linear foot, delivered on barges.

Rope, bolts, wire, spikes, nails, etc., were purchased by contract when large quantities were needed; otherwise in open market.

## SUPPLY DEPOT.

All supplies, except stone, brush, and piles, were delivered at the depot, foot of Arsenal street, St. Louis, and thence distributed on approved requisitions to the several works. In addition to this function of the depot it is a general repair shop and yard, where all repairs to plant not requiring dockage were made.

## REPAIRS OF PLANT.

The steamer *Gen. Gillmore* was taken out on the ways at Carondelet, where new cylinder timbers were put in and other extensive repairs made. Necessary repairs were also made to pile drivers, barges, quarter boats, and all floating plant. The 13 model barges, contracted for during the previous fiscal year, were completed and delivered.

A reference to the report of Mr. S. S. Van Norman, who had immediate supervision of the supply depot and of the repairs, which is forwarded herewith, will show all details of the work.

1716 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

VALUE OF PROPERTY.

The present value of the property belonging to this work is shown in the following table:

Class of property.	Balance June 30, 1891.	Debits.*	Credits.†	Balance June 30, 1892.
Barges, model and flat.....	\$56,306.41	\$61,994.75	\$26,225.00	\$92,016.16
Boat, machine shop.....	800.00	1,509.51		2,399.51
Boats, small.....	13,757.12	132.49	4,225.64	9,603.97
Drivers, pile.....	39,992.95	550.73	7,650.00	32,893.68
Shanties, portable.....	7,598.34		1,443.69	6,154.65
Steamer General Gillmore.....	11,742.07	2,988.86	2,002.99	12,727.04
Launches, steam.....	6,466.62		1,000.00	5,466.62
Tents.....	190.75			190.75
Supply depot.....	3,812.78		371.78	3,441.00
Tools and appliances.....	4,397.65	745.18	2,110.27	3,032.56
Boarding outfit.....	9,661.89	618.61	966.19	9,314.31
Office furniture.....	385.63			385.63
Surveying instruments.....	456.70	157.00		613.70
Photographic apparatus.....	200.48	20.63		230.16
Total.....	155,769.37	68,756.81	45,905.64	178,510.64

\* Includes only extraordinary repairs and additions.

† Includes only assumed deterioration.

GAUGES.

The gauges at Grafton and Grays Point were read daily during the year, and the readings are appended, marked A.

Eight new gauges were also established at intervals between Jefferson Barracks and Jones Point, and were all read daily. The object of these gauges was to observe if any change in slope of the water surface was caused by the works of improvement.

CONDITION OF THE RIVER.

The channel depths, as furnished by the Mississippi and Ohio Rivers Pilots' Association for the year, are appended, marked B. A full list could not be obtained, as the pilots' reports are not all preserved by the association.

The river was closed to navigation by ice from January 7 to February 5, 1892. The stage of water was lowest in October, 1891, when it fell to standard low water. The highest stage was reached on May 19, 1892, when the reading on the St. Louis gauge was 36 feet. This is the highest stage since 1858. The record shows but three higher known stages, viz, 37.11 in 1858, 36.61 in 1851, and 41.39 in 1844. The river therefore was to within 5.39 feet of the highest known stage, that of the flood of 1844. Standard low water, reading 4 feet on the gauge, the oscillation of the river was 32 feet.

During the period of lowest water, channel depths in the improved portion were reported as small as 4.5 feet with the lead.

Owing to low water and lack of business the Anchor Line packets were laid up for three months, viz, October, November, and December, 1891.

The water has not as yet subsided sufficiently to show the effect of the recent high water, but it is probable that large deposits have been made behind the hurdles, and that a much improved channel will result during the coming low water season. The works now extend for a distance of 35 miles below St. Louis.

## ESTIMATE.

The amount that can be profitably expended during the year ending June 30, 1894, is \$1,000,000. It is proposed to expend this sum in carrying out the programme heretofore adopted; that is, to carry on the work of improvement continuously from St. Louis downstream, reclaiming land by building up new banks, thus reducing the river to an approximate width of 2,500 feet, alluvial banks to be protected from erosion. It is proposed to obtain by this means a channel of at least 8 feet at low water. The depth is now liable to become as small as 4 feet or even less in some places, and less at every locality where the width is more than 2,500 feet.

This general statement of the proposed application of the appropriation is as specific as the nature of the case admits. The changeable character of the river renders it impracticable to give in advance the exact locality where works will be required.

The original estimated cost of this work, as revised in 1883, was \$16,997,100; the aggregate amount appropriated to June 30, 1892, is \$4,529,600; the amount expended to June 30, 1891, \$4,129,014.16.

Abstract of appropriations made for this work:

By act of—		By act of—	
June 10, 1872 .....	\$125,000	June 14, 1880 .....	320,000
March 3, 1873 .....	200,000	March 3, 1881 .....	620,000
June 23, 1874 .....	200,000	August 2, 1882 .....	600,000
March 3, 1875 .....	200,000	July 5, 1884 .....	520,000
August 14, 1876 .....	229,600	August 5, 1886 .....	375,000
June 18, 1878 .....	240,000	August 11, 1888 .....	300,000
March 3, 1879 .....	200,000	September 19, 1890 .....	400,000

*Money statement.*

July 1, 1891, balance unexpended .....	\$400,365.84
June 30, 1892, amount expended during fiscal year .....	276,168.99
<hr/>	
July 1, 1892, balance unexpended .....	124,196.85
July 1, 1892, outstanding liabilities .....	3,827.58
<hr/>	
July 1, 1892, balance available .....	120,369.27
Amount appropriated by act approved July 13, 1892 * .....	525,000.00
<hr/>	
Amount available for fiscal year ending June 30, 1893 .....	645,369.27
<hr/>	
{ Amount (estimated) required for completion of existing project ....	11,942,500.00
{ Amount that can be profitably expended in fiscal year ending June 30, 1894 † .....	758,333.33
{ Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	

## REPORT OF MR. WILLIAM S. MITCHELL, ASSISTANT ENGINEER.

ST. LOUIS, MO., June 30, 1892.

MAJOR: I have the honor to submit the following report on the construction of the extension to Alton Dike during the fiscal year ending June 30, 1892:

The original dike was built in 1882 and 1884. It extends from the Missouri shore above the tow-head of Ellis Island 4,850 feet downstream and diagonally across the river to within 1,250 feet of the Illinois shore at a point 700 feet above the pump-

\* This appropriation was made for improving Mississippi River between mouths of the Ohio and Missouri Rivers.

† For continuing work between mouths of the Ohio and Missouri rivers.

1718 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

house of the Alton waterworks. Up to the level of low water it was constructed of mattresses, each about 80 feet long, 40 feet wide, and 2.5 feet thick, of brush laid in two crossed crosses between grillages of poles and sewed through with wire rope. These mattresses were built on ways on the Missouri shore above the head of the dike, and after having been launched were sunk with stone in their proper places in tiers, each tier overlapping that next below it 10 feet toward the channel, thus giving the proper slopes to the sides of the dike, and the whole was dressed with stone. Above the brush work the dike was raised with stone riprap to a height of 14 feet above low water for 4,000 feet of its length. At that point the height dropped to 9 feet, and thence the dike sloped off to 3 feet above low water at its lower end. When the extension was begun last fall the work was found in excellent condition, but its crest was about 2 feet lower than when built. This was probably not due to settling, but to ice passing over the dike when running out after each breaking up in the spring.

The extension was begun August 10, 1891, and was completed May 3, 1892. It is 2,400 feet in length and extends from the lower end of the old work to a point about 70 feet below the center line of Piasa street, approaching within 1,100 feet of the Alton levee at low water. It does not follow the prolongation of the old dike, but diverges from it about 2° 30' towards the Missouri shore. The new work is similar in plan to the old, except that the mattresses were increased in width to 50 feet and were built and launched continuously from way barges instead of in sections from ways on shore. They were guided into place by piles spaced 50 to 100 feet apart and were in four tiers for 2,100 feet of the dike, three tiers for the remaining 300 feet, and for 140 feet at about the center of the work, where it crossed the deepest water encountered on the line, a fifth tier was required.

The mattress work and as much of the stone work as was required to bring the level of the whole to 185.5 feet above the office datum plane, or 3½ feet above Alton low water, were completed December 16, when work was stopped for the winter. In the spring it was resumed March 17 and continued until May 3, during which time the lower 800 feet of the old dike and 2,100 feet of the new, which were at about the same level, were raised with stone 3 feet or to 188.5 feet above the office datum. This work exhausted the appropriation and the dike is left with the following profile:

Four thousand feet (old work) with its crest 4 to 6 feet and 12 feet above low water; 2,900 feet (800 feet old work 2,100 feet new work) with crest 12 feet wide and 6 feet above low water; 300 feet (new work) with crest 16 feet wide and 3½ feet above low water.

Throughout the time of construction of the extension the Missouri River was higher than the Mississippi and in consequence backwater from the former so deadened the current at this locality that the work has had but little effect on the deposit in the Alton Harbor, which it is intended to remove. At least one high water from the Mississippi at the time of a lower stage in the Missouri must be had before any material change can be expected.

All work was done by contract by Mr. H. S. Brown, of Quincy, Ill., in accordance with the plans and specifications prepared in this office, and the long-continued low water of last fall and the absence of current during the entire working season were most favorable for the prosecution of the work. Had the contractor's plant been larger and the supply of brush and stone by subcontractors more prompt, the entire work might easily have been completed last fall.

The accompanying chart shows the location of the new dike and the comparative depths found at the beginning and ending of the work on it, and the following table gives the details of expenditures and the quantities of material used:

Pile timber, for guides, 110 sticks, 3,691 feet, at 10 cents.....	\$369. 10
Brush, for mattresses, 9,413 linear feet by 50 feet by 2.605 feet, 45,400.67 cubic yards, at 65 cents.....	29,510. 44
Stone riprap, 8,371.65 cubic yards, for sinking mattresses, 9,050.09 cubic yards above low water, 17,421.74 cubic yards, at \$1.....	17,421. 74
Engineering and contingencies.....	2,698. 72

Total expended = appropriation..... 50,000.00

Very respectfully, your obedient servant,

WM. S. MITCHELL,  
Assistant Engineer.

Maj. A. M. MILLER,  
Corps of Engineers, U. S. A.



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

St. LOUIS, MO., June 30, 1892.

MAJOR: I have the honor to submit the following report upon the improvement of the Mississippi River, between the Illinois and Ohio rivers, for the fiscal year ending June 30, 1892, and to transmit the reports of assistants in local charge, which are intended to form part of it.

Works were prosecuted at Rush Tower and Ste. Genevieve.

*Rush Tower.*—This locality extends from the foot of Lucas to the foot of Fish Bend, and the works this year include the protection of the bank at Calico Island, hurdles on the east side near James Landing, and hurdles on the west side near Wilcox; all located as shown on the accompanying sketch.

Work was in progress on hurdles Nos. 4 and 5 on the east side at the beginning of the year. The only navigable channel was there, impinged against the bank above No. 4, and was eroding it to a distance of 375 feet below No. 5. A large portion of the river flowed down the west side, divided into three streams or chutes, one down the Missouri shore, another crossing below, and the third above Osborne tow-head.

To prevent further erosion of the east bank a low-water protection mattress was placed from a point 295 feet above Hurdle No. 4 to a distance of 1,570 feet downstream to the lower end of the erosion. The chute down the Missouri shore was then closed, when a navigable channel opened in that above Osborne tow-head. The hurdles on the east side were then extended as nearly to completion as was practicable at the low stage of water which prevailed, and their foundation mattresses were completed.

On the west side the hurdles were extended as far out on the bar as was practicable at the stage of water and connected with the Missouri shore by solid stone dikes, which were built as far as the depth of the earth on the bed rock was insufficient to hold piles.

The river was closed by ice during the winter, and when it opened the hurdles on the east side were found intact with the exception of small breaks in Nos. 2, 3, and 4. On the west side the damage was more serious. There was a break 300 feet long in No. 3, while of Nos. 4 and 5 little remained except the stone dikes connecting them with the shore.

During the spring, No. 2 on the east side was repaired and completed and No. 3 on the west side was extended to connect with the bar at high stages, and the old work was in part repaired. The break near its west end remained open when field operations were closed on account of the flood stage May 7, while its connection with the bar had been severed.

The hurdles built aggregate 9,710 linear feet, of which 5,920 feet are on the east side and 3,790 feet on the west.

During the spring the stages of river fluctuated rapidly, high water causing suspension of work twice before it was closed in May by the flood.

*Protection.*—The protection of a portion of Calico Island became necessary, the direction of the current having changed so as to impinge with eroding force against its west face about 1,500 feet below its head. A mattress, below standard low water, 120 feet wide and 4,000 feet long, was placed to cover the eroded section. A revetment of stone was placed on 1,350 feet near the upstream end of the mattress and to such heights as were practicable without excessive grading, ranging between 10 and 20 feet above extreme low water.

The quantities of work, material expended, and other details are shown in the report of Mr. John O. Holman, superintendent.

*Ste. Genevieve.*—The work at this locality was in continuation of that in advanced progress at the close of the last fiscal year, consisting of hurdles Nos. 2, 3, and 4. These were completed by sinking drift on No. 2 and wattling and placing curtains on Nos. 3 and 4.

For the quantities of work, material expended, and other details reference is made to the accompanying report of Mr. John O. Holman, superintendent.

*Material.*—Brush was procured by hired labor and purchase of royalty. Details are shown in the report of Mr. C. D. Lamb, superintendent.

Stone was procured by contract from the Grafton Quarry Company, with the exception of a small quantity purchased in open market during the season of low water, the delivery in either case being upon Government barges at the quarries.

Piles were procured by contract delivered at the works during the first half of the year and by purchase in open market delivered on Government barges during the last half.

Other materials, including rope, wire, spikes, nails, and bolts, were purchased by contract when needed in large quantities, otherwise in open market.

*Plant.*—The steamer *Gen. Gillmore* was taken out on the ways at Carondelet and extensively repaired, including new cylinder timbers.

## 1720 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Thirteen model barges, Nos. 101 to 113, inclusive, which had been contracted for and were in process of construction at the close of the last fiscal year were finished. The other plant received such repairs as were needed.

Details relating to the repairs and other operations at the Engineer Depot are shown in the report of Mr. S. S. Van Norman, superintendent.

Very respectfully, your obedient servant,

D. M. CURRIE,  
*Assistant Engineer.*

Maj. A. M. MILLER,  
*Corps of Engineers, U. S. A.*

### REPORT OF MR. JOHN O. HOLMAN, SUPERINTENDENT.

ST. LOUIS, MO., *June 30, 1892.*

MAJOR: I have the honor to submit the following report of operations at Rush Tower for the fiscal year ending June 30, 1892:

The work done on the Rush Tower stretch consisted of hurdles in James Chute on the east side, hurdles on the west side near Wilcox, and protection work at Calico Island.

*Hurdles.*—At the beginning of the fiscal year two hurdles, Nos. 4 and 5, had been started on the east side just above Lillys Landing, and as the bank at that place was cutting very fast the shore mattress of No. 4 was extended down to connect with No. 5 hurdle. This mattress, 650 feet long, July 1 was extended to a distance of 375 feet below No. 5 and 220 feet upstream above No. 4, making the low-water protection continuous for a distance of 1,570 feet, but the only revetment placed was the usual amount at the ends of the hurdles. The piling on these hurdles was completed to the channel, a distance of 100 feet from the shore, early in July.

To cause a fill on the Illinois side of the chute inducing more water to run down the Missouri shore, hurdles Nos. 2 and 3 were begun July 20. By the middle of August these hurdles had been extended a distance of 850 and 650 feet, respectively, causing such a fill at the end of No. 4 that this hurdle was built to a length of 600 feet in the early part of September.

These hurdles, completed to the channel, largely increased the current on the Missouri side, but the channel there was divided below Kennett's between the two Osborne towhead chutes and the chute down the Missouri shore past Wilcox, all of which were too shoal for steamboat channels. To shut off the channel next the Missouri shore the construction of hurdles was begun near Wilcox on September 14.

Three hurdles were built across this chute, Nos. 3, 4, and 5. The piling and foundation mattress on these lines were completed October 17, but the dikes of stone and brush which were placed at the shore end of each line, where piles could not be driven on account of bed rock, were not completed until the last of November. The mattress on these lines, however, was carried well out upon the bar, and the hurdle piles were tightly curtained as soon as driven, so that nearly all the water running down past Kennett's was turned through the Osborne chutes. The lower chute soon began cutting, but any considerable increase in depth was prevented by the gravel bar which was found there at a 1-foot stage. Meanwhile the upper chute was cutting slowly, and on October 12 this channel, though narrow, was of sufficient depth to carry any boat then running on that part of the river.

The closing of the east or James Chute was then resumed and hurdles Nos. 2, 3, 4, and 5 were completed from the towhead to the work done during the summer. A scour which developed under the foundation mattress of No. 2 hurdle near the shore end early in December was checked by placing a mattress 320 feet in length by 45 feet in width above the drift row. An extra row of piles was driven just above the weakened hurdle to protect it from drift.

The force was then disbanded and the plant towed to the winter harbor December 10.

All of the hurdles, except No. 5 east side, were broken more or less by the flow of ice during the winter, the loss amounting to 580 feet of the 5,550 feet on the east side and 1,500 feet of the 2,790 feet on the west side, or a total of 2,080 feet out of the 8,340 feet constructed during the fall season.

Field operations for the repair of the upper hurdle on each side of the river were resumed March 4. Hurdle No. 2, east side, was repaired in March. Two breaks, one of 280 feet and one of 50 feet, were redriven and the hurdle extended 40 feet nearer the towhead. A row of clumps, 3 piles in each, was also driven just above the drift row along the middle portion of the hurdle to protect the broken piles from drift. The small amount of drift collected at the main shore end was sunk and the extension at the towhead was wattled.

In hurdle No. 3, west side, a break of 300 feet just outside of the shore dike was the

only loss from the run of ice, but during the storms of March the remaining drift row, 940 feet in length, gave way without damage to the hurdle row. A row of three-pile clumps 12 feet apart was driven immediately below to strengthen the hurdle row while sinking the drift collected above it.

The east end of the hurdle, which could not be driven in the low stage prevailing in the fall season, was completed to the towhead, a length of 800 feet. The construction of the foundation mattress for this portion of the hurdle was greatly retarded by the strong current and the quick rises of the river over the 26-foot stage April 7 and 22, each rise causing a suspension of several days. The loss of 160 linear feet of mattress just before the second break made the completion of the hurdle more difficult owing to the greater depth and increased current through the break. A large body of drift was sunk above the old portion of the hurdle, the mattress placed on it averaging from 40 to 60 feet in width. Drift mattress was also placed above the new portion with exception of 150 feet near the towhead, but the quantity of drift sunk was not as large.

At the west or shore end, 200 linear feet of hurdle had been driven in the gap when the first rise carried it away. After the second rise another attempt was made to close it. A row of clumps, four piles in each, was driven 170 feet above the line of the hurdle, and 40 linear feet of mattress had been constructed, when the rise of May 7 swept it away.

Work for the season was then closed, and later in the month the plant was taken to the harbor at Bushberg.

*Method of construction.*—The ordinary forms were used, except in the construction of the foundation mattress at the main shore end of hurdles Nos. 3 and 4, on the east side, which was built across the channel during the high water of July and August. The current was so strong on these hurdles that the drift piles driven to hold the mattress were scoured out before it could be sunk. The mattress, therefore, was placed before the piling, that on No. 3 hurdle being held during construction by lines to clumps of piles, 75 feet apart, about 200 feet above the line of the hurdle, the mattress on No. 4 hurdle by lines fastened to No. 3 hurdle. The same method was used in the extension of No. 3, west side, during the high water of April, but in this case the mattress was held by clumps only 75 feet above the hurdle. The distance was found too short for the depth of water, but the steamboat channel passing just above prevented any increase of distance. This method of placing the mattress obviates all danger of scour between the piles when they are driven, but it is slower and more expensive.

The Illinois shore was revetted up to a 20-foot stage for the usual distance above and below the ends of the hurdles, but the towhead opposite was protected by the extension of the foundation mattress to the edge of the willows, a distance of 50, 125, 175, and 250 feet respectively from the piling on each line. Curtains made with a 4-inch mesh were built to a 6-foot stage on No. 2, a 12-foot stage on No. 3, and to the stringer at a 16-foot stage on Nos. 4 and 5 hurdles.

On the west side the curtains of Nos. 4 and 5 were carried to the stringers and on No. 3 only to a 6-foot stage. The dikes at the shore ends of these hurdles were built of brush mattresses up to a 4-foot stage and from that plane to 12 feet above low water with stone, 700 yards of which was procured from the bank in the immediate vicinity. Each mattress was about 3 feet thick and 50 feet wide, and all above the bottom tier were placed about 12 feet farther upstream than the one next beneath it. Two tiers were used on No. 3, four on No. 4, and three on No. 5 hurdle, so that the bottom of the dikes varied in width from 60 feet on No. 3 to 85 feet on No. 4, about two-thirds of which were on the downstream side of the crest of the dike. The length of the lower dike was 150 feet, the others 175 feet.

*Protection.*—The construction of mattress to protect the west shore of Calico Island was begun October 19, 1,500 feet below its head and about 200 feet above the foot of the bar outside, which extends to the Lucas hurdles.

This mattress was built on flats and placed with its inner edge at a 4-foot stage where possible. The ordinary width was 120 feet, but it was made wider when necessary to protect a bay or excess on its inner edge. Construction was continuous down to station 15 + 50 feet or to a point 1,550 feet below the head of the mattress, where it was launched from the ways and sunk, as the mattress showed signs of breaking. Construction was then resumed and the mattress was made continuous to station 40, when work was suspended for the season, December 9. The total amount built was 4,000 linear feet, or 489,750 square feet, completing the low water protection on that part of the island that seems in immediate danger of erosion.

The revetment was begun November 24 at station 1+35, the head of last season's erosion, and carried up to a 20-foot stage down to station 7. The next 200 feet was revetted to a 15-foot stage, and from station 9 to 14+85, to a 10-foot stage. The portions left unprotected are very steep, but will probably be graded by the current during the next high-water season.

The revetment placed amounts to 1,350 linear, or 69,800 square feet.

1722 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Work done—Hurdles and bank protection.

Hurdle.	East side.				West side.			Total.
	2.	3.	4.	5.	3.	4.	5.	
Piles driven .....number..	1,124	875	730	676	1,737	323	426	5,900
Stringers placed.....do.....	233	164	171	144	312	58	87	1,169
Piling built.....linear feet..	1,800	1,360	1,430	1,330	2,240	775	775	9,710
Foundation mattress.....do.....	1,450	1,530	1,605	1,600	2,495	875	800	10,355
Do.....square feet..	98,940	111,050	109,725	104,200	171,075	56,875	52,000	705,085
Drift mattress.....linear feet..	170				1,990			2,160
Do.....square feet..	5,400				98,785			104,185
Wattling and curtains..lin. ft..	1,000	1,000	1,050	1,150	650	450	775	6,075
Do.....square feet..	13,400	17,175	22,825	18,650	2,925	7,100	16,875	98,950
Shore dikes.....linear feet..					175	175	150	500
Do.....cubic feet..					2,200	4,825	2,040	9,065
Revetment.....linear feet..	230	155	270	200				855
Do.....square feet..	6,120	2,205	8,100	6,000				22,425

Shore mattress between hurdles Nos. 4 and 5.

Linear feet .....	1,100
Square feet .....	108,100

Calico Island protection.

Mattress .....	square feet..	489,750
Revetment.....	linear feet..	1,350
Revetment .....	square feet..	69,800

All of the employes were subsisted at the works. The largest number employed in November was 397, which was the maximum.

During the fall season the work was in charge of Mr. C. D. Lamb, superintendent.

Very respectfully, your obedient servant,

JOHN O. HOLMAN,  
Superintendent.

Maj. A. M. MILLER,  
Corps of Engineers, U. S. A.

REPORT OF MR. JOHN O. HOLMAN, SUPERINTENDENT.

St. Louis, Mo., June 30, 1892.

MAJOR: I have the honor to submit the following report of operations for improving the Mississippi River at Ste. Genevieve, Mo., during the fiscal year ending June 30, 1892.

The system of hurdles at this locality was nearly completed at the close of the previous fiscal year under the direction of Mr. William S. Mitchell, superintendent.

The continuation of the work in July completed the foundation mattress to the river end of hurdle No. 4, the driving of the lower row of piles, the revetment at the shore end and the wattling of the hurdle row with curtain mattresses to the 10-foot stage. Hurdle No. 3 was also wattled with curtains to the same stage. The drift, collected at the shore end of No. 2, the upper hurdle, was sunk. This hurdle was not wattled, as the drift which had been sunk before the entire line answered the purpose.

A large deposit was soon formed under the hurdles after the close of work, July 17. To induce a further fill the wattling of Nos. 3 and 4 was raised to the 20-foot stage, March 11 to 23, 1892.

Hurdle.	Length.	Piles driven.	Stringers placed.	Mattress.	Wattling.	Revetment.
	Feet.	Number.	Number.	Sq. feet.	Sq. feet.	Sq. feet.
No. 2.....	1,500			8,700		
No. 3.....	1,350				12,450	
No. 4.....	900	324	70	24,830	9,490	1,500
Total .....	3,750	324	70	33,530	21,940	1,500

Very respectfully, your obedient servant,

JOHN O. HOLMAN,  
Superintendent.

Maj. A. M. MILLER,  
Corps of Engineers, U. S. A.

## REPORT OF MR. C. D. LAMB, SUPERINTENDENT.

ST. LOUIS, Mo., June 30, 1892.

MAJOR: I have the honor to submit the following report on procuring brush during the fiscal year ending June 30, 1892:

The force which, on July 1, 1891, was working at Durfees Point, was moved to various places within a few miles of the construction work at Rush Tower, where the brush was used, and was finally disbanded December 2 at Fish Bend and the plant towed into harbor at Bushberg.

Work was resumed for the spring season at Horsetail Bar, east side, near hurdle No. 20. Operations were much interfered with by high water; but little brush was procured at various points in the vicinity until finally disbanded, May 12, on account of the extreme high water.

The brush procured and the time spent at each locality is shown in the following table:

Locality.	Time.	Cords.
Durfees Point .....	July 1 to July 10, 1891 .....	300.0
Fosters Island .....	July 11 to July 23, 1891 .....	441.9
Horsetail Bar, west side .....	July 24 to Aug. 12, 1891 .....	1,037.1
Horsetail Bar, east side .....	Aug. 13 to Aug. 23, 1891 .....	831.1
Twin Hollows, west side .....	Aug. 24 to Sept. 1, 1891 .....	1,028.8
Rush Tower Towhead .....	Sept. 2 to Oct. 23, 1891 .....	3,336.1
Lee's Island .....	Sept. 26 to Oct. 6, 1891 .....	1,533.4
Penitentiary Point .....	Oct. 30 to Oct. 31, 1891 .....	406.3
Calico Island .....	Nov. 1 to Nov. 6, 1891 .....	323.4
Fish Bend .....	Nov. 7 to Dec. 2, 1891 .....	1,047.7
Horsetail Bar, east side .....	Mar. 2 to Apr. 19, 1892 .....	1,105.3
Carrolls Island .....	Apr. 20 to Apr. 25, 1892 .....	210.9
Beards Island towhead .....	Apr. 26 to Apr. 30, 1892 .....	420.6
Jim Smiths .....	Apr. 30 to May 4, 1892 .....	243.2
Illinois shore, near Fosters Island .....	May 5 to May 12, 1892 .....	238.6
Total .....	.....	13,204.4

All the brush procured during the year was loaded with the derrick, which, as at present arranged, will handle about 50 cords of brush per hour with a force of 8 laborers and a steam engineer.

Very respectfully, your obedient servant,

C. D. LAMB,  
Superintendent.

Maj. A. M. MILLER,  
Corps of Engineers, U. S. A.

## REPORT OF MR. S. S. VAN NORMAN, SUPERINTENDENT.

ST. LOUIS, Mo., June 30, 1892.

MAJOR: I have the honor to submit my report of operations at the engineer depot for the fiscal year ending June 30, 1892:

*Towboat.*—The steamer *Gen. Gillmore* was hauled out on the ways July 28, where her cylinder timbers, fan-tails, and 161 outriggers were renewed, and such minor repairs made as were found necessary and not practicable while the boat was in the water.

The boat was taken off the ways August 12, and the additional repairs incident to renewal of the cylinder timbers were completed at the depot.

A water-closet was also rebuilt, the boiler deck-rail repaired, 40 floor timbers in the hull renewed, 2 carlins put in under the deck at the after-cabin bulkhead, and 10 kevels and 4 fenders made.

*Launches.*—The stack knees of No. 2 were renewed and the rudder couplings of both launches changed so as to connect them on the top of the rudders.

The boiler sills, a swinging fender, nosing on the head, and all the wheel buckets, except one, were also renewed on No. 2, and the machinery repaired and launch painted.

*Pile-drivers.*—The machinery of Nos. 1, 2, 10, 13, 16, 18, and 20 was thoroughly repaired and the rake ends of all the drivers were calked, most of them twice and a few three times during the year.

1724 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Renewal of different parts of the drivers were made as follows:

Three leads, 2 on No. 18 and 1 on No. 20; 4 timber heads, 1 on No. 10 and 3 on No. 20; 1 sill to leads on No. 20; 1 crab frame and 10 stanchions under beams on No. 11; 6 side braces to leads, 1 on No. 12, 1 on No. 13, 1 on No. 16, 1 on No. 18, and 2 on No. 20.

A mast was also placed on No. 4 for use in connection with other appliances in loading brush.

Besides, the following repairs were made as found necessary:

Patching and calking decks, splicing braces, renewing kevels, patching cabins, and painting cabins and smokestacks.

Five models of drivers were also constructed.

*Barges.*—Thirteen new barges, numbered from 101 up, were built under contract at Cincinnati, Ohio, and added to the fleet. Thirty-six gas-pipe pumps were made and placed on barges, and all barges calked above the light water line as required.

A side dock was placed under No. 26 and the seams and butts below water line were calked.

Models of five barges were also made.

*Barges with quarters.*—Nos. 16, 17, 18, 19, 21, 22, 24, 25, and 26 were calked on the sides, and minor repairs, such as patching quarters and decks, made.

Models of two quarter barges were made.

*Machine shop.*—The old hull of pile-driver No. 15 was repaired and fitted up as a machine shop, as follows: The upper strakes of gunwales on both sides, six rake plank, the deck frame, and deck, and most of the bottom planking were renewed. A cabin 26 feet long by 16 feet wide, with a skylight 8 feet by 16 feet, was built on the hull, and the interior provided with a vise bench and two vises, a drill press, gas-pipe vise, rack for gas-pipe, sixty bins for gas-pipe fittings, forge and anvil, and a locker.

New engine timbers were laid and the engines, boiler, lathe, and shafting placed and lined up.

The hull and cabin were painted two coats.

*Small boats.*—Ninety-five flats were repaired by renewing timber-heads, renewing and splicing head-blocks and deck stringers, and calking as required.

Ways for mats were placed on 3 flats, platform built on 2, dunnage renewed on 5, and ways for stringing piles erected on 4.

One skiff was built and 35 skiffs and 22 yawls were repaired.

*Tools and appliances.*—A mast, 18 water gauges, 4 pump plungers, and 15 pump boxes were made, and 50 cant hook, 14 pike, 20 axe, 3 hatchet, and 2 spiko maul handles prepared.

A grindstone, 31 blocks, 21 wheelbarrows, and a plane table shade were repaired.

*Boarding outfit.*—Fifty meat boxes were made, 3 water coolers repaired, and seats of 24 chairs renewed.

*Portable building.*—Six and a half sections were repaired and erected on barge No. 26, the inside being whitewashed and the outside painted.

*Supply depot.*—A photographic dark room was built; a vise post and bench and a drill press were fitted up in the blacksmith shop; the roofs of warehouses repaired; the depot fences and sheds whitewashed; cellar steps in warehouse rebuilt, and the sills, platform, and a corner iron of the wagon scales renewed.

Very respectfully, your obedient servant,

S. S. VAN NORMAN,  
Superintendent.

Maj. A. M. MILLER,  
Corps of Engineers, U. S. A.

APPENDIX X—REPORT OF MAJOR MILLER.

1725

Construction account, showing total cost of works to June 30, 1892.

Name of work.	Expended prior to July 1, 1891.	Expended during fiscal year ending June 30, 1892.	Total cost to June 30, 1892.
Piasa Island Dam .....	\$37,910.41		\$37,910.41
Piasa Island Dam, cutting channel .....	3,118.88		3,118.88
Alton Dam .....	33,740.05		33,740.05
Alton Dike .....	78,703.06	\$49,948.78	128,652.74
Sawyer Bend, protection .....	96,803.63		96,803.63
Venice Dikes .....	36,341.85		36,341.85
St. Louis Harbor .....	117,470.42	26,578.52	144,048.94
Arsenal Island, protection .....	42,599.06		42,599.06
Closing Cahokia Chute .....	119,958.21		119,958.21
Channel opposite St. Louis .....	58,455.54		58,455.54
Horsetail Bar, dikes 1 to 5 inclusive .....	225,066.31		225,066.31
Horsetail Bar, training wall .....	81,253.28		81,253.28
Horsetail Bar, hurdles .....	548,834.08		548,834.08
Horsetail Bar, bank protection .....	40,993.55		40,993.55
Carrolls Island, hurdle .....	4,093.58		4,093.58
Twin Hollows, west side, hurdles .....	248,837.82		248,837.82
Twin Hollows, west side bank protection .....	31,370.55		31,370.55
Twin Hollows, east side bank protection .....	128,920.30		128,920.30
Pulltight, hurdles .....	340,778.57		340,778.57
Beards Island, primary hurdle .....	7,166.24		7,166.24
Beards Island, bank protection .....	84,258.76		84,258.76
Jim Smiths, hurdles .....	365,803.33		365,803.33
Jim Smiths, bank protection .....	7,569.58		7,569.58
Chesley Island, bank protection .....	64,416.04		64,416.04
Chesley Island, hurdles .....	27,808.61		27,808.61
Sulphur Springs, hurdles .....	177,964.24		177,964.24
Lucas, hurdles .....	128,056.65		128,056.65
Foster Island .....	44,296.02		44,296.02
Rush Tower, hurdles .....	9,333.32	165,435.82	174,769.14
Rush Tower, protection .....		15,630.18	15,630.18
Fort Chartres Dam .....	36,812.86		36,812.86
Turkey Island .....	24,463.85		24,463.85
St. Genevieve, hurdles .....	36,059.47	11,111.59	47,171.06
Kaskaskia, protection .....	66,465.62		66,465.62
Liberty Island Dam .....	5,053.91		5,053.91
Liberty Island, protection .....	45,129.40		45,129.40
Devils Island, Dike 1 .....	65,871.17		65,871.17
Devils Island, dams 1 and 2 .....	66,526.88		66,526.88
Minton Point, hurdles .....	33,436.37		33,436.37
Cape Girardeau, primary hurdles .....	31,930.18		31,930.18
Cairo protection .....	160,439.82		160,439.82
<b>Total .....</b>	<b>3,702,110.35</b>	<b>268,704.89</b>	<b>4,030,815.24</b>

Property account.

Class of property.	Value July 1, 1891.	Extraordi- nary re- pairs, pur- chases, and additions.	Assumed, deteriora- tion charged to works of improve- ment, etc.	Value June 30, 1892.
Steamer Gen. Gillmore .....	\$11,742.07	\$2,988.86	\$2,002.99	\$12,727.04
Launches .....	6,466.62		1,000.00	5,466.62
Barges, model .....	51,039.00	49,434.75	22,175.00	73,299.35
Barges, with quarters .....	5,266.81	12,500.00	4,050.00	13,716.81
Pile-drivers .....	39,992.95	550.73	7,050.00	32,893.68
Machine shop .....	800.00	1,500.51		2,399.51
Small boats .....	13,757.12	132.49	4,225.64	9,663.97
Portable quarters .....	7,598.34		1,443.09	6,154.65
Tents .....	190.75			190.75
Supply depot .....	3,812.76		371.76	3,441.00
Tools and appliances .....	4,397.65	745.18	2,110.27	3,032.56
Boarding outfit .....	9,661.89	618.61	966.19	9,314.31
Office furniture .....	385.03			385.03
Survey instruments .....	456.70	187.00		613.70
Photographic apparatus .....	200.48	29.08		230.16
<b>Total .....</b>	<b>155,769.37</b>	<b>68,756.81</b>	<b>45,995.54</b>	<b>178,530.64</b>

1726 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Material account.

Class of material.	Value on hand July 1, 1891.	Value purchased.	Expended and charged to works of improvement, etc.	Value on hand June 30, 1892.
Subsistence.....	\$989.01	\$17,921.84	\$18,458.42	\$452.43
Brush.....	978.89	14,242.47	14,455.70	765.65
Piles.....	36.88	22,572.16	20,486.09	2,123.35
Stone.....	301.25	10,903.98	10,391.89	813.34
Rope.....	11,476.72	729.25	4,789.53	7,416.44
Wire.....	1,019.58	.....	853.87	156.71
Iron.....	258.48	140.32	150.50	248.30
Nails.....	358.26	251.48	349.66	268.08
Spikes.....	679.07	103.50	444.08	338.49
Bolts.....	3,152.09	59.73	1,489.43	1,722.39
Lumber.....	636.68	746.12	991.20	391.51
Oakum.....	231.29	.....	195.05	36.24
Coal.....	307.09	7,197.59	7,481.77	22.91
Ice.....	.....	1,828.95	1,828.95	.....
Miscellaneous material.....	1,832.66	2,619.78	4,075.88	376.56
<b>Total</b> .....	<b>22,248.94</b>	<b>79,317.17</b>	<b>86,441.71</b>	<b>15,122.40</b>

Construction account showing cost of works during fiscal year ending June 30, 1892.

Class of expenditures.	Localities.					Total.
	Alton Dike.	St. Louis Harbor, hurdles.	Rush Tower, hurdles.	Rush Tower, protection.	St. Genevieve, hurdles.	
Contract.....	\$49,948.78	.....	.....	.....	.....	\$49,948.78
Labor and superintendence..	.....	\$12,985.86	\$44,721.50	\$4,654.08	\$3,871.60	66,233.04
General expense.....	.....	1,012.22	10,200.00	593.10	367.72	12,173.04
Towboats.....	.....	2,078.42	16,543.61	1,782.19	1,274.92	21,679.14
Ordinary repairs and care of plant and tools.....	.....	1,080.18	12,784.68	720.54	814.32	15,399.72
Deterioration of plant.....	.....	1,906.10	26,834.80	1,295.90	1,565.56	31,592.42
Subsistence and ice.....	.....	297.32	12,789.58	1,418.37	1,007.04	15,512.31
Fuel.....	.....	129.11	1,857.64	54.91	90.16	1,931.82
Material used in construction.	.....	7,089.31	39,903.41	5,111.03	2,130.27	54,234.02
<b>Total</b> .....	<b>49,948.78</b>	<b>26,578.52</b>	<b>165,435.82</b>	<b>15,630.18</b>	<b>11,111.50</b>	<b>268,704.80</b>



APPENDIX X—REPORT OF MAJOR MILLER.

1727

Record of gauge at Grafton, Ill., for fiscal year ending June 30, 1892.

[Height of water above a plane 200 feet below St. Louis City Directrix.]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
1....	197.25	193.89	191.93	190.63	191.40	191.30	192.22	194.63	195.60	196.04	203.20	213.84
2....	193.00	193.90	191.84	190.60	191.38	191.21	192.20	194.28	195.71	198.70	203.54	213.82
3....	193.80	193.90	191.78	190.57	191.32	191.18	192.11	194.00	195.83	196.40	203.90	213.65
4....	193.30	193.83	191.59	190.54	191.35	191.04	191.97	193.75	195.82	201.55	204.30	213.43
5....	193.10	193.79	191.53	190.50	191.36	190.92	191.75	193.82	194.02	204.20	205.79	213.21
6....	193.70	193.73	191.52	190.50	191.32	190.88	191.61	194.53	196.14	206.30	206.60	212.92
7....	193.50	193.68	191.50	190.48	191.30	190.84	191.50	195.10	196.74	207.20	207.63	212.61
8....	193.41	193.20	191.47	190.53	191.27	190.80	191.88	196.50	197.77	207.16	208.55	212.89
9....	193.30	193.10	191.45	190.84	191.31	190.77	191.25	196.92	197.91	206.30	209.45	212.25
10....	193.02	192.35	191.41	190.72	191.39	190.66	193.30	196.90	196.20	205.16	210.00	212.00
11....	197.95	192.80	191.40	190.75	191.46	190.60	193.60	196.75	197.63	204.30	211.24	211.80
12....	197.92	192.82	191.34	190.60	191.50	190.60	193.50	196.51	197.51	203.00	212.00	211.57
13....	196.80	192.76	191.30	190.83	191.52	190.67	193.70	196.24	197.32	203.21	212.92	211.35
14....	196.28	192.78	191.20	190.87	191.57	190.80	193.85	196.07	197.20	202.91	213.98	211.15
15....	195.97	193.22	191.15	191.00	191.53	191.18	193.90	195.40	196.93	203.00	214.80	210.91
16....	195.71	193.62	191.09	191.02	191.49	191.43	194.00	195.70	196.70	203.50	215.40	210.70
17....	195.43	193.92	190.90	191.60	191.47	191.60	194.11	195.40	196.54	203.90	215.65	210.67
18....	195.10	194.38	190.83	191.91	191.47	191.82	194.19	195.60	196.38	204.20	215.85	210.50
19....	194.81	195.35	190.80	191.99	191.45	192.31	194.26	196.25	196.20	204.55	215.74	210.21
20....	194.70	195.35	190.77	192.43	191.44	192.73	194.37	196.55	196.11	205.00	215.38	209.80
21....	194.60	196.35	190.71	192.42	191.42	192.81	194.66	196.38	196.03	206.06	215.19	209.65
22....	194.30	196.82	190.68	192.40	191.40	192.78	194.90	196.27	196.08	206.75	215.03	209.42
23....	194.20	196.00	190.64	192.36	191.38	192.72	195.20	197.30	196.18	207.01	214.70	209.34
24....	194.07	195.85	190.62	192.20	191.60	192.66	195.53	196.45	196.30	206.95	214.42	209.33
25....	193.88	195.02	190.63	192.04	191.32	192.57	195.83	195.40	196.51	206.61	214.13	209.48
26....	193.70	194.50	190.62	191.88	191.30	192.51	195.75	195.38	196.70	205.03	214.06	209.53
27....	193.60	193.90	190.60	191.77	191.76	192.47	195.64	195.37	196.31	204.45	213.97	209.60
28....	193.68	193.30	190.63	191.63	191.72	192.38	195.50	195.40	196.90	203.80	213.85	209.87
29....	193.68	192.76	190.67	191.52	191.70	192.32	195.32	195.52	197.07	203.40	213.49	210.29
30....	193.71	192.33	190.66	191.45	191.42	192.28	195.20	.....	197.32	203.20	213.76	210.61
31....	193.75	192.15	.....	191.40	.....	192.25	194.80	.....	197.68	.....	213.81	.....

Standard low water at St. Louis 170.19 feet.  
Zero of St. Louis gauge 166.19 feet.

Record of gauge at Grays Point, Mo., for fiscal year ending June 30, 1892.

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

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
1....	107.11	102.26	99.51	93.61	92.71	93.76	94.26	96.66	103.16	104.01	112.51	120.71
2....	107.56	102.86	98.96	93.46	93.61	93.21	94.51	95.91	103.16	105.36	111.66	120.56
3....	108.76	103.46	98.51	93.26	93.51	92.76	94.66	96.81	102.66	106.06	110.71	120.51
4....	109.56	103.26	97.91	93.06	93.46	92.51	95.31	97.31	102.36	108.36	109.86	120.66
5....	110.41	102.56	97.61	92.96	93.41	92.41	95.66	97.06	101.96	110.66	108.91	120.96
6....	110.56	101.96	97.16	92.86	93.36	92.26	96.76	97.81	101.96	112.71	109.06	121.36
7....	110.26	101.56	96.76	92.86	93.36	92.31	96.76	98.71	102.11	114.81	109.66	121.51
8....	109.36	101.86	96.51	92.86	93.36	92.51	96.06	100.81	101.96	116.01	111.66	121.51
9....	108.26	101.86	96.31	92.86	93.46	92.71	94.71	102.36	102.26	116.61	113.46	121.21
10....	107.46	101.36	96.06	92.86	93.56	92.86	93.71	103.51	103.26	116.51	114.26	121.06
11....	107.26	101.21	95.86	92.96	93.66	92.76	93.71	103.86	105.86	115.91	115.16	120.66
12....	107.56	100.71	95.71	93.11	93.66	92.51	93.61	103.76	106.46	115.06	115.66	120.16
13....	107.71	100.61	95.56	93.41	93.66	92.31	91.81	103.36	106.16	113.66	116.86	119.66
14....	107.46	100.61	95.41	93.81	93.56	92.36	90.56	102.81	105.46	112.56	118.46	119.06
15....	106.56	100.21	95.26	94.51	93.51	92.46	90.36	102.06	104.76	111.81	120.26	118.51
16....	105.86	99.66	95.16	94.71	93.66	92.61	90.86	101.36	104.01	111.61	121.06	117.86
17....	105.51	99.61	95.01	94.96	93.76	92.71	91.41	101.06	103.36	111.51	121.71	117.16
18....	105.31	100.26	94.86	95.06	93.76	92.96	92.51	100.96	102.81	111.51	122.31	116.56
19....	105.16	100.76	94.76	95.11	93.76	93.11	92.06	100.56	102.26	111.66	122.76	116.01
20....	104.86	101.91	94.66	95.11	93.81	93.36	92.81	100.46	101.91	112.76	123.16	115.16
21....	104.21	103.11	94.56	95.01	94.01	93.56	93.51	101.06	101.66	114.31	123.41	114.51
22....	103.76	105.46	94.41	94.86	94.16	93.66	94.36	105.66	101.36	115.86	123.51	113.86
23....	103.41	107.26	94.36	94.76	94.61	93.81	94.76	105.96	101.36	116.11	123.36	113.06
24....	102.86	106.91	94.26	94.56	95.06	94.06	95.21	105.16	101.26	116.36	123.16	112.36
25....	102.66	105.66	94.16	94.51	94.76	94.21	95.31	104.06	101.71	116.26	122.86	112.11
26....	102.51	103.76	94.11	94.46	94.81	94.36	95.41	103.06	102.16	115.86	122.76	112.36
27....	102.51	104.06	94.01	94.31	95.01	94.51	95.46	102.46	102.36	115.86	122.51	112.71
28....	102.76	103.26	93.91	94.21	94.91	95.66	95.66	102.56	102.51	114.91	122.06	112.66
29....	102.91	102.16	93.76	94.11	94.26	94.61	95.76	103.16	102.41	114.16	121.66	113.06
30....	102.76	101.06	93.71	94.01	93.86	94.31	98.26	.....	102.41	113.31	121.06	113.36
31....	102.16	100.21	.....	93.91	.....	94.16	97.76	.....	102.81	.....	120.76	.....

Standard low water at St. Louis, 170.19 feet.  
Zero of St. Louis gauge, 166.19 feet.

1728 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Depth of water in feet upon the

Date.	Stage above standard low water by St. Louis gauge.	Name of steamer furnishing report.	Direction.	Arsenal Island.	Quarantine.	Pulltight.	Twin Hollows.	Fines Bluff.	Meramec River.	Jim Smith's.	Sulphur Springs.	Harrisonville.
1891												
July 2	17.80	Gen. Gillmore	Down	22½		13½	13½		22½			
3	16.70	City of Hickman	do									
8	16.70	S. H. H. Clark	do	18	18		12	15			19½	
11	16.50	John Gillmore	do	19½			12		15			
11	16.50	Gen. Gillmore	do	18		12	18		18			
15	14.40	City of St. Louis	do				12					
17	13.50	Gen. Gillmore	do	18		10½	15		18			
19	12.90	John Gillmore	do				15		12			
19	12.90	City of Providence	do				10½					
20	12.20	Gen. Gillmore	do	16½	15	9½			0			
21	11.80	Arkansas City	do	15			16½					
22	11.30	City of New Orleans	do				10½	12				
23	10.80	H. M. Hoxie	do	16½	16½		13½		10½		18	18
25	10.50	Oakland	do	12			15				15	10½
26	10.60	Belle Memphis	do				13½		10½		15	
29	10.40	City of Monroe	do				12					
29	10.40	City of Hickman	do				12	12				
30	10.00	S. H. H. Clark	do	15			9	10½			15	
Aug. 2	11.00	City of Providence	do				12					
4	10.20	Arkansas City	do				12		15		16½	
15	7.00	Snag boat J. N. Macomb	do				0					
17	7.70	do	do									
18	8.50	do	do									
19	9.40	Gen. Gillmore	do	16½	18	12			12			
26	11.80	do	do	16½	16½	9			18			
29	8.20	My Choice	do				0					
31	6.50	Gen. Gillmore	do	9½	13½	6½			12	10½		12
Sept. 1	6.10	Arkansas City	do				12		10½	10½		
3	4.70	City of Hickman	do				7			9		
4	4.70	Gen. Gillmore	do	9½	9½	7			10½	10½		9½
5	4.30	Belle Memphis	do	12	12		0		10½		12	
7	3.70	Gen. Gillmore	do	9	7½		0½					
9	3.20	City of New Orleans	do	8					8			
16	2.10	J. P. Jackson	do				5½	10½	7½			
16	2.10	City of St. Louis	do	8	9		5½		9	12		
17	1.90	Gen. Gillmore	do	8	8½		5		6½	9		
23	1.30	do	do	7	7		4½		6	7½		
26	1.00	City of Cairo	do	9			5½	9	8			
28	.80	Gen. Gillmore	do	0½	7		4½		6½	7½		6½
Oct 1	.50	do	do	8	7		4½		6	6		6
4	.10	City of Monroe	do									
5	.00	Nellie Spler	do	7	7	5		8½	6½		8½	
8	.00	Gen. Gillmore	do	7	6		4		5½	7		6
12	.80	do	do	8½	8½		4½		5½			5½
17	2.30	City of Sheffield	do	9							10½	
19	2.20	Gen. Gillmore	do	8½		4½			5½			5½
21	1.90	Ferd. Herold	do	7½			6		7½		8	
26	1.30	Gen. Gillmore	do	8		4½			5½			5½
Nov 5	.40	do	do	9		5½			6			8½
9	.50	do	do	9		4½			6			8½
19	.90	City of Sheffield	do				5½		6			
19	.90	Gen. Gillmore	do	9		5			6½			8
25	1.60	Ferd. Herold	do				7½		9			
27	1.20	Gen. Gillmore	do	9½		6½			9			7½
30	.10	City of Cairo	do									
Dec. 26	1.00	Cherokee	do				6		8			
1892												
Jan. 16	Frozen	do	do				5		5			
Feb. 3	3.20	Crystal City	do		9				9			
14	8.80	City of Monroe	do				9					
25	9.40	City of New Orleans	do									
26	8.80	City of Monroe	do				13½					
Mar. 2	10.00	City of Cairo	do									
8	10.00	Gen. Gillmore	do	18		16½			10½	18		
17	10.50	do	do	15		16½				10½		
28	9.90	do	do	16		9			13½	18		

cars between St. Louis and Cairo.

Lucas.	Herculanum.	Swashin.	Calico Island.	Cornice Island.	Osborne towhead.	James Landing.	Kennetts Castle.	Forest Home Land- ing.	Perry Towhead.	Rush Towhead.	Salt Lake Landing.	Brickeys Mill.	Fort Chartres Land- ing.	Establishment Creek	Crookes Landing.	Maddis Landing,	Stantons Landing.	St. Genevieve.	Moro Island.
19½									12						15				
18½						10½		10½	16½	18	18				12		15		
18									16½		10½				14			10½	
16½			13½			15		18	13½						12	15			
16½			13½			12			13½	15	13½				9			12	
16½			12												13½				
10½									15						12	15			
12			9	13½		13½		15	13½		15				8		13½		
			15	13½				12	12		15				7	13½	10½	12	
15			12			12		9	12					8	9	13½	12		
9								9½	8½		10½				9	9	9		
15						15			15	12			9½		12	12	12		
10½								8			9				10½			10½	
13½								12											
16½									18										
10½						10½			9		12		8		9½			10½	
13½	12		12	10½		9½													
9½		8½	10½	8		10½			8½		9½		7		7			9	
8	9½		8½	8½					9		7		5½				9		
8	9½		8½	8½		8½			9	9	7		5½				9		
8			8	8		7½			7½		8		5				9		
6½			6	6		6			5		6		6				6		
7½		7				6			8½		6½		6	5½			6		
7	6½		7	7															
7	6½		7½	7		6½			8½				5½				5	6	
7	6½		6½	7	4½				8		5								
8½		6	6	6	4½						6		5		6	6	4½		
				7½			6½		5	6	5½		6		6	6	4½		
		5½	6	5½					9		6		6						
		6½	6½	6½	5	6		6½	9	9	6		6	6			6		
	6½		6½	6½	5½				9	9	7		6½		5	7			9½
	5½		6½	6½							4½		4½						
	6		6	6							5		4½		5½				
		9	9	9					9	0	9		6			9	9	12	
					8					5½			5½		7				
	9						4½		4½									6	6
							9	8			9				7½				
															0				
			16				12			9									
				13½	12										13½				
					9½				10½						15				
															9½				





# 1732 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

## COMMERCIAL STATISTICS.

Receipts and shipments at St. Louis, Mo., during the years 1889, 1890, 1891.

Articles.	Receipts.			Shipments.		
	1889.	1890.	1891.	1889.	1890.	1891.
Barbed wire and ores and metals (pig and manufactured).....	Tons. 31,663	Tons. 21,782	Tons. 13,741	Tons. 5,885	Tons. 3,945	Tons. 4,802
Cement.....	6,876	15,892	18,621			
Coal and coke.....	88,845	81,565	55,980	1,701	734	148
Cotton (and products).....	4,603	4,230	2,046	200	527	38
Groceries and dairy products.....	8,815	8,262	7,604	8,047	7,428	9,675
Hay, seeds, and grain (including flour, meals, etc.).....	90,265	92,914	96,526	538,329	440,728	377,416
Jute.....	3,473	235				
Live stock and products.....	12,805	17,347	15,217	15,428	18,379	15,166
Lumber.....	127,695	132,940	142,690	6,470	8,526	6,245
Merchandise and sundries.....	281,579	284,589	234,817	131,540	117,806	95,842
Vegetables.....	7,980	3,530	4,110	2,612	1,739	1,435
White lead, oils, etc.....	756	204	63	1,799	1,379	1,555
Wines and liquors.....	102	60	121	647	608	590
Wool.....	102	189	304	35	3	18
<b>Total.....</b>	<b>671,685</b>	<b>663,730</b>	<b>592,140</b>	<b>712,700</b>	<b>601,682</b>	<b>512,930</b>

Transferred by ferries across the river at St. Louis.

	Tons.
1889.....	2,717,760
1890.....	3,052,166
1891.....	3,268,753

Shipments down the river from landings between St. Louis and Cairo during the years 1889, 1890, 1891.

	Tons.
Grain, including flour, meals, etc.:.....	20,209
1889.....	34,267
1890.....	20,353
1891.....	

### RECAPITULATION.

	1889.	1890.	1891.
Receipts and shipments at St. Louis.....	Tons. 1,384,385	Tons. 1,205,592	Tons. 1,105,070
Transferred by ferries at St. Louis.....	2,717,760	3,052,166	3,268,753
Shipped from landings between St. Louis and Cairo.....	29,209	34,267	20,353
<b>Total.....</b>	<b>4,131,354</b>	<b>4,352,025</b>	<b>4,394,176</b>

NOTE.—Increase of 42,151 tons for year 1891 over year 1890.

List of steam-power boats that arrived at St. Louis during the year 1891.

Name.	Length.	Breadth.	Depth.	Gross tonnage.
	Feet.	Feet.	Feet.	
Altea.....	58	10	1.8	8.75
Alert.....	115	10	3	100.00
Alice Brown.....	193	34	4	651.36
A. L. Mason.....	252	52.6	6	1,139.34
Annie Berner.....	(*)	(*)	(*)	(*)
Antelope.....	(*)	(*)	(*)	(*)
Archie Parker.....	70.6	15	6.2	45.16
Arkansas City.....	273.7	44.7	7.8	1,236.99
A. S. Willis.....	153.1	26.5	3.6	139.99
A. W. Van Sant.....	(*)	(*)	(*)	(*)
Bald Eagle.....	292.3	30	5.4	454.71
Belle Memphis.....	267	42.7	7.6	1,222.89

\* Not known.

## List of steam-power boats, etc.—Continued.

Name.	Length.	Breadth.	Depth.	Gross tonnage.
	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	
Benton .....	197	23	5	394.08
Borealis Rex .....	121.5	22	4.5	163.16
Calhoun .....	230	36	5.4	631.74
Charlotte Boeckeler .....	140	20.4	4.1	143.48
Cherokee .....	216.4	33.9	5.4	631.29
City of Alma .....	110	20	4	96.07
City of Cairo .....	271.2	44	7.8	1,206.12
City of Florence .....	160	32	5.3	358.31
City of Hickman .....	285	44.5	9.5	1,555.17
City of Monroe .....	275	45	8	1,038.25
City of New Orleans .....	290	48	8.5	1,586.28
City of Paducah .....	190	34	5.5	318.91
City of Providence .....	273.1	44.5	7.8	1,303.81
City of Savannah .....	189	31.2	5.3	335.55
City of Sheffield .....	183	35	5.5	329.74
City of St. Louis .....	300	49	8.8	1,614.02
City of Vicksburg .....	273.7	44.5	8.2	1,356.52
C. R. Suter .....	189.6	52	7	(*)
Crystal City .....	234	42.2	7	828.28
Des Arc .....	95	18	3	40.88
D. H. Pike .....	199.0	33.5	5.5	465.75
Dick Clyde .....	95.8	17.4	3.9	76.64
Dolphin .....	135.8	22.8	4.8	156.16
Dolphin No. 2 .....	159	30	4.5	186.03
Dora .....	109.5	25.2	4.3	392.23
Eagle .....	155.0	24.8	4.2	231.30
Edith .....	101	24	3.1	69.59
Emma .....	55	13	3	17.68
E. M. Norton .....	174	30	6	549.53
Ferd. Herold .....	244.0	34	7.2	900.58
Future City .....	187.4	36	6.1	589.30
Gem City .....	263	29.8	5.0	580.58
General Barnard .....	215	37	5	500.00
General Gillmore .....	149	28	4	125.00
George Lysle .....	174	33	6	426.74
Grand Republic .....	260	50	8.5	1,985.92
Harry Reid .....	85	18	3.5	58.94
Helena .....	194	33	4.5	352.31
Helene Schulerberg .....	130.3	25.4	3.7	107.95
Henry Lourey .....	209.6	35.2	5.3	649.79
Herbert .....	134	27	3	316.26
H. F. Frisbie .....	109.4	32.2	5.8	270.45
H. G. Wright .....	190	62	8	(*)
Hiawatha .....	140.5	30	5.5	240.45
H. M. Hoxie .....	213.2	34.3	5.6	622.30
H. M. Townsend .....	116.7	18	3.1	89.70
Ida Morse .....	51.6	10.8	3.2	10.83
Idlewild .....	207.6	35.6	5.7	520.36
Imperial .....	89.3	19	4.8	68.08
Iron Age .....	176	38	5.5	385.91
Iron Duke .....	177	32.0	6	421.25
Ironsides .....	154	30	6.4	282.80
Jack Frost .....	165	30	5.4	350.77
Jas. B. McPherson .....	(*)	(*)	(*)	(*)
Jay Gould .....	186.8	30.4	6	446.25
Jennie Campbell .....	144	26	4	225.16
Jennie Gilchrist .....	100.5	18.5	3.8	74.48
Jessie B .....	121	21.6	4.3	78.34
Joe Long .....	120	22	4.4	130.22
Joe Peters .....	177.2	34.4	4.8	525.90
John Barrett .....	124.8	31	5.5	187.23
John Bertram .....	180	34	5	390.49
John Gilmore .....	183	34	6	503.09
John L. Ferguson .....	111.0	25.6	8.6	79.81
John M. Abbott .....	92	20	3.6	97.78
John N. Macomb .....	176.9	62	7	(*)
Joliet .....	97	17.4	7.1	102.65
Joliet .....	155.2	28.8	4.8	240.77
Josephine .....	143	28	5	237.51
Jonie .....	101	29.6	5.5	257.74
J. P. Jackson .....	107	22	3.6	58.51
Julia .....	138.6	29.2	4	237.09
Kit Carson .....	(*)	(*)	(*)	(*)
Lady Byron .....	(*)	(*)	(*)	(*)
Libbie Conger .....	168	29.5	4.5	324.09
Lily .....	178	28	4.3	200.00
Little Eagle No. 2 .....	130.7	19.2	3.9	82.65
Lizzie Gardner .....	124.5	21	3.6	70.54
Louis Houck .....	210	37	6	913.27
Mary M. Michael .....	143.3	26.3	4.4	234.34
Mary Morton .....	210	32.5	6	456.96

\* Not known.

1734 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

List of steam-power boats, etc.—Continued.

Name.	Length.	Breadth.	Depth.	Gross tonnage.
	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	
Maude.....	100	20.6	4.5	191.20
Mississippi.....	175	32.5	6	390.14
Musser.....	137	24	4.6	163.63
My Choice.....	183	35	5	402.23
Nellie Speer.....	145.4	27	5	224.10
New Idea.....	125	26	4	140.61
Niagara.....	98	17.6	7.2	99.41
Oakland.....	210	35	6	628.81
Oliver Bierne.....	265	43.6	7	1,017.78
Patrol.....	111.6	26	4	121.63
Philip Sheckel.....	114	20.5	3	108.00
Pittsburgh.....	250	39.2	5.8	722.17
Polar Wave.....	146	25.7	5	150.34
Rambler.....	(*)	(*)	(*)	2.00
Randall.....	92	19	3	34.49
E. A. Speed.....	124	22	4.2	210.13
Reindeer.....	125	23	3.3	219.16
Rescue.....	121	26.8	3.4	139.03
Robert Dodd.....	128.5	25	5.7	128.61
Sam Brown.....	177	39	7.2	474.10
Satellite.....	76.5	15.9	3.9	53.55
S. C. Clubb.....	85	18	6	52.09
Scotia.....	100.5	18.4	3	31.57
S. H. H. Clark.....	210	37.6	6.2	711.67
Sidney.....	221.3	35.5	3.5	617.88
Sidney Dillon.....	175	33.8	5.5	429.58
Spread Eagle.....	224.5	33.8	5.7	629.34
State of Kansas.....	252	52.6	6	1,130.34
St. Paul.....	300	36.3	6.2	833.53
Thistle.....	150	28.5	4.8	193.45
Tom Roes No. 2.....	108	20	5.4	327.02
Verona.....	43.2	11	2	6.13
White Eagle.....	238	29	3.8	312.75
Wm. Stone.....	136.2	26	4.9	174.00

\* Not known.

List of barges and scows that arrived at St. Louis during the year 1891.

Name.	Length.	Breadth.	Depth.	Gross tonnage.
	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	
Abbott, Nos. 7 and 8.....	(*)	(*)	(*)	(*)
Adelaide.....	154.4	28	5	190.24
A. K. Brookbank.....	(*)	(*)	(*)	733.47
Alaska.....	(*)	(*)	(*)	(*)
Allegheny.....	(*)	(*)	(*)	908.60
Anchor Line No. 1.....	107.5	32.6	7.5	634.82
Anchor Line No. 2.....	107.5	32.8	7.5	692.19
Angel.....	(*)	(*)	(*)	(*)
Annie.....	130.6	19.3	5.0	101.64
Annie Spies.....	(*)	(*)	(*)	(*)
Annie T.....	(*)	(*)	(*)	(*)
A. P. Shinkle.....	(*)	(*)	(*)	(*)
Argent.....	(*)	(*)	(*)	(*)
Argentine No. 2.....	(*)	(*)	(*)	58.97
Argentine No. 3.....	(*)	(*)	(*)	(*)
Bayou Sara.....	(*)	(*)	(*)	(*)
Boy Blue.....	200	28.8	8	414.60
Buckeye.....	(*)	(*)	(*)	48.55
Cape Girardeau Transportation Co. (18 in all).....	(*)	(*)	(*)	(*)
Centennial.....	(*)	(*)	(*)	(*)
Chester.....	186.4	34.6	7.1	885.09
Chicago Belle.....	(*)	1*	(*)	(*)
Commerce.....	(*)	(*)	(*)	(*)
Commonwealth.....	(*)	(*)	(*)	(*)
Confidential.....	(*)	(*)	(*)	(*)
Della.....	(*)	(*)	(*)	12.20
Dickey.....	(*)	(*)	(*)	(*)
Dolomite.....	154.4	26.8	5	172.49
Dove.....	(*)	(*)	(*)	685.84
Eagle Sand Company No. 4.....	(*)	(*)	(*)	(*)
Emma Wilson.....	(*)	(*)	(*)	(*)
Enterprise Bath.....	(*)	(*)	(*)	(*)
E. Robinson.....	(*)	(*)	(*)	(*)
Fannie.....	153.4	27.9	6	181.08

\* Not known.



APPENDIX X—REPORT OF MAJOR MILLER.

1735

List of barges and scows, etc.—Continued.

Name.	Length.	Breadth.	Depth.	Gross tonnage.
	Feet.	Feet.	Feet.	
Garry.....	(*)	(*)	(*)	133.74
Geogobio.....	(*)	(*)	(*)	(*)
Gilchrist, Nos. 1 to 3.....	(*)	(*)	(*)	(*)
Grafton.....	(*)	(*)	(*)	(*)
Grand Tower, No 2.....	(*)	(*)	(*)	(*)
Griffith and Adams, Nos. 13, 16, 17, 18.....	(*)	(*)	(*)	(*)
Helena.....	186.4	34.6	7	862.16
Homestead.....	(*)	(*)	(*)	(*)
Illinois.....	228	37	7.3	1,220.91
Irondale.....	(*)	(*)	(*)	700.62
Ironsides No. 4.....	(*)	(*)	(*)	629.46
Jap.....	(*)	(*)	(*)	(*)
J. Barrett & Sons (6 in all).....	(*)	(*)	(*)	(*)
Jennie Flowerree.....	200	28.8	8	414.09
Jessie.....	152.4	27.4	5.4	188.72
Josie.....	152.4	27.6	5.4	197.78
Josie.....	(*)	(*)	(*)	(*)
Josie S.....	(*)	(*)	(*)	(*)
Joy Bros. (15 in all).....	(*)	(*)	(*)	(*)
J. Walton.....	(*)	(*)	(*)	(*)
Kennebec.....	(*)	(*)	(*)	(*)
Kentucky.....	(*)	(*)	(*)	(*)
Keokuk No. 1.....	140.0	20.4	3.5	88.58
Lella.....	154	27.9	5	182.02
Little Dan.....	(*)	(*)	(*)	(*)
Lone Star.....	(*)	(*)	(*)	(*)
Louisa.....	(*)	(*)	(*)	203.33
Lyle & Co (3 in all).....	(*)	(*)	(*)	(*)
Mack.....	(*)	(*)	(*)	(*)
Maggie Monks.....	212.4	28.3	8	443.52
Mamie B.....	(*)	(*)	(*)	(*)
Mamie E.....	(*)	(*)	(*)	204.61
Mandan.....	(*)	(*)	(*)	(*)
Matt No. 1.....	(*)	(*)	(*)	(*)
McCormick No. 8.....	(*)	(*)	(*)	(*)
Metropolis.....	(*)	(*)	(*)	(*)
Milton.....	180.6	38.3	7.2	898.91
M. Michael.....	146	24.2	4.2	118.07
Missouri Sand Company, Nos. 3 and 4.....	(*)	(*)	(*)	(*)
Mose.....	152	26.4	4.6	153.56
Nellie Peck.....	(*)	(*)	(*)	(*)
New St. Louis Sand Company, No. 5.....	(*)	(*)	(*)	(*)
O'Neill & Co. (3 in all).....	(*)	(*)	(*)	(*)
Orient.....	(*)	(*)	(*)	669.04
Ostrich.....	(*)	(*)	(*)	(*)
Pike No. 2.....	171.6	27.2	5.2	188.79
Pingapore.....	(*)	(*)	(*)	21.63
P. King.....	(*)	(*)	(*)	(*)
Rachel.....	189.6	34.8	6.4	639.50
Rachel.....	(*)	(*)	(*)	(*)
Randall No. 1.....	(*)	(*)	(*)	(*)
R. A. Speed, Nos. 2 to 4.....	(*)	(*)	(*)	(*)
R. G. Ferrel.....	(*)	(*)	(*)	(*)
Rover No. 1.....	165	28	6	474.62
Rover No. 2.....	165	28	6	215.74
Rover No. 3.....	137.8	28	5.2	158.22
Rover No. 4.....	138.2	28.2	5.2	156.77
Ruth.....	179.2	34.7	6.6	759.66
Saugamon Eagle.....	(*)	(*)	(*)	(*)
Sitka.....	(*)	(*)	(*)	(*)
Snow.....	(*)	(*)	(*)	(*)
Sunny Side.....	(*)	(*)	(*)	(*)
Swan.....	(*)	(*)	(*)	28.64
St. James.....	152	27	5	194.81
St. Louis and Mississippi River Packet Company, Nos. 1 and 2.....	(*)	(*)	(*)	(*)
St. Louis and Mississippi Valley Transportation Company—	(*)	(*)	(*)	(*)
No. 20.....	201.2	35.6	8	1,011.18
21.....	200.0	36	7.8	1,002.40
22.....	200.6	36	7.8	1,015.91
23.....	200	36	8	986.62
24.....	200.5	35.2	7.3	1,018.84
25.....	201.4	35.6	7.2	1,029.60
26.....	203.5	36	7.6	1,060.70
27.....	200.5	35.6	7.4	1,038.47
29.....	201	35.0	7.6	1,021.19
30.....	225.6	34.8	8	1,126.85
32.....	224.6	34.8	8.2	1,130.69
33.....	227	35	8.8	1,171.99
34.....	225.6	34.8	8	1,135.15

\* Not known.

1736 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

List of barges and scows—Continued.

Name.	Length.	Breadth.	Depth.	Gross tonnage.
St. Louis and Mississippi Valley Transportation Company—				
Continued.				
35.....	<i>Frc't.</i> 225.0	<i>Feet.</i> 34.8	<i>Feet.</i> 8	1,129.63
36.....	225.0	34.8	8.2	1,166.14
37.....	227	35	8.4	1,193.11
38.....	229	36.5	8.3	1,197.31
39.....	230	36.7	8.3	1,201.29
40.....	226	36.6	8	1,110.48
41.....	226	36.4	8.2	1,211.79
42.....	226	36.2	8.2	1,192.14
44.....	225	36	8.2	1,164.18
45.....	210	40.4	8.2	1,287.81
46.....	224	36.4	8	1,181.26
47.....	226	37	8	1,179.72
48.....	226.8	36	8	1,161.10
50.....	210	40	6.0	1,311.66
52.....	228	36	3.2	1,177.15
53.....	223	40.6	6	1,165.81
57.....	225	36	7.6	1,248.54
58.....	225	36.3	7.6	1,248.54
59.....	225	36.3	5.7	1,107.39
60.....	220.4	32	7.7	1,146.31
61.....	220.4	32	7.7	1,154.02
62.....	221.7	34.5	7.5	1,121.53
64.....	220.8	34.6	7.5	1,096.63
65.....	219.6	34.7	7.4	1,096.56
66.....	225	36.3	5.3	1,107.39
67.....	225	36.8	6.2	1,140.05
70.....	226	36	6.8	1,164.15
72.....	227	36.6	6.0	1,171.60
75.....	226.6	36.3	6.7	1,137.10
76.....	226.5	36	6.6	1,123.63
77.....	226	36.6	6.8	1,151.06
78.....	226	36	6.8	1,163.78
79.....	230	36	6.8	1,144.13
80.....	227.7	36.2	6.8	1,118.74
81.....	226.6	36	6.6	1,101.11
82.....	226	36	6.8	1,105.29
83.....	226	36	6.0	1,101.63
84.....	226.4	36	6.7	1,102.45
85.....	225.5	36	6.0	1,127.97
86.....	226	36.6	6.6	1,123.09
87.....	226	36.4	8.2	1,202.23
88.....	229	36.4	8	1,174.62
89.....	227.7	36	7.9	1,079.81
90.....	210.7	35	7.6	998.98
91.....	202.7	36	8	1,154.49
92.....	216.8	37	8.2	1,218.76
93.....	228.4	37	7.3	1,220.91
95.....	227.7	37	7.2	1,220.60
96.....	225.5	36.5	8.1	1,185.64
97.....	238.4	36.4	8.8	1,237.12
98.....	226	36.8	8.2	1,141.80
99.....	228.6	36.6	9	1,274.81
100.....	225	35	5.3	860.31
101.....	225	35	5.3	860.31
102.....	225	36	6.0	835.31
103.....	225	36	6.0	835.31
104.....	227.8	31.2	6	1,007.27
105.....	227.8	31.2	6	1,012.53
106.....				
Tennessee, and Ohio, and Mississippi River Packet Company,				
Nos. 2 to 4.....	(*)	(*)	(*)	(*)
Tom Wells.....	(*)	(*)	(*)	(*)
Transfer No. 1.....	(*)	(*)	(*)	229.57
Ukon.....	(*)	(*)	(*)	(*)
U. S. Engineer Department (16 in all).....	(*)	(*)	(*)	(*)
Vidalia.....	(*)	(*)	(*)	(*)
V. W. Flowerree.....	200	23.8	8	414.69
W. H. Brown's Sons (107 in all).....	(*)	(*)	(*)	(*)
Whitney.....	(*)	(*)	(*)	(*)
W. J. V. B., Nos. 1 and 5.....	(*)	(*)	(*)	(*)
William Gordon.....	227.7	36.6	6.6	1,262.01
Wood.....	(*)	(*)	(*)	128.10
Yantic.....	(*)	(*)	(*)	(*)

\*Not known..

pended for this purpose. The navigation of the river has been very materially improved by this method and the danger to boats lessened.

During the fiscal year ending June 30, 1893, the sum of \$96,497.23 was expended upon this improvement. Two snag boats were employed in removing obstructions to navigation between the mouth of the Missouri River and New Orleans, La. The boats worked a total of fifteen months, removing 2,946 snags, cutting down 8,214 trees, removing 16 drift piles, and traveling a total of 17,982 miles.

The work accomplished by the snag boats has been of great benefit to navigation and commerce. Formerly the wrecking of steamboats from running against snags was of frequent occurrence, but since the snag boats have been regularly at work such wrecks are seldom heard of.

The boats were thoroughly overhauled during the past spring, and necessary repairs were made to them together with some small renewals of machinery.

An annual appropriation for carrying on this work was made by act of August 11, 1888.

The amount expended during fiscal year ending June 30, 1893, was \$96,497.23.

(See Appendix Y 1.)

2. *Mississippi River between Ohio and Missouri rivers.*—The original condition of the navigable channel of this portion of the Mississippi River, before the work of improvement was begun, was such that the natural depth at low water was in many places from  $3\frac{1}{2}$  to 4 feet. The channels were divided by islands which formed sloughs and secondary channels, thus wasting water available for navigation.

The project adopted for improvement consisted in closing sloughs and secondary channels, and also in construction of works of contraction in order to concentrate the flow into a single channel about 2,500 feet wide, the object being to thereby obtain a depth of 8 feet in the channel between St. Louis and Cairo, and 6 feet between St. Louis and the mouth of the Missouri, at standard low water which corresponds to a reading of 4 feet on the St. Louis gauge. Also in revetment of banks when necessary.

The amount expended up to the close of the fiscal year ending June 30, 1892, was \$4,080,803.15, and the result of the work was that but little difficulty to navigation was experienced throughout the improved portion, and then only at extreme low water.

For stages of water above 4 feet on the St. Louis gauge there was generally a depth of at least 6 feet in the channel.

The amount expended during the fiscal year ending June 30, 1893, was \$283,767.17, and was applied to repairing plant and carrying on works at the following-named localities:

*Twin Hollows.*—One hurdle 362 feet long was built and another partly built.

*Pulltight.*—The work consisted in repairing Hurdle No. 4, in extending it 630 feet, and in driving 400 linear feet of drift clumps above the old part of this hurdle to protect it; also in repairing Hurdle No. 5, and restoring it to its original length. Hurdle No. 1 was extended. Hurdle No. 2 was repaired and extended 1,200 feet, and 1,500 linear feet of new work (Hurdle 6) built.

*Chesley Island.*—The bank protection was repaired.

*Rush Tower Reach.*—Operations consisted in the construction of 6,800 linear feet of protection of the Illinois shore above Durfees Land-

ing. About 1,225 feet of bank along Lowrys Field was partially re-  
vetted. Three hundred linear feet of hurdle at Michaels was repaired.  
Construction of hurdles was begun at Fish Bend and 1,815 linear feet  
nearly completed.

*Fort Chartres Reach.*—The work of the year consisted in protection  
of the bank, below medium stage of water, from Sycamore Landing  
downstream for a distance of 5,500 feet, and the building of Hurdles  
2 and 3, having a total length of 3,525 feet, on the west side of Bruce  
Island. These hurdles were considerably damaged upon the breaking  
up of the ice in the latter part of February, and subsequently by heavy  
fields of driftwood. As soon as possible, in March following the  
breakup, the work of repairing these hurdles was undertaken, and was  
continued until about the middle of May when, on account of the high  
stage of water, work on the hurdles was temporarily suspended.

The total amount expended during the fiscal year ending June 30,  
1893, was \$283,767.17.

The original estimated cost of the work, as revised in 1883, is  
\$16,397,500, of which \$5,388,333.33 from appropriations to date has  
been available for the work.

In general the works constructed have benefited the navigation.

July 1, 1892, balance unexpended .....	\$124, 196. 85						
Amount appropriated by act approved July 13, 1892 .....	525, 000. 00						
Amount appropriated by sundry civil act approved March 3, 1893.....	658, 333. 33						
	1, 307, 530. 18						
June 30, 1893, amount expended during fiscal year.....	283, 767. 17						
	1, 023, 763. 01						
July 1, 1893, balance unexpended .....	1, 023, 763. 01						
July 1, 1893, outstanding liabilities .....	\$30, 565. 40						
July 1, 1893, amount covered by uncompleted contracts....	149, 295. 24						
	179, 860. 64						
	843, 902. 37						
<table border="0" style="margin-left: 20px;"> <tr> <td>{ Amount (estimated) required for completion of existing project.....</td> <td>11, 009, 166. 67</td> </tr> <tr> <td>{ Amount that can be profitably expended in fiscal year ending June 30, 1895 .....</td> <td>758, 333. 33</td> </tr> <tr> <td>{ Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.</td> <td></td> </tr> </table>		{ Amount (estimated) required for completion of existing project.....	11, 009, 166. 67	{ Amount that can be profitably expended in fiscal year ending June 30, 1895 .....	758, 333. 33	{ Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	
{ Amount (estimated) required for completion of existing project.....	11, 009, 166. 67						
{ Amount that can be profitably expended in fiscal year ending June 30, 1895 .....	758, 333. 33						
{ Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.							
(See Appendix Y 2.)							

3. *Harbor at St. Louis, Mo.*—St. Louis Harbor is about 18 miles  
long and divided into two nearly equal parts by the Eads Bridge. The  
upper part, included between the bridge and the northern limits of the  
city, is about 10 miles in length. Three miles above the Eads Bridge  
is the Merchants' Bridge. The lower part of the harbor, included be-  
tween Eads Bridge and River Des Peres, is 8 miles long. The channel  
in this part of the harbor has sufficient depth and accessible landings  
at all points. Good depth exists above the Merchants' Bridge,

Congress, by act approved September 19, 1890, appropriated \$182,000  
for this harbor.

The navigable reach between the Eads Bridge and Merchants' Bridge  
was at that time obstructed by a number of middle bars. The project  
adopted for improvement of the harbor under the appropriation of 1890  
consisted in a contraction of the waterway, between those bridges, to  
a width of about 2,000 feet in order to concentrate the flow upon the  
bars and thus cause scour to the depth desired. The contraction works

TABLE NO. 2.—Summary of expenditures for operating United States snag boats H. G. Wright and J. N. Macomb, etc.—Continued.

Expenditures.	1892.	1893.		
	December.	January.	February.	March.
Office expenses .....	\$605.00	\$603.00	\$753.00	\$653.00
Supervision .....			78.16	12.25
Expenses of snag boat H. G. Wright:				
Crew .....	4,365.67		2,212.00	2,465.85
Outfit .....	14.00	207.54	72.62	
Fuel .....	1,206.54	915.12	1,168.00	1,172.00
Subsistence .....	357.44	843.41	503.14	616.88
Supplies .....	9.22	191.93	130.46	8.55
Repairs .....		224.04	51.10	15.00
Miscellaneous .....			2.65	
Expenses of snag boat J. N. Macomb:				
Crew .....	4,286.18		2,142.00	5,407.49
Outfit .....	7.50	717.14		
Fuel .....	1,050.07	1,322.90	1,177.80	1,038.00
Subsistence .....	625.00	240.40	1,027.12	185.27
Supplies .....	61.39	88.37	.25	
Repairs .....	87.94	3.00	12.00	
Miscellaneous .....	2.35			
Store boat Abert .....	100.00		50.00	90.00
<b>Total .....</b>	<b>12,839.21</b>	<b>5,357.75</b>	<b>9,380.30</b>	<b>11,712.20</b>

Expenditures.	1893.			Total.
	April.	May.	June.	
Office expenses .....	\$147.30	\$565.50	\$275.00	\$5,398.35
Supervision .....	24.50	423.45	236.75	1,916.07
Expenses of snag boat H. G. Wright:				
Crew .....		2,821.99	1,367.41	20,849.75
Outfit .....	11.75		1,713.23	2,772.66
Fuel .....	784.37	60.00		8,404.61
Subsistence .....	577.75	185.81	791.24	6,584.73
Supplies .....	105.60	6.80	215.64	1,429.80
Repairs .....	147.55	478.00	726.29	2,131.86
Miscellaneous .....			3.25	54.02
Expenses of snag boat J. N. Macomb:				
Crew .....		2,838.00	1,420.00	23,308.50
Outfit .....	7.05		236.02	5,075.47
Fuel .....	140.25	88.20	17.00	7,643.12
Subsistence .....	656.12	200.06	813.50	6,587.17
Supplies .....	101.73	2.67	197.43	923.89
Repairs .....	265.40	1,031.43	360.66	2,795.90
Miscellaneous .....	2.00			70.83
Store boat Abert .....		35.00		451.00
<b>Total .....</b>	<b>2,971.37</b>	<b>8,736.91</b>	<b>8,408.51</b>	<b>96,497.23</b>

Y 2.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS.

The object of the improvement is to obtain a minimum depth at standard low water of 6 feet from the mouth of the Missouri River to St. Louis, a distance of 16 miles, and of 8 feet at the same stage of water from St. Louis to the mouth of the Ohio River, 191 miles, the natural depth being, in many cases, from 3½ to 4 feet. The channel is divided at a number of points by islands forming sloughs and secondary channels behind them through which a good deal of the volume of flow is diverted to the detriment of navigation.

The initial point of the work for the lower portion is St. Louis, the programme being to make the work continuous, proceeding downstream from that city.

The first work for improvement began in 1872 and was continued for a number of years as appropriations were made, the works consist-

ing of dikes and dams of brush and stone, erected with a view to confining the low-water volume to one channel, and of revetments to hold and preserve the banks where necessary or advisable.

The present project is a continuation of the plan adopted in 1881, and contemplates a reduction of the river to an approximate width of 2,500 feet below St. Louis, the natural width being in many cases from 1 to 1½ miles, and protection of the alluvial banks from erosion. The methods employed are the building up of new banks from the solid matter brought down by the river and which is collected by means of hurdles and revetment of the banks, both new and old, when necessary.

At the beginning of the fiscal year the work for improvement had extended to a distance of about 5 miles below the head of Rush Tower Reach, but the construction at a number of points had been left incomplete as to number and extent of works, in order to observe the effect of the hurdles as built. Considerable damage from floods, ice, and driftwood had been sustained, and some new banks formed by the hurdles required revetment to secure their permanency.

During the fiscal year new work was prosecuted at a number of points, and as far as Turkey Island, 42 miles below St. Louis, and extensions and repairs were also made, all as given below:

#### TWIN HOLLOWES, WEST SIDE, 5 MILES BELOW ST. LOUIS.

Work of constructing additional hurdles began at this point on May 27, last.

One hurdle (No. 5½), 362 feet long, was built, and another (No. 7) was partly built by the close of the year. Please see Pl. No. 2.

#### PULLTIGHT.

This locality is nearly opposite Twin Hollowes. The work of repairing and extending the system began March 27 and continued until April 30, when, on account of extreme high water, it was suspended and force and plant were removed to Rush Tower Reach. Afterward, May 21, the force and plant which had been engaged on the Fort Chartres Reach was brought to Pulltight to complete the work at that point.

The work done at Pulltight consisted in repairing Hurdle No. 4, in extending it 630 feet, and in driving about 400 linear feet of drift clumps above the old part of this hurdle to protect it; also in repairing Hurdle No. 5, and restoring it to its original length; also, in repairing Hurdle No. 2, and extending it 1,200 feet to the original channel limit, and in extension of Hurdle No. 1, and construction of 1,500 linear feet of new work of Hurdle No. 6. Please see Pl. No. 2.

The completion of Hurdles 1 and 6, and curtaining all the hurdles except No. 2, remained at the close of the year to be done.

#### CHESLEY ISLAND, 11 MILES BELOW ST. LOUIS.

The bank protection at this point was repaired. This was done during the first half of the fiscal year. The location is shown on Pl. No. 2.

## RUSH TOWER REACH, 28 MILES BELOW ST. LOUIS.

During the fiscal year, operations consisted in the construction of 6,800 linear feet of bank protection of the Illinois shore from a point near the Osborne field to the lower end of the wooded bank just above Durfee's Landing. This work was begun August 10 and finished November 26. About 1,225 feet of bank along Lowry's field was partially revetted. Three hundred linear feet of Hurdle No. 3, at Michael's were repaired. Construction of Hurdles 3 and 6 was begun at Fish Bend, May 1, and work on them continued to May 31. One thousand four hundred and fifty linear feet of Hurdle 3 were nearly completed and 365 feet of Hurdle 6 partly completed. The location of these works is shown on Pl. No. 3.

## FORT CHARTRES REACH, 35 MILES BELOW ST. LOUIS.

This reach extends from Brickey Mill to the head of Turkey Island. The work projected for its improvement includes protection of the left bank of the river below Sycamore Landing, and construction of a series of hurdles to close the chute west of Bruce Island; also a series of hurdles above the head of Turkey Island.

The work of the year consisted in protection of the bank, below medium stage of water, from Sycamore Landing, downstream, for a distance of 5,500 feet, and the building of Hurdles 2 and 3, having a total length of 3,525 feet, on the west side of Bruce Island. These hurdles were considerably damaged upon the breaking up of the ice in the latter part of February, and subsequently by heavy fields of driftwood.

As soon as possible, in March, following the break-up, the work of repairing these hurdles was undertaken, and was continued until about the middle of May, when, on account of the high stage of water, work on the hurdles was temporarily suspended.

The location of the work is shown on Pl. No. 4.

All the above work was done by hired labor.

## PROCURING MATERIALS.

The brush was procured by hired labor.

Of the stone, 8,670.10 cubic yards were purchased upon bids in open market, and 20,584.13 cubic yards were quarried by hired labor.

Piles were procured partly by contract and partly by purchase in open market.

Rope, bolts, wire, spikes, nails, etc., were purchased by contract when large quantities were needed; otherwise, in open market.

At the beginning of the fiscal year the available plant was insufficient for carrying on the work under the appropriation made by the river and harbor act of July 13, 1892, and large additions were provided for by contracts entered into last fall. These contracts provided for construction and delivery of 1 towboat, 2 steam tenders, 13 model barges, 6 quarter boats, 21 pile-driver hulls and cabins (8 for new drivers and 13 to replace those worn out), 103 flats, and 60 skiffs. All of this plant excepting the towboat were to have been delivered on or before May 1. The towboat was to have been delivered June 1. But owing to various causes the delivery, that of the skiffs excepted, has not yet been completed.

2150 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Proposals were also invited for construction of three office and survey boats.

Please see abstracts of proposals, hereto appended.

Parts of new plant not provided for by contract were prepared and minor repairs made by hired labor and purchase of material in open market.

In order to better prosecute work under the appropriation of \$658,333.33, made by the act of March 3, 1893, proposals to be opened July 17, 1893, have been invited for construction and delivery of additional plant.

PLATES.

Plate 1 is a general map of the river from Bissells Point to Kaskaskia Island. Plate No. 2 shows the river from Carrolls Island to Chesley Island. Plate No. 3, from Oalico Island to Penitentiary Point; and Plate 4, from Brickey Mill to White Sand Depot.

SUPPLY DEPOT.

All supplies, excepting stone, brush, and piles, and some minor items, were delivered at the depot at the foot of Arsenal street, St. Louis. In addition the depot is a general repair shop and yard, where repairs to plant not requiring dockage were made.

VALUE OF PROPERTY.

The present value of the property belonging to this work is shown in the following table:

Class of property.	Value July 1, 1892.	Purchases, additions, and repairs.	Expenses and deterioration charged to works of improvement.	Value June 30, 1893.
Steamer General Gilmore.....	\$12,727.04	\$21,647.84	\$23,503.80	\$10,871.98
Steam launches.....	5,466.02	688.65	1,572.00	4,582.37
Steam tenders.....		10,060.38		10,060.38
Barges, model.....	78,299.35	25,051.38	26,066.22	76,684.51
Barges, with quarters.....	13,716.81	8,105.75	4,355.75	17,166.81
Quarter boats.....		1,733.33		1,733.33
Pile-drivers.....	32,893.68	13,006.73	14,966.80	51,533.55
Machine shop.....	2,390.51	34.25	490.16	1,943.00
Derrick boat.....		1,500.00		1,500.00
Small boats.....	9,603.97	13,593.44	10,087.42	12,269.99
Portable quarters.....	6,154.65	3,224.24	2,327.71	7,051.18
Tents.....	190.75			190.75
Supply depot.....	3,441.00	965.65	1,301.15	3,105.50
Tools and appliances.....	3,032.56	6,756.99	3,054.76	6,734.79
Boarding outfit.....	9,314.31	5,513.55	2,930.90	11,896.96
Office furniture.....	385.63	143.20	77.56	451.27
Survey instruments.....	613.70	81.75	61.37	634.08
Photographic apparatus.....	230.16	50.00	23.02	257.14
Total.....	178,530.64	112,757.13	92,619.58	108,668.19

GAUGES.

The eight gauges established during the fiscal year ending June 30, 1892, between Jefferson Barracks and Jones Point, were read daily. These gauges were established with a view of determining, from their



readings, whether any change in slope of the water surface results from the works of improvement.

#### DETAILS OF THE WORK.

For full details of the work done, reference is made to the reports, herewith, of Mr. D. M. Currie, principal assistant engineer, and Messrs. W. S. Mitchell, John O. Holman, and Gerald Bagnall, assistant engineers.

The operations at the supply depot are given in full in the report, herewith, of Mr. C. D. Lamb, superintendent.

#### CONDITION OF THE RIVER.

A statement of channel depths, as furnished by the Mississippi and Ohio Rivers Pilots' Society, is herewith.

The river was closed to navigation by ice from December 21, 1892, to February 19, 1893. The stage of water was lowest in November, when 1 foot above standard low water was reached. During the period of lowest water a channel depth of 4 feet was found at two crossings in portions of the river where the works for improvement had not been entirely completed.

There were two high-water seasons. The first in July, when the river reached a height of  $31\frac{1}{10}$  feet above extreme low water, and the other in May, when it reached a height of about  $31\frac{1}{2}$  feet above the same stage.

The river has not yet subsided sufficiently to show the effect of the recent high water, but it is probable that large deposits have been made behind the hurdles, and that a much improved channel will result during the coming low-water season wherever works have been constructed.

In general, the works for improvement have benefited navigation. They extend for a distance of 45 miles below the southerly limit of St. Louis, from which point the distances to the several localities and reaches reported upon are given.

#### STATISTICS.

Tables of statistics of the commerce of the river are hereto appended. These, as well as the statistics for other works of improvement, were compiled by Mr. Elliott Jones, chief clerk.

#### ESTIMATE.

The amount that can be profitably expended during the year ending June 30, 1895, is \$758,333.33, which is the sum estimated in the last Annual Report for the fiscal year ending June 30, 1894. It is proposed to expend this sum in carrying out the programme heretofore adopted; that is, to carry on the work of improvement continuously from St. Louis downstream, reclaiming land by building up new banks, thus reducing the river to an approximate width of 2,500 feet, alluvial banks to be protected from erosion. It is proposed to obtain by this means a channel of at least 8 feet at low water. The depth is now liable to become as small as 4 feet or even less in some places, and less at every locality where the width is more than 2,500 feet.

2152 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

This general statement of the proposed application of the appropriation is as specific as the nature of the case admits. The changeable character of the river renders it impracticable to give in advance the exact locality where works will be required.

The original estimated cost of this improvement of the river between the mouth of the Ohio and the mouth of the Missouri River, as revised in 1883, is \$16,397,500.

The aggregate amount from appropriations available for this work, to June 30, 1893, is \$5,388,333.33.

Amount expended to June 30, 1892, is \$4,080,803.15. Amount expended during fiscal year ending June 30, 1893, is \$283,767.17.

The balance available will be expended in prosecuting work according to the programme.

The appropriations made for this work are as follows:

By act of—		By act of—	
June 10, 1872.....	\$100,000.00	August 2, 1882.....	\$600,000.00
March 3, 1873.....	200,000.00	July 5, 1884.....	520,000.00
June 23, 1874.....	200,000.00	August 5, 1886.....	375,000.00
March 3, 1875.....	200,000.00	August 11, 1888.....	300,000.00
August 14, 1876.....	200,000.00	September 19, 1890....	400,000.00
June 18, 1878.....	240,000.00	July 13, 1892.....	525,000.00
March 3, 1879.....	200,000.00	March 3, 1893.....	658,333.33
June 14, 1880.....	250,000.00		
March 3, 1881.....	600,000.00	Total .....	5,568,333.33

Of these amounts, \$180,000 was allotted by acts and projects for improvement between the Illinois and Missouri rivers, including Alton Harbor, leaving amount applicable for general improvement between the mouth of the Ohio and Missouri rivers, \$5,388,333.33.

*Money statement.*

July 1, 1892, balance unexpended.....	\$124,196.85
Amount appropriated by act approved July 13, 1892 .....	525,000.00
Amount appropriated by sundry civil act approved March 3, 1893....	658,333.33
	<hr/>
June 30, 1893, amount expended during fiscal year .....	1,307,530.18
	<hr/>
July 1, 1893, balance unexpended .....	1,023,763.01
July 1, 1893, outstanding liabilities.....	\$30,565.40
July 1, 1893, amount covered by uncompleted contracts..	149,295.24
	<hr/>
	179,860.64
	<hr/>
July 1, 1893, balance available .....	843,902.37
	<hr/>
{ Amount (estimated) required for completion of existing project....	11,009,166.67
{ Amount that can be profitably expended in fiscal year ending June 30, 1895.....	758,333.33
{ Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

Abstract of proposals received for furnishing piles, manila and steel rope, wire, nails, spikes, and screw bolts, opened October 10, 1892, by Maj. A. M. Miller, Corps of Engineers, U. S. Army, St. Louis, Mo.

Balance available..... \$500,000.00  
 Total estimated amount, according to awards..... 25,027.45

No. of proposal.	Piles.....	500	1,800	3,100	1,800	1,000	800	Amount.
		25 to 30 feet long, 14,000 feet—price per foot.	31 to 35 feet long, 60,300 feet—price per foot.	36 to 40 feet long, 80,850 feet—price per foot.	41 to 45 feet long, 78,300 feet—price per foot.	46 to 50 feet long, 48,500 feet—price per foot.	51 to 60 feet long, 44,000 feet—price per foot.	
1	Whitney Gilbreath, Ava, Ill.....	Cents. 6	Cents. 6½	Cents. 7	Cents. 7½	Cents. 8	Cents. 8½	\$23,970.50
2	John Cleary, Chester, Ill.....	5	6	6½	7	7½	7½	72,051.75
3	William G. Allison and Sebastian Oliver, Chester, Ill.....	6	6½	7	7½	8	8½	23,970.50
4	John W. Reno, New Madrid, Mo....	6	6	6	5½	5½	5½	19,064.00

No. of proposal.	Name and address of bidder.	Manila rope (30,000 pounds.)		Sisal rope (8,000 pounds.)		Wire (20,000 pounds.)		Nails (20,000 pounds.)	
		Price per pound.	Amount.	Price per pound.	Amount.	Price per pound.	Amount.	Price per pound.	Amount.
5	S. C. Forsaith Machine Co., Manchester, N. H.	Cents. 12.65	\$3,795.00	Cents. 8.95	\$716.00	Cents. 4.85	\$970.00		
6	Thos. S. Maxwell, St. Louis, Mo.....	11.19	3,307.00	{8.12} {7.63}	620.20				
7	Anchor Line Store, St. Louis, Mo.....	11.75	3,525.00						
8	James Ward & Son, St. Louis, Mo.....	12.10	3,630.00	Cents. 8.09	695.20				
9	James J. Hawk, St. Louis, Mo.....	11.14	3,342.00	Cents. 7.74	619.20	Cents. 2.55	510.00		
11	M. M. Buck & Co., St. Louis, Mo.....	18.00	3,900.00	Cents. 10.00	800.00	Cents. 3.25	650.00	Cents. 2.19	\$438.00
13	St. Louis Wire Mill Co., St. Louis, Mo.....					Cents. 2.50	500.00		

\* For ½-inch rope. † For ¼-inch and ⅜-inch rope.

No. of proposal.	Names and address of bidder.	Spikes (17,500 pounds.)		Screw bolts (5").		Remarks.
		Price per pound.	Amount.	Price per pound.	Amount.	
2	John Cleary, Chester, Ill.....	Cents.		Cents.		Slight informality in proposal.
3	William G. Allison and Sebastian Oliver, Chester, Ill.....					Do.
4	John W. Reno, New Madrid, Mo.....					Do.
5	S. C. Forsaith Machine Co., Manchester, N. H.					Do.
6	Thos. S. Maxwell, St. Louis, Mo.....					Do.
7	Anchor Line Store, St. Louis, Mo.....	2.73	\$477.75			Do.
10	Fred. Meyer, St. Louis, Mo.....			2.50	\$637.50	Do.
11	M. M. Buck & Co., St. Louis, Mo.....	3.30	577.50	2.88	734.40	Do.
12	James B. Dunkerely, St. Louis, Mo.....			2.80	566.60	Do.

No. 2.—Guarantee not signed.

Nos. 3, 5, 7, and 12.—One witness to guarantee.

No. 4.—Erasure and change in price to 5½ cents, fourth item of piles; made and explained before opening.

No. 6.—Erasure and change in prices of sisal rope; made and explained before opening.

No. 10.—Guarantee not signed in proper place; no witness to guarantee; no jurisdiction of grantors.

**2154 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.**

*Abstract of proposals received for furnishing 1 towboat, 2 steam tenders, 6 quarter boats, 13 barges, 21 pile-driver hulls and cabins, 103 flats, and 60 skiffs, opened November 7, 1892, by Maj. A. M. Miller, Corps of Engineers, U. S. Army, St. Louis, Mo.*

Balance available..... \$450,000.00  
 Amount according to awards..... 171,481.50

Number of proposal.	Name and address of bidder.	One tow-boat.	Two steam tenders.		Six quarter boats.		
		Price.	Price for each.	Amount.	Number proposed to furnish.	Price for each.	Amount.
5	Ed. J. Howard, Jeffersonville, Ind.	\$21,750.00	\$8,945.00	\$17,890.00	3	\$8,575.00	\$19,725.00
9	Sam'l W. Coffin & Son, Cincinnati, Ohio	22,264.00	9,747.00	19,494.00	6	5,200.00	31,200.00
10	The Frisbie Engine and Machine Co., Cincinnati, Ohio	22,078.00	10,168.00	20,336.00	6	5,800.00	34,800.00
11	M. A. Sweeney Co., Jeffersonville, Ind.	21,450.00	4,980.00	9,960.00	6	8,975.00	53,850.00
13	Luther M. Emerson, St. Louis, Mo.						

Number of proposal.	Name and address of bidder.	Thirteen barges.			Twenty-one pile driver hulls, etc.		
		Number proposed to furnish.	Price for each.	Amount.	Number proposed to furnish.	Price for each.	Amount.
1	S. M. Fleisher, Levanna, Ohio	6	\$4,375.00	\$26,250.00			
5	Ed. J. Howard, Jeffersonville, Ind.	4	4,150.00	16,600.00	10	\$2,545.00	\$25,450.00
8	Clements Bros., Paducah, Ky.	6	3,700.00	22,200.00	10	2,400.00	24,000.00
9	Sam'l W. Coffin & Son, Cincinnati, Ohio	13	3,847.00	50,011.00	21	1,494.00	31,374.00
11	M. A. Sweeney Co., Jeffersonville, Ind.				21	1,640.00	34,440.00
12	Louis H. Skinner, Wilmington, N. C.				21	1,561.61	32,793.81
13	Luther M. Emerson, St. Louis, Mo.				6	3,000.00	18,000.00

Number of proposal.	Name and address of bidder.	Fifty-three large size decked flats.			Forty small size decked flats.		
		Number proposed to furnish.	Price for each.	Amount.	Number proposed to furnish.	Price for each.	Amount.
2	Thomas G. Isherwood, Davenport, Iowa				40	\$130.00	\$5,200.00
3	L. Cramer & Son, Parkersburg, W. Va.	53	\$385.00	\$20,405.00	40	282.00	11,280.00
4	David S. Barmore, Madison, Ind.	53	674.26	35,735.78			
9	Sam'l W. Coffin & Son, Cincinnati, Ohio	53	415.00	21,995.00	40	213.00	8,520.00
11	M. A. Sweeney Co., Jeffersonville, Ind.	53	496.00	26,288.00	40	346.00	13,840.00
12	Louis H. Skinner, Wilmington, N. C.	53	336.50	17,834.50	40	189.75	7,590.00

Abstract of proposals received for furnishing 1 towboat, 2 steam tenders, 6 quarter boats, 13 barges, 21 pile-driver hulls and cabins, 103 flats, and 60 skiffs, etc.—Continued.

Number of proposal.	Name and address of bidder.	Ten open flats.		Sixty skiffs.			
		Number proposed to furnish.	Price for each.	Amount.	Number proposed to furnish.	Price for each.	Amount.
2	Thomas G. Isherwood, Davenport, Iowa	10	\$95.00	\$950.00			
8	L. Cramer & Son, Parkersburg, W. Va.	10	240.00	2,400.00			
6	T. H. Truscott & Sons, St. Joseph, Mich.				60	\$28.40	\$1,704.00
7	James P. Simms, St. Louis, Mo.				6	85.00	1,122.00
					24	38.00	
9	Sam'l W. Coffin & Son, Cincinnati, Ohio	10	124.00	1,240.00	60	39.00	2,340.00
11	M. A. Sweeney Co., Jeffersonville, Ind.	10	296.00	2,960.00			
12	Louis H. Skinner, Wilmington, N. C.	10	129.59	1,295.90			

No. 2.—Rejected account of substitution of different kind of material from that required.  
 No. 7.—No guaranty to proposal.

AWARDS.

Proposal No. 6.—T. H. Truscott & Sons:	
60 skiffs, at \$28.40 each.....	\$1,704.00
Proposal No. 8.—Clements Bros:	
6 barges, at \$3,700 each.....	22,200.00
Proposal No. 9.—S. W. Coffin & Son:	
6 quarter boats, at \$5,200 each.....	31,200.00
7 barges, at \$3,847 each.....	26,929.00
21 pile-drivers, at \$1,494 each.....	31,374.00
10 open flats, at \$124 each.....	1,240.00
Proposal No. 11.—M. A. Sweeney Co.:	
1 tow boat, at.....	21,450.00
2 steam tenders, at \$4,980 each.....	9,960.00
Proposal No. 12.—Louis H. Skinner:	
53 large decked flats, at \$336.50 each.....	17,834.50
40 small decked flats, at \$189.75 each.....	7,590.00

Abstract of proposals for three office and survey boats, received in response to advertisement dated April 11, 1893, and opened May 11, 1893, by Maj. Charles J. Allen, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	Price.	Amount.
1	Thomas P. Morse, South St. Louis, Mo.....	\$6,048.70	\$18,146.10
2	Louis H. Skinner, Wilmington, N. C.....	4,800.30	14,670.90
3	Diamond Jo Line Steamers, Dubuque, Iowa.....	4,400.00	13,200.00
4	Ed. J. Howard, Jeffersonville, Ind.....	5,000.00	15,000.00
5	David S. Barmore, Madison, Ind.....	4,920.00	14,760.00
6	Weigel Brothers & Co., Elizabeth, Pa.....	4,950.00	14,850.00

Available \$256,254.40, from appropriation of July 13, 1892.  
 No. 3, lowest; acceptance recommended.

## 2156 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

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

ST. LOUIS, MO., June 30, 1893.

MAJOR: I have the honor respectfully to submit the following report upon the improvement of the Mississippi River between the Ohio and the Missouri rivers, for the fiscal year ending June 30, 1893, including as part of it the accompanying reports of assistants in local charge:

Work was prosecuted at Twin Hollows, Pulltight, Chesley Island, and on both sides of the river at Rush Tower and at Fort Chartres, in accordance with the general plan of improvement adopted to secure a minimum depth of 8 feet at standard low water by reducing the average width to 2,500 feet, and protecting the banks to maintain that width permanently, beginning at St. Louis and extending continuously downstream.

At the beginning of this fiscal year the improvement had been extended to Rush Tower, but the work at several points had been left unfinished to await developments, considerable damage from floods, ice, and driftwood had been sustained, and new banks formed by the works needed protection to secure their permanency. All of these required further work to complete the improvement, but only that portion of it necessary to repair damages sustained as stated can be considered as duplication of the work. The additions and extensions found necessary after sufficient time had been allowed for developments, were contemplated in the several projects of improvement. The works prosecuted during this year at Twin Hollows, Pulltight, and Chesley Island were partly in repairs and partly in extensions and additions necessary to complete original projects. At Rush Tower, that on the west side was in repairs, while that on the east side at this locality and on both sides at Fort Chartres, were in extension of the improvement downstream.

The condition of the works constructed since the adoption of the plan of improvement to obtain the desired results by means of permeable system of hurdles to build up new banks in wide reaches and the protection of the banks to secure the permanency of the results in connection with this year's operations, shows the advance made in the prosecution of the improvement beginning at the head of Arsenal Island and proceeding in their regular order downstream.

*Arsenal Island and Cahokia Chute.*—Cahokia Chute was closed first by a stone dam built to the stage of 2 feet above standard low water prior to the adoption of the permeable system, and afterwards by hurdles to the stage of 16 feet above same plane. At higher stages a small stream of water still finds an outlet through the chute.

In connection with the closing of the chute, the west face of the island was protected to the top of the bank near its head, but on the lower part only to the medium stage, or about 15 feet above low water. This medium-stage protection has been damaged by the erosion of the bank during higher stages of several years, but chiefly during the long flood stage of 1892.

No work was done at this locality during the fiscal year just closed.

*Horsetail Bar.*—In this reach, extending from the River Des Peres to the head of Carrolls Island, nothing has been done since 1884, when all of the work was completed with exception of the protection of the new banks. On the east side several depressions in bars give outlets to small streams of water during high stages and some erosion has occurred on the lower end of the reach. On the west side the protection needs extension to the lower end of the new bank.

*Head of Carrolls Island to Jim Smith's.*—(Divided for purposes of administration into Carroll Island, Twin Hollows east and west, Pulltight, and Beards Island.)

The work in this reach was begun during the fiscal year 1881-'82 upon a project which included a series of works on the west side extending down to the foot of Fine's Bluff, the protection of the bank on the east side from the foot of Carrolls Island to Pulltight landing, afterwards known as Pulltight, and a series of hurdles from that point to include one behind Beards Island followed down stream by the protection of the west bank of Beards Island. During that and succeeding years to include the fiscal year ending June 30, 1884, the bank protection and hurdles on the east side were completed and the series of hurdles on the west side was extended down to include No. 5, as shown on plate No. 2, when on account of a persistent effort of the channel to make a crossing to the west bank at a point near the mouth of White House Creek, the project was revised in 1888, and the Pulltight hurdles, Nos. 1, 2, and 4, were extended and No. 5 was built, when work was again suspended to await developments. During low-water seasons the depth has been very small in the channel crossing to the west bank near White House Creek, while hurdles No. 1, 2, 4, and 5, Pulltight, were seriously damaged by ice, driftwood, and floods, and further work was projected during this fiscal year having for its object the reduction of the reach from the head of Carrolls Island to Jim Smith's to an average width of 2,500 feet to secure a minimum depth of not less than 8 feet at standard low water. This included hurdles on the west side of

Carrolla Island, the protection of new bank, repairs to hurdles No. 9 to 8, inclusive, and the construction of additional hurdles at Twin Hollows, and the repairs and extension of hurdles No. 1 to 5, inclusive, and the construction of No. 6 at Pulltight (for the location and extent of all these reference is made to plate No. 9).

For administration, the work done during the year has been divided into two sections, known as Twin Hollows and Pulltight.

During last low water season, the depth at Twin Hollows was only 8 feet, and at Pulltight 14 feet, and was less than found on any other bars within the reach from St. Louis to Brickey Mill, which had been partly improved.

*Twin Hollows.*—Continued high water during the spring of this year added to the insufficiency of available plant and the urgency of other work delayed the beginning of work at this locality until the last half of May. New hurdles, Nos. 6, 6, and 7 were built as shown on plate No. 2, and the work was progressing under favorable conditions of weather, stage of river, and increased plant at the close of the fiscal year.

For quantities of work done, and further details, reference is made to the accompanying part of Mr. Gerald Bagnall, Assistant Engineer, in local charge.

*Pulltight.* At this locality work was begun at the opening of the spring season, was prosecuted until the end of April, suspended on account of excessive difficulties in constructing in the great depths and swift currents consequent upon the high stage of river resumed about the middle of May, and continued to the close of the year at a rate of progress which increased with the improved conditions of weather, stages of river, and facilities for its prosecution. Hurdles Nos. 1, 2, 4, and 5, were repaired and extended, and No. 3 was in process of construction as shown on plate No. 2.

Reference is made for details and quantities of work to the accompanying report of Mr. W. S. Mitchell, Assistant Engineer, in local charge.

*Chesley Island.* The bank protection placed below medium stage of river on the east side of Chesley Island during the fiscal years 1882 '83, and 1883 '84 was considerably damaged by erosion above it, the hurdle closing Meramec River was also damaged during the long flood stage which prevailed from about the first of May to the middle of July. This protection was repaired during the fiscal year just closed and upon a part of the Island the protection was extended to the top of the bank. The work was done during the first half of the fiscal year, under the supervision of Mr. C. D. Lamb, Assistant Engineer, to whose report reference is made for further details. Its location is shown on plate No. 2.

*Jim Smith's.* This work was begun in 1882, and prosecuted through to 1886, in accordance with the plans adopted in the original project, which contemplated a series of hurdles on each side of the river to reduce its width to 2,500 feet, but before that portion on the west side could be built the channel changed and crossed to the west bank, below the foot of Chesley Island, instead of to Waters Point, and upon a revised project hurdles on the east side were extended to reduce the river to the average width of 2,500 feet.

At high stages a small channel remains open through the hurdles, near their eastern ends.

A short section of the bank between hurdles Nos. 0 and 1, has been protected.

No work was done during the fiscal year.

*Sulphur Springs.* The work in this locality was begun in 1886-1887 and a series of hurdles was built extending from the foot of Jim Smith's to the head of Fosters Island. Some of the hurdles have been seriously damaged by ice, driftwood, and floods, and several small streams remain open through them at high stages.

No work has been done during this fiscal year.

*Fosters Island.* The protection to the medium stage of the west bank of Fosters Island was placed during the years 1882 to 1884 and has been damaged by the erosion of the bank above during the flood stages, notably during that of 1892.

No work was done during this fiscal year.

*Lucas.* The construction of hurdles in this reach, which extends from the foot of Fosters Island to the head of Calico Island, was begun in 1888 and continued to the close of the fiscal year ending June 30, 1890. Hurdles were built as shown on plate No. 1, and the construction of others was deferred to await developments. The upper one has been seriously damaged by ice, driftwood, and floods; others have sustained some injuries.

No work was done during this fiscal year.

*Rush Tower.* In this reach, which extends from the head of Calico Island to Brickey Mill, are included several detached works, the protection of the west side of Calico Island, hurdles on the east side near James' Landing, hurdles on the west side below Kennel's Castle, bank protection from Osborne Field to Durfee's Landing, and hurdles below Durfee's, upon all of which works have been prosecuted under the projects for the expenditures of appropriations approved September 19, 1890, and July 13, 1892, and other works were indicated in outline in the chute cut-

## 2158 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

ting off Fish Bend when developments shall have reached a stage which will give an average width of 2,500 feet to the channel through the chute.

During this fiscal year works were prosecuted for repairs of Hurdle No. 3, on the west side, below Kennet's Castle. The protection of the bank below medium stages between Osborne Field and Durfee's Landing, and on the construction of hurdles Nos. 3 and 6, of the series projected below Durfee's.

For location of these works, reference is made to plate No. 3, and for quantities of work done and further details to the accompanying report of Mr. John O. Holman, assistant engineer, in local charge.

*Fort Chartres.*—This reach, extending from Brickey Mill to the head of Turkey Island, includes the protection of bank below Sycamore Landing and a series of hurdles to close the chute west of Bruce Island, upon which work was done under the project for the expenditure of the appropriation approved July 13, 1892. A series of hurdles was also indicated in the same project above the head of Turkey Island, upon which work has been deferred until funds become available from future appropriations.

The work of this fiscal year placed a protection upon the bank below medium stages of river from Sycamore landing to a distance of 5,500 feet downstream, built hurdles Nos. 2 and 3 on the west side of Bruce Island and partly repaired the same after they were considerably damaged by ice upon the breaking up of the gorges formed during the winter and subsequently by heavy fields of driftwood which accumulated and were carried over them by the high water of March and April. On account of excessive difficulties encountered there during the high stages of river work was suspended on these hurdles about the middle of May.

The location of these works is shown on plate No. 4, and further details in the accompanying report of Mr. W. S. Mitchell, assistant engineer, in local charge.

### PROCURING MATERIAL.

*Brush.*—The necessary quantity of brush was procured by hired labor and the payment of royalty.

The accompanying report of Mr. C. D. Lamb shows details.

*Stone.*—Of the necessary quantity of stone, 8,670.10 cubic yards were purchased upon bids in open market, and the remainder, 20,584.15 cubic yards, were procured by hired labor and the payment of royalty.

Reference is made to the report of Mr. W. S. Mitchell, assistant engineer, for details relating to the stone procured by hired labor.

*Piles.*—Were procured by contract and by purchase in open market. Other material, including rope, wire, spikes, nails, and bolts, were procured by contract and by purchase upon bids in open market.

*Plant.*—At the beginning of the year the available plant was not sufficient for the expenditure of the appropriation made by the river and harbor bill approved July 13, 1892, and large additions were provided for by contracts, in which were included a towboat, 2 steam tenders, 13 model barges, 6 quarter boats, 21 pile-driver hulls and cabins (8 for new drivers and 13 for repairs), 3 office and survey boats, 103 flats, and 60 skiffs, but for several causes the delivery has not been completed.

Parts of the new plant, now provided for by contract, were prepared, and minor repairs to available plant were made by hired labor and the purchase of material in open market.

Very respectfully, your obedient servant,

D. M. CURRIE,  
*Assistant Engineer.*

Maj. CHAS. J. ALLEN,  
*Corps of Engineers, U. S. A.*

### REPORT OF MR. GERALD BAGNALL, ASSISTANT ENGINEER.

#### *On work at Twin Hollows.*

TWIN HOLLOWS, WEST, June 30, 1893.

MAJOR: I have the honor to make the following report of operations at Twin Hollows, west side, for the fiscal year ending June 30, 1893.

Work was commenced on Hurdle No. 5 $\frac{1}{2}$  on May 27 and continued until June 30. This line crosses the chute between the Missouri shore and Twin Hollow tow-head, and has a width of 362 feet. The hurdle consists of a row of clumps of piles, 12 feet apart, driven through a foundation mattress 85 feet wide; each clump is composed



of 4 piles, driven 6 feet apart, and drawn together and bolted at the heads with 1-inch bolts. Above the hurdle line, at a distance of about 100 feet, a row of anchor clumps was driven, to which the mattress was attached while being sunk. Shore mats were constructed in place on both shore ends of hurdle, and small extra mats were sunk, where necessary, to prevent scour. A large quantity of drift came down the chute during the progress of the work and made it necessary to sink the foundation mattress in three sections, but the greater portion of it lodged above the anchor clumps and remained there until the completion of the hurdle, when it was pulled down as needed and sunk in layers, one on top of the other, forming a loose dam, each layer overlapping the one below it on the upstream side.

On June 23 hurdle line No. 7 was commenced and continued until June 30, the method of construction being practically the same as that followed in the case of Hurdle No. 5½.

The extent and location of work done is shown on the accompanying tracing.

Table of work done.

	Hurdle line.		
	No. 5½.	No. 6.	No. 7.
Piles driven.....number..	148	19	129
Foundation mattress constructed.....square feet..	58,424	.....	53,875
Shore mattress constructed.....do.....	6,000	.....	6,800
Drift mattress constructed.....do.....	51,690	.....	.....
Bank revetted.....do.....	1,000	.....	.....
Bank graded.....cubic yards..	500	.....	.....

Very respectfully, your obedient servant,

GERALD BAGNALL,  
*Assistant Engineer.*

Maj. CHAS. J. ALLEN,  
*Corps of Engineers, U. S. A.*

REPORT OF MR. WILLIAM S. MITCHELL, ASSISTANT ENGINEER, ON WORK AT PULLTIGHT, ILL.

St. Louis, Mo., June 30, 1893.

MAJOR: I have the honor to submit the following report upon the progress of the works at Pulltight, Ill., during the fiscal year ending June 30, 1893.

There was no work done during the fall, but late in March a force was organized by Mr. Holman for the repair of the hurdles and their restoration to the east channel limit in this reach.

The party arrived March 27 and was engaged until April 30, when, on account of extreme high water, work here was suspended and the force and plant were removed to Rush Tower, Ill. Afterwards, May 21, the force which had been engaged at Fort Chartres works was brought to Pulltight to complete the project for this locality.

Work was begun March 27 on hurdle No. 4, which was repaired and restored for 630 feet with both foundation mattress and piling, restoring it to its full length. In addition, about 400 linear feet of drift clumps were driven above the old work to protect it.

At the end of April three small breaks, each about 100 feet in length, were made in the line by drift and scour. They were not closed, because of the high water, until the latter part of May, when the line received the few repairs needed.

Hurdle No. 5 was repaired and restored to its former length in April, the work done being about 1,700 feet in length, and included a new foundation mattress 65 feet in width, extending 15 feet above the piling and 50 feet below it.

After the passage of the high water the few necessary repairs were made to the piling across the slough next Beards Island.

In May and June hurdle No. 2 was repaired and restored for 1,200 feet to the channel limit on a line running upstream from the old hurdle and at right angles to that limit. The foundation mattress was 100 feet in width, woven continuously and sunk from anchor piles 100 feet above it. The mattress was held in place during fabrication and sinking by three-quarter-inch wire anchor cables made fast to the piling at the river bottom.

2160 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

The anchor piles were spaced about 25 feet apart and the cables were released as rapidly as the mattress was sunk, and were used again. After sinking the mattress the piling for the hurdle was driven through its center in 4 pile clumps spaced 10 feet apart and drawn together at the tops by 16-strand wire cables.

The line was completed, including wattling or screening with brush curtains, which were brought to the level of the 20-foot and 10-foot stages on the old and new work, respectively.

Until the latter part of June the water was too deep to undertake the restoration of hurdle No. 1, and the old piling was so nearly submerged that repairs could not be made, but by that time the river had fallen to a 22-foot stage and the work was begun, the force and plant used being moved to this hurdle as rapidly as it was released from No. 2.

The line of the extension is 900 feet in length and parallel to that in No. 2, at right angles with the channel.

At the close of the year 700 linear feet of this new work and the repairs to the old piling were completed.

In character the new work is similar to that described as done on hurdle No. 2.

About the middle of June hurdle No. 6 was begun 3,700 feet below No. 5. It is 1,500 feet in length, and except at the outer end is in shoal water. It is intended to close the small slough next the island and to fix in direction the channel past the upper hurdles. For 850 feet it consists of a single row of piles driven through a mattress 65 feet wide 15 feet from its upper edge. From that point the mattress is in deep water and is 100 feet wide; 100 linear feet have been fabricated, and the piling which is to be driven along its center line has been begun.

Between the piling and the timber line the island bank has been protected with a mattress and stone revetment.

The completion of lines Nos. 1 and 6 and curtaining all the hurdles except No. 2 remain to be done at the close of the year.

The accompanying chart shows the location of the work done, the condition of the hurdles, and the depths found throughout the reach. The tables show the service of plant and the amounts of material expended.

Very respectfully, your obedient servant,

WM. S. MITCHELL,  
*Assistant Engineer.*

Maj. CHAS. J. ALLEN,  
*Corps of Engineers, U. S. A.*

REPORT OF MR. JOHN O. HOLMAN, ASSISTANT ENGINEER, ON WORK AT RUSH TOWER.

ST. LOUIS, MO., *June 30, 1893.*

MAJOR: I have the honor to submit herewith the following report of operations at Rush Tower for the fiscal year ending June 30, 1893.

The work consisted of bank protection on the Illinois shore, the repair of hurdle No. 3 at Michaels, and the construction of hurdles Nos. 3 and 6 at Fish Bend.

BANK PROTECTION.

*Table of work done.*

	No. of linear feet.	No. of square feet.
Mattress.....	6,800	816,000
Revetment.....	6,800	146,325
Grading.....	1,225	*8,100

\* Cubic yards.

The bank protection extends from the middle of the timber below the Osborne field to the lower end of the wooded bank just above Durfee's Landing, a distance of 6,800 feet. The working season covered a period of 103 days, from August 10 to November 26. The mattress was built in 86 days—an average of 79 feet per day, or 92 feet excluding Sundays. The maximum rate of construction was made in the last week of October, when a rate of 145 feet was maintained during the six working days.

The mattress was built to the usual width of 120 feet, with its inner edge, when placed, resting on the bank at the water surface, which varied during the construction of the mattress from the 12 to the 5 foot stage. Cables about one-half inch in diameter were used to strengthen the river edge of the mattress. From one to four were used, according to the strength of the current.

The head of the mattress, station 0, was placed at the foot of the shore bar, which extends up river to the hurdles above. Its construction proceeded without interruption to station 16, when the steamer *Monroe* ran over it just above the mooring barge, breaking the outer portion of the mattress. A day's time was lost in sinking the broken portion into its position and replacing the weaving flats ready for construction.

The next difficulty occurred at station 60. The four cables, which had been used along the strong current from station 50, parted, but whether by breaking or through improper fastening could not be ascertained. The loss of mattress amounted to 70 feet.

The bank along Lowry's field was graded for a length of 1,225 feet between station 2+75 and 15 to a slope of 2 to 1, but only a small portion of it was revetted to the top of the bank. Riprap was placed above the mattress to the foot of the bluff bank. The widths of the revetment and the stage to which it was carried is given in the following table:

Stations.	Widths.	Stage
0 to 2+75.....	29	14
2+75 to 4.....	54	26
4 to 10.....	26	14
10 to 17.....	12	10
17 to 24.....	10	9
24 to 42.....	35	13
42 to 50.....	20	11
50 to 68.....	12	8

## HURDLES.

Table of work done.

	Michael's No. 3.	Rush Tower.	
		No. 3.	No. 6.
Length constructed.....feet.....	300	1,450	385
Piles driven.....number.....	212	600	96
Stringers placed.....do.....	38	23	.....
Mattress.....linear feet.....	640	1,450	385
Mattress.....square feet.....	38,960	145,000	36,500

*Michael's No. 3 hurdle.*—During the progress of the protection work on the Illinois shore a small force was engaged in closing the gap at the shore end of No. 3 hurdle.

Across the gap, 300 feet in length, piles were driven in two rows 20 feet apart, the rows composed of three pile clumps well supported with stringers and cross stringers between. The foundation mattress was 285 feet long by 60 feet wide.

Above the upper row of clumps 260 cords of old brush was spread which was covered with a drift mattress averaging 52 feet in width and then sunk to the bottom. This mattress, 355 feet in length, reached from the shore dike to the bar at the end of the old hurdle. The shoredike, 210 feet long, joins the end of the hurdle. It was raised to the 12-foot stage, in which work 3,300 cubic yards of riprap was used. The remainder of the old brush on hand, 160 cords, was used in the construction of a mattress which connected with the shore dike and extended 130 feet into the hurdle. Its width was 18 feet and its depth 7, with its upper edge at the 5-foot stage when placed. The space between the mattress and the clumps of the upper row was filled with riprap.

*Fish Bend, Nos. 3 and 6 hurdles.*—These hurdles were built in the spring season, May 1 to 31. The form used in their construction differs somewhat from that previously adopted. In the method used the mattress was built 100 feet in width, held in position during its construction by lines to a row of clumps 150 feet above, driven only for the purpose of holding the mattress. The hurdle piles were driven in two rows 6 to 8 feet apart through the middle of the mattress with the piles in these rows pulled together in clumps of four piles.

2162 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

In shoal water a stringer was placed on the piles in the upper row with a brace pile driven under each one.

On No. 3 hurdle 1,450 linear feet of mattress was constructed, the same length of clump row above, and 1,150 feet of hurdle row was driven. After the mattress at the shore end was placed some of the piles in the clump row were pulled and re-driven in the hurdle row, but the pile timber thus recovered was not a compensation for the labor expended.

On No. 6 hurdle the clump row was driven across the chute and 365 linear feet of mattress constructed, 230 at the tow head and 135 feet at the Illinois end. The hurdle was left in an unfinished condition, as the plant was required for work at Twin Hollow, where it was transferred at the close of May.

Very respectfully, your obedient servant,

JOHN O. HOLMAN,  
*Assistant Engineer.*

MAJ. CHAS. J. ALLEN,  
*Corps of Engineers, U. S. A.*

REPORT OF MR. C. D. LAMB, ASSISTANT ENGINEER, ON WORK AT CHESLEY ISLAND.

ST. LOUIS, MO., June 30, 1893.

MAJOR: I have the honor to submit the following report of operations at Chesley Island during the fiscal year ending June 30, 1893:

The protection on the east side of Chesley Island built during 1882 and 1883 remained in good condition until the last high water, when the bank was cut away inside the old work in several places. An examination made early in October showed that a semicircular cave 140 feet in diameter had been made just inside the head of the island, the bank above a 10-foot stage had been cut away from station 5+25 to 8+70, and also from station 27+75 to the lower end of the revetment at station 43+30. From station 3+50 to 6+90, and from 36+45 to the foot of the work the bank was cut away between the mattress and revetment, a trough having an average width of 35 feet being scooped out by the current to a depth of 10 feet.

The needed repairs were begun on the 11th of October near the upper end of the work; sections of mattresses 40 feet wide were built on flats from brush cut on the island, and placed in the spaces between the mattress and the revetment; the cave at the head of the island was graded and revetted, the revetment was repaired and extended to the top of the bank down to station 10, and the damaged part near the foot of the protection was repaired up to a 15-foot stage.

This work was completed November 23, and the force was then disbanded and the plant towed into winter harbor.

The amount of work done during the season is shown in the following table:

Mattress built and placed, 1,045 linear or 45,000 square feet.

Revetment placed, 1,700 linear or 74,000 square feet.

The old revetment was carried up to heights varying from 15 to 20 feet above low water, and much of the bank above those stages has been eroded by high water and now needs protection. Measurements taken at the close of the season showed that about 28,000 square feet of bank remain to be protected between station 10 and the lower end of the work.

Very respectfully, your obedient servant,

C. D. LAMB,  
*Assistant Engineer.*

Maj. CHARLES J. ALLEN,  
*Corps of Engineers, U. S. A.*

REPORT OF MR. WILLIAM S. MITCHELL, ASSISTANT ENGINEER, ON WORK AT FORT CHARTRES.

ST. LOUIS, MO., June 30, 1893.

MAJOR: I have the honor to submit the following report on the progress of the work for improvement of the river in the Fort Chartres Reach during the fiscal year ending June 30, 1893.

The project for these works embraced the revetment of the soft, caving Illinois bank between Sycamore and Fort Chartres landings, and the construction of a series of hurdles to close the chute between the Missouri shore and Fort Chartres or Bruce Island, and thus force this water to pass between the island and the Illinois

shore, to the great improvement of the present low-water channel over the persistent and dangerous shoal opposite the lower half of the island.

The general trend of the channel through this reach is from the Missouri shore at Brickey's Mill, crossing above Bruce Island Bar to the Illinois shore at Sycamore Landing; thence following the east bank for about 2 miles it crosses over the shoal to the foot of Bruce Island and back to the Missouri shore above White Sand Depot.

Work was begun on September 6 and continued until the close of the fall season. The force employed consisted of a mattress and revetment gang for the east side, and six pile-drivers with their crews and a hurdle gang for the west side.

On the east side the low-water mattress, which was of the usual character and width was 5,500 feet in length. It was fabricated and sunk without difficulty in 20 to 35 feet of water, and extends from Sycamore Landing, along the caving bank, to the heavily wooded bank a mile below.

Between the shore edge of the mattress, which was placed at about the level of low water, and the foot of the abrupt bank at about the contour of 10 foot stage, (St. Louis gauge), a stone revetment was laid. This revetment was begun September 13, and followed the mattress as rapidly as it was placed, extending its entire length, and averaging 23.4 feet in width.

Above the 10-foot contour nothing was attempted, it being expected that the bank would be graded approximately to the required slope by the river when at a higher stage, and also that it could be then more economically revetted.

During the season the river fell gradually from 9 to 5 feet (average about 6 feet) on the St. Louis gauge; the current was only strong enough to aid in launching the mattress, and the depths encountered were insufficient to cause any difficulty in sinking it. The rate of progress under these favorable conditions was very good, being 102 linear feet per working day of eight hours, or 85 linear feet daily during the season. The total force employed was about 75 men, and on the completion of this work, November 9, they were transferred to the west side to aid in the construction of the hurdles there.

On the west side, hurdles Nos. 1 and 2 were projected 1,600 feet and 600 feet, respectively, above old stone dam, closing the chute, but when soundings were taken on these lines previous to beginning work the cross sections were found uniformly very deep, 18 to 22 feet at the 9-foot stage (St. Louis gauge) then prevailing. To have driven on these lines would have required excessive lengths of pile timber, and to avoid the expense to be thus incurred the construction of the upper hurdle (No. 1) was abandoned for this season, and the location of No. 2 was changed to the line of the stone dam, the piling being driven through the stone work, the crest of which came about to low-water level. The cost of pile timber was thus reduced and the construction of a foundation mattress was avoided altogether.

Work on the line was begun September 6 at the island, and was continued until October 7, when the piling had been extended across the chute to the rock ledge, within 60 feet of the Missouri shore.

The drift piles were driven 5 feet apart in the upstream slope of the dam and were braced by piles spaced 10 feet apart and driven 7 feet back from them, each brace and its two adjacent piles being drawn together and bolted, forming drift clumps of three piles each, spaced 10 feet apart. In each clump one pile came to the level of a 25-foot stage of river, the other pile and the brace reached the 20-foot stage, at which level all the clumps were connected by a stringer, and a second stringer connected the drift piles at the 10-foot level.

In order that the braces and piles in the hurdle row should not be driven in the back slope of the dam, but in its crest, this line was placed only 12 feet back from the drift clumps. The piles were spaced the usual 6 feet apart and every pile was braced but alternately at the 20 and 10-foot levels, at which levels they were also connected by stringers.

Cross stringers connected the two rows of piling every 12 feet at the 20-foot level and every 20 feet at the 10-foot level.

Near the Missouri shore the dam seemed never to have been completed, and as the shore found here was insufficient to hold the piling, and in some places sand to the depth of 5 to 7 feet was found to overlie the rock ledge from the bluff, a mattress, 268 by 60 feet, was constructed and sunk over this bed of sand to protect it from scour, and after the piles had been driven through it they were further strengthened by stone thrown around them.

From the Missouri shore to the piling a spur dike of stone was built up to the 12-foot level. It was about 125 feet in length, and a part of the stone used in its construction was found on the bank. Another similar but very short spur, about 25 feet in length, connected the east end of the hurdle with the island revetment, and the latter was strengthened and extended upstream 160 feet by a mattress heavily weighted with stone, covering the bank between the low water and 20-foot contours. These spurs and the addition to the island revetment were not undertaken until November 22-26, when the force which had just completed hurdle No. 3 was available for the work.

Before the close of the season small drift had collected along the entire length of the piling in this hurdle from about the 7-foot level to the base of the piles, and it had packed so closely as to create a head of water of about 15 inches above the line, obviating the necessity of wattling in any form.

The total length of hurdle No. 2 is 1,575 feet.

Hurdle No. 3 was begun October 5. It is 1,000 feet below and parallel to hurdle No. 2. The average depth of water found on the line was  $6\frac{1}{2}$  feet and the maximum depth 12 feet, the St. Louis gauge reading  $5\frac{1}{2}$  feet. The construction of this hurdle was similar to that of No. 2, with the following exceptions: that the piles in the drift row were driven 6 feet between centers instead of 5 feet, making the drift clumps 12 feet apart instead of 10 feet; the distance between drift and hurdle rows was widened to 25 feet; no pile rose above the 20-foot stage, and the hurdle was wattled with curtains of brush along its entire length from the foundation mattress to the lower stringer at about the 10-foot level. The river banks at both ends of the hurdle were heavily revetted with stone up to the 20-foot contour, which on the Missouri bank was laid in a mattress. Short stone spurs up to the 12-foot level connected the hurdle ends with these revetments.

The hurdle is 1,950 feet in length and was completed November 22.

On the completion of the stone spurs for the upper hurdle, November 26, the force was discharged and the plant was towed to Bushberg for the winter.

In the spring, March 8, an examination was made of the works to ascertain the damage done by the ice in February, and both hurdles were found to have been broken through.

In hurdle No. 2 there were three gaps, each 100 feet in width, from which the piling had been carried out. That on the west began 200 feet from the Missouri end of the line, and between it and the middle gap the hurdle piles above remained in good condition, all the drift clumps, about 400 linear feet, having been broken down; between the middle and east gaps there remained about 100 feet of the hurdle row only, but badly wrecked and weak.

East of the last gap the drift row was gone for 100 feet further, but the remainder of the hurdle, about 500 feet, was unharmed and in very good condition.

The ice flowing through these gaps in the upper line evidently had united in one stream and had broken the lower hurdle, No. 3, leaving a clear gap 250 feet in length between 600 and 850 feet from the island.

A force was at once organized to repair the hurdles, and March 17, with the necessary plant and materials, was towed to Fort Chartres Island.

Meanwhile the river had risen from a 12-foot stage, at which the works were first examined, to a 20-foot stage, and had brought down large quantities of drift, which had done some additional damage to the upper hurdle and had lodged in enormous masses against the piling.

The small portion of Hurdle No. 2 lying between the middle and east gaps had been carried away, leaving one large gap 300 feet wide, through which the water poured with tremendous current.

In Hurdle No. 3 the gap had increased to 750 feet in width, the drift piles having been scoured out by the flow of water along the piling toward the gap from both sides, and the hurdle piles were broken down by the drift.

In the upper hurdle all the old work was strengthened by additional piles and braces on the lower side, and the west gap was closed twice, but each time the piling was broken down or scoured out, 30 to 35 feet of water being found on the line and the current very swift.

The main gap was narrowed to about 200 feet, working from each side, but beyond that it was found impossible to drive piles, as the water deepened rapidly from 35 to 60 feet in the center of the break, showing that the old stone dam in which the piling had been driven had settled or had been broken by the tremendous pour through this opening, due to the head of water, about 28 inches, created by the sides of the hurdle, the latter having become almost water-tight through the packing in the drift.

The river rose steadily until May 3, when it reached a stage about 5 feet above the average June flood, an almost unprecedented height for a spring rise.

This made the work very difficult and slow, and created a current impossible to withstand in this gap. An attempt was made to close the latter by driving around it in a  $\Lambda$  shape, but even then the depths and current were too great for successful work although a foundation mattress, in sections, was finally placed along the east branch of the  $\Lambda$  and around its head, but the depth of water had become too great, 40 feet, for piling to be driven.

A small section of mattress on the west branch was lost from scouring of anchor piles.

When the river had reached its highest level, Bruce Island and the Illinois shore were overflowed, and all unshaken drift was carried over the hurdles, so that the force was literally drowned out from work.

When the water began to recede a very strong but open curtain or screen, 100 by

250 feet, with its downstream end buoyed up on barrels, was constructed on poles and wire cables to be placed in front of the gap, with the hope that it would check the current sufficiently to induce deposit below it, but it was at once swept from its anchorage, and as the water was still too high for work, and fell very slowly, the force was withdrawn from this line to await a lower stage of river.

While strengthening the old piling in the upper line the enormous mass of drift, 500 feet long by 75 feet wide by 10 feet deep, which had accumulated above the piles between the island and the gap, was sunk by building a mattress over it and weighting it with stone. As more drift accumulated there this process was repeated, and a third mattress was built and sunk over a portion of the line. This sunken mass came nearly to the top of the hurdle and added about 60 feet to the width of its base upstream, making a permeable dam of drift.

The spur dike of stone at the east end of the hurdle was raised to the level of the island bank, and the revetment of the latter was strengthened and repaired.

The gap in the lower hurdle, No. 3, was narrowed to 250 feet, but as the water then deepened from 40 to 55 feet it was impossible to go farther with the piling.

The mattress was found intact entirely across the break, but it seemed to have settled with the ridge of sand on which it lies, as 75 feet depths were found below it and above as far as the lower side of Hurdle No. 2.

A second small break which developed to the west of the main gap during the high water was quickly closed, and the drift which had collected above the hurdle for 550 and 200 feet at its east and west ends, respectively, was sunk, and the old work was thoroughly strengthened and repaired.

As this completed all work that could be done at this locality the force and plant were removed May 20 to 22, to Pulltight works.

Although there has been great scour in the channel connecting the breaks in the two hurdles, yet their general effect, as well as can be seen from high-water soundings, has been to increase the bars below them, and to give greater channel depths over the bar lying between the Island and the Illinois shore, as was desired.

The excessive and long continued high water, the frequent rains and severe storms throughout the season, interfered with and delayed the work very much and greatly increased its labor and expense.

During September and October a new survey was made by Mr. Freis from Brickeys Mill to the head of Ste. Genevieve Works.

This section of the river is shown on two charts, their junction being at the head of Turkey Island, and during their execution the party was quartered at Fort Chartres Works, but as it was impossible to extend the work farther down stream from that point as a base a small quarter boat was obtained from the Missouri River commission, and Mr. Freis being left in charge at Fort Chartres, the party was moved November 1 to Ste. Genevieve and thence to the Okaw River, and the survey was extended by November 21 to the head of Kaskaskia Cut-off, 17.5 miles from Brickey Mills.

On the following day the party was towed to Quarantine to begin the annual low-water survey through the reaches under improvement. This was completed December 5 and embraced that section of the river lying between Jefferson Barracks and Hurdle No. 6 of the Sulphur Springs series, where it joined the survey completed by Mr. Holman. The outfit was then taken into winter harbor at Bushberg and the party was discharged.

The charts of the survey were completed during the winter and filed.

Very respectfully, your obedient servant,

WM. S. MITCHELL,  
*Assistant Engineer.*

Maj. CHAS. J. ALLEN,  
*Corps of Engineers, U. S. A.*

REPORT OF MR. C. D. LAMB, SUPERINTENDENT, ON PROCURING BRUSH.

ST. LOUIS, MO., June 30, 1893.

MAJOR: I have the honor to submit the following report on procuring brush during the fiscal year ending June 30, 1893:

Work was begun for the fall season with a small force at Fort Chartres Towhead, on the 12th of August, which was as soon as teams could be handled on the deposit left by the extremely high water of May and June.

About 15 cords of brush per hour were loaded during August, but this rate was increased to suit the demands, 40 cords per hour being handled on many days in October.

The force was disbanded November 11, at Durfees Point, having procured all the brush needed for the season's construction work.

2166 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

The procuring of brush for the spring season of 1893 was begun with a small force on the 16th of March, at Horsetail Bar, east side.

About 100 cords per working day was loaded at this locality until work was interrupted by high water on the 2d of May. Work was resumed May 16, but again suspended on the 5th of June; resumed on the 8th instant, and continued until the present time.

The time spent and cords procured at each locality are shown as follows:

Locality.	Time of work.	Cords.
Fort Chartres Towhead.....	Aug. 12 to Aug. 15, 1892	206.3
Kaskaskia Cut-off.....	Aug. 14 to Aug. 26, 1892	843.7
Ste. Genevieve Towhead.....	Aug. 27 to Oct. 11, 1892	7,304.8
Missouri shore below Clearyville.....	Oct. 12 to Oct. 14, 1892	412.5
Foot of Kaskaskia Island.....	Oct. 15 to Oct. 21, 1892	845.5
Durfees Point.....	Oct. 22 to Nov. 11, 1892	2,790.4
Horsetail Bar, east side.....	Apr. 16 to Apr. 22, 1893	2,583.3
Cliff Cave.....	Apr. 23 to May 2, 1893	309.3
Mudds Point.....	May 15 to May 23, 1893	402.5
Fosters Island.....	May 24 to May 29, 1893	300.0
Sulphur Springs, east side.....	May 30 to June 6, 1893	100.0
South bank Missouri River at mouth.....	June 8 to June 15, 1893	731.8
Montgomery Towhead.....	June 16 to June 20, 1893	400.0
Jim Smith's.....	June 21 to June 30, 1893	2,102.3
Total.....		19,132.4

The brush procured during the fall season was loaded with the derrick on pile-driver No. 4, having a capacity of 50 cords per hour with 8 laborers. During the winter this was replaced by a derrick set up on pile-driver hull No. 5, which will handle about 60 cords an hour with 6 laborers. This derrick has a mast 42 feet long, supported by sheer and stiff legs, with a boom made of two 7-inch steel channel beams.

The power is furnished by a 20-horse power double-cylinder hoisting engine, taking steam from the pile-driver boiler.

The average haul during the fall season was longer than for several years past, but improved methods of handling reduced the cost of this part of the work by about 15 per cent, as shown by comparing the fall of 1892 with that of 1891, when the amount procured was about the same.

	1892.	1891.
Cost of—		
Cutting and loading, per cord.....	\$0.43	\$0.51
Hauling, per cord.....	.35	.20
Material, per cord.....	.03	.03
Subsistence, per cord.....	.10	.16
Royalty, per cord.....	.05	.08
Total.....	1.02	.98

With a medium haul this cost can be probably further reduced.

Very respectfully, your obedient servant,

C. D. LAMB,  
Superintendent.

Maj. CHAS. J. ALLEN,  
Corps of Engineers, U. S. A.

REPORT OF MR. WILLIAM S. MITCHELL, ASSISTANT ENGINEER, ON PROCURING STONE.

St. LOUIS, Mo., June 30, 1893.

MAJOR: I have the honor to submit the following report of operations at the quarry for procuring riprap, at Little Rock, Mo., for the half year ending June 30, 1893:

As the quarries near St. Louis could not be relied on to furnish stone cheaply enough to admit of the long tow to the works as they progressed each year further downstream, it was decided to open a quarry in the vicinity of the prospective works for the next four years, and in September a lease or quarry right was obtained to procure riprap from the land of Andrew F. Wilder and Herman Weber, extending about



two-thirds of a mile along the bluff above Little Rock landing and for 600 feet back from the river. For this privilege there was charged a royalty of 2 cents per cubic yard of riprap removed and a small rental, \$25 per year, for ground occupied by the buildings erected for office quarters, tool houses, etc.

The site is admirably adapted for the purpose, and two quarries had already been opened on the property, but neither had been worked for some years, and then they were evidently worked very badly and cheaply for small quantities of stone without stripping or clearing away refuse spalls.

Work was begun September 11 to clear up the lower quarry on Mr. Wilder's land, and at first only about 100 cubic yards were procured daily. The quantity was gradually increased until, in November, 350 cubic yards per day were had, which was the maximum that could be handled with barrows on the available river front of this quarry.

In October the second quarry was opened about one-half mile further upstream on the Weber land, but only about 50 cubic yards were procured daily.

Work was suspended November 22, but during the winter a small force was employed in stripping the lower quarry and building a loading terrace and tramway to be used when loading with derricks.

In the spring work was resumed, but not upon a large scale as only one construction work to be supplied with stone was carried on in the vicinity. The loading track was laid, but during the very high water in May it was flooded.

During the latter part of May the force was much reduced, only being retained to prepare for active work in the fall by completing the terrace, preparing stations for the loading derrick, and raising the track about 4 feet, so as to be above the level of any probable high water, and increasing its grade that the cars may be delivered more quickly to the derricks.

During the fall season almost all of the drilling was done by hand, but a steam drill belonging to the department was also set up and used. In the spring the drill, having been put up in thorough good order, was used continually and much hand drilling avoided.

A derrick was erected on a pile-driver, and during June was used very successfully to load the few barges required, although it was only a temporary expedient. With this exception all loading has been done with barrows. This will be changed when stationary derricks are erected.

Blasting has been done with dynamite, 40 per cent pure nitroglycerine.

In the fall the force was subsisted and lodged in the department's quarters, but as laborers could be had who lived in the vicinity the quarters were not used in the spring and no one was subsisted.

Nearly 19,000 cubic yards of stone were procured during the year, at a cost of about 65 cents per cubic yard loaded on barges ready for removal. The total expense of the quarry has been greater than this, but the excess has gone toward fitting it for future work. With a demand for large quantities of stone, and with the loading tracks and derricks in operation, it is thought that the rate will not exceed 50 cents per cubic yard, but only with eight hours per day it will hardly be possible to quarry directly for riprap as cheaply as it can be bought from quarries which sell it as refuse, but the added expense of a long tow in the latter case will more than overbalance the difference in first cost.

The quarries were opened and operated until March 1, by Mr. Lamb, from whose reports the facts given relative to that time have been taken.

Very respectfully, your obedient servant,

WM. S. MITCHELL,  
Assistant Engineer.

Maj. CHAS. J. ALLEN,  
Corps of Engineers, U. S. A.

---

REPORT OF MR. C. D. LAMB, SUPERINTENDENT, ON ENGINEER DEPOT.

UNITED STATES ENGINEER DEPOT,  
St. Louis, Mo., June 30, 1893.

MAJOR: I have the honor to submit the following report of operations at the engineer depot during the fiscal year ending June 30, 1893:

The work done at this place comes under two general heads—the extraordinary, which includes the work of construction and such repairs as increase the value of the plant, and the ordinary, which includes miscellaneous work and repairs to plant required to maintain it in a condition suitable for use.

*Extraordinary.*—The wooden leads, sills, and braces on pile-driver No. 17 were taken down and replaced by steel bars of the shape and length required. Five sets

## 2168 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

of steel leads, complete with all necessary chocks and kevels, were prepared for setting upon the new hulls being built by contract at Cincinnati. The leads on pile-driver No. 5 were taken down and a derrick set up in their place 42 feet high, with sheer and stiff legs, and a 20-horse-power hoisting engine was placed in the cabin for use in loading brush.

Two new barges, Nos. 114 and 115, received from the contractor at Paducah, were supplied with iron pumps and made ready for service.

A set of temporary quarters for 60 men was built on each of barges Nos. 1, 3, and 5.

Four caulking flats, each 8 inches by  $7\frac{1}{4}$  by  $27\frac{1}{4}$  feet, were built for use in repairing barges.

Sixty new skiffs received from Truscott & Sons, of Michigan, were painted two coats and made ready for service.

Twelve trucks and boxes were constructed for use at the quarry, 200 stage planks were made from Oregon fir, and other tools made as required.

Eighteen new ice chests were constructed, 2 each for the 3 sets of temporary quarters, 1 each for the 6 sets of portable buildings on barges, and 2 each for 3 new office and quarter boats.

A set of models was made of papiermaché for the World's Fair at Chicago, one on a scale of  $\frac{1}{1200}$ , showing a portion of the river at Horsetail Bar with the construction work built there and its effect; one on a scale of  $\frac{1}{40}$ , showing part of a construction work in process of construction with the necessary plant; another on the same scale of a protection work and the equipment used. A model of a barge was also made of wood to a scale of  $\frac{1}{4}$ , showing all the details of construction.

*Ordinary.*—The following statement shows the repairs made upon the plant during the year, including the work done at the winter harbor during the late summer and early spring.

The wheel of the steamer General Gillmore was repaired, and the knee and swinging fenders and both strainer plates renewed.

Launches Nos. 1 and 2 were both painted two coats and their nosing and wheels renewed.

The leads of pile-drivers Nos. 8, 9, 10, 11, 13, 15, 17, and 18 were entirely renewed and one new lead set up on Nos. 1, 3, and 20. Two new sills were put in on Nos. 7, 8, 11, 15, 16 and 18, and one each on Nos. 9, 10 and 19. The roofs on Nos. 5, 7, 8, 9, 10, 16 and 20 were renewed and repairs made upon the crab frames, braces, chocks, hulls, and cabins of all the drivers as required. Small repairs were also made at the depot upon the machinery of Nos. 1, 3, 7, 8, 10, 11, 12, 13, 15, 16, 17, and 18 by the engineer and machinist.

The stems of barges Nos. 2, 4, 6, 8, 9, and 29 were renewed, and one each put in Nos. 3, 11, and 30. A new capstan was placed on No. 6, and one on No. 9, and the top sides of all the barges were calked and repaired in the fall and spring.

The flats, skiffs, and yawls on hand at the depot during the summer were calked in the fall, and at the close of the season 65 flats, 42 skiffs, and 9 yawls were pulled out upon the bank and repaired in the spring when required for work.

Various repairs were made upon tools and appliances and boarding outfit.

A shipping shed 14 by 30 feet was built at the depot near the upper end of the gangway. The road was covered with cinders and a new bridge built across the causeway near the middle of the yard.

Subsistence stores and supplies of all kinds were ordered and shipped to the works below when required.

Very respectfully, your obedient servant,

C. D. LAMB,  
*Superintendent.*

Maj. CHAS. J. ALLEN,  
*Corps of Engineers, U. S. A.*

Detail construction account, showing cost of works during fiscal year ending June 30, 1893.

Labor, plant, and material.	Twin Halls hurdles.	Pulltight hurdles.	Chesley Island protection.	Rush tower hurdles.
Labor, superintendence, etc .....	\$5,706.29	\$16,190.78	\$1,927.73	\$11,343.03
U. S. Engineer office.....	593.92	1,580.80	267.04	1,228.11
General expense.....	745.04	1,987.20	225.91	1,362.19
Telephone.....			6.38	10.37
Gauge-readers.....			34.31	58.00
Care of plant.....	486.43	1,297.28	84.47	902.05
Care of material.....	108.05	283.00	6.50	301.72
Steamer Gen. Gillmore.....	3,042.00	4,602.00	597.25	2,459.56
Launches.....	96.72	256.68		214.58
Barges.....	1,413.20	3,481.12	559.85	2,448.56
Quarter barges.....	360.00	604.60		546.86
Pile-drivers.....	479.02	2,037.74		1,784.94
Machine shop.....			48.00	40.63
Small boats.....	688.37	1,680.24	114.71	1,362.64
Portable quarters.....	100.80	275.10		133.39
Supply depot.....	106.16	281.60	2.46	200.43
Tools and appliances.....	189.53	455.94	99.30	507.69
Boarding outfit.....	235.48	522.68		502.16
Office furniture.....	5.85	15.00	2.44	11.78
Subsistence.....	1,509.26	3,349.88		3,008.75
Brush.....	1,427.05	4,434.40	314.10	2,119.55
Piles.....	647.05	5,138.88		2,145.50
Stone.....	1,808.88	2,791.53	1,680.79	3,149.24
Rope.....	25.80	202.40	55.93	303.07
Wire.....	135.55	446.60	14.10	153.96
Iron.....				
Nails.....	17.16	52.31	9.78	24.70
Spikes.....	75.98	106.37	5.26	62.86
Bolts.....	25.30	165.74		76.30
Lumber.....	2.89	48.30	9.66	6.30
Oakum.....		3.90		
Coal.....	51.81	665.61		231.78
Coal, blacksmiths.....		88		
Ice.....	69.57	154.42		231.24
Miscellaneous material.....	44.56	276.20	4.00	95.72
<b>Total.....</b>	<b>20,257.82</b>	<b>53,500.78</b>	<b>5,938.18</b>	<b>37,692.76</b>

Labor, plant, and material.	Rush tower protection.	Fort Chartres.		Total.
		Hurdles.	Protection.	
Labor, superintendence, etc .....	\$10,664.82	\$18,457.47	\$5,358.52	\$39,648.64
U. S. Engineer office.....	2,503.88	2,224.79	758.97	8,155.51
General expense.....	1,271.93	2,288.70	642.06	8,523.03
Telephone.....	35.79	29.42	18.06	100.00
Gauge readers.....	193.24	158.93	97.52	540.00
Care of plant.....	1,098.14	1,655.50	675.76	3,199.61
Care of material.....	590.24	641.01	365.85	1,301.37
Steamer Gen. Gillmore.....	5,442.62	5,280.64	2,080.73	23,503.80
Launches.....	272.38	397.73	81.17	1,319.26
Barges.....	3,677.85	4,922.45	2,666.19	19,166.22
Quarter barges.....	591.55	1,026.75	981.16	4,110.92
Pile-drivers.....	2,328.72	5,782.80	385.62	12,798.84
Machine shop.....	162.08	150.87	33.33	454.16
Small boats.....	1,920.81	3,311.76	1,539.09	10,628.62
Portable quarters.....	619.78	553.40	359.77	2,042.24
Supply depot.....	206.70	365.70	138.10	1,301.15
Tools and appliances.....	835.34	392.84	171.97	2,652.61
Boarding outfit.....	575.69	799.02	295.87	3,930.90
Office furniture.....	13.90	21.05	6.94	77.56
Subsistence.....	2,790.71	4,451.10	1,437.68	16,547.38
Brush.....	6,289.43	2,843.50	4,547.85	21,975.88
Piles.....		8,283.26		18,212.69
Stone.....	7,860.44	4,907.69	4,530.59	26,689.16
Rope.....	801.67	1,154.65	691.66	3,295.18
Wire.....	311.97	297.77	215.39	1,575.34
Iron.....		3.67		8.67
Nails.....	52.52	32.74	78.08	267.27
Spikes.....	117.03	104.90	97.84	630.84
Bolts.....		762.69		1,030.03
Lumber.....	25.29		21.00	113.45
Oakum.....	1.26	6.89		12.05
Coal.....	88.16	706.63	39.18	1,783.17
Coal, blacksmiths.....				.88
Ice.....	181.55	391.90	101.56	1,120.83
Miscellaneous material.....	86.14	456.88	57.61	1,020.61
<b>Total.....</b>	<b>50,620.54</b>	<b>72,854.69</b>	<b>28,475.12</b>	<b>268,729.89</b>

2170 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Construction account, showing cost of works to June 30, 1893.

Name of work.	Expended—		Total cost to June 30, 1893.
	Prior to July 1, 1892.	During fiscal year ending June 30, 1893.	
Piassa Island Dam	\$37,910.41		\$37,910.41
Piassa Island Dam, cutting channel	3,116.86		3,116.86
Alton Dam	33,740.05		33,740.05
Alton Dike	126,652.74		126,652.74
Sawyer Bend, protection	96,803.63		96,803.63
Venice Dikes	36,341.85		36,341.85
St. Louis Harbor	144,048.94		144,048.94
Arsenal Island, protection	42,590.06		42,590.06
Closing Cahokia Chute	119,958.21		119,958.21
Channel opposite St. Louis	58,455.54		58,455.54
Horsetail Bar, dikes 1 to 5, inclusive	225,066.31		225,066.31
Horsetail Bar, training wall	81,253.28		81,253.28
Horsetail Bar, hurdles	548,834.08		548,834.08
Horsetail Bar, bank protection	40,093.55		40,093.55
Carrolls Island, hurdle	4,093.58		4,093.58
Twin Hollows, west side, hurdles	248,837.82	\$20,257.82	269,095.64
Twin Hollows, west side, bank protection	31,376.55		31,376.55
Twin Hollows, east side, bank protection	128,929.30		128,929.30
Pulltight, hurdles	340,778.57	53,500.78	394,279.35
Beards Island, primary hurdle	7,166.24		7,166.24
Beards Island, bank protection	84,258.76		84,258.76
Jim Smiths, hurdles	365,803.33		365,803.33
Jim Smiths, bank protection	7,569.58		7,569.58
Chesley Island, bank protection	64,410.04	5,938.18	70,354.22
Chesley Island, hurdles	27,808.61		27,808.61
Sulphur Springs, hurdles	177,964.24		177,964.24
Lucas, hurdles	128,056.65		128,056.65
Foster Island	44,296.02		44,296.02
Rush Tower, hurdles	174,769.14	37,082.76	211,851.90
Rush Tower, protection	15,630.18	50,620.54	66,250.72
Fort Chartres Dam	36,812.86		36,812.86
Fort Chartres, west side, hurdles		72,864.00	72,864.00
Fort Chartres, east side, bank protection		28,475.12	28,475.12
Turkey Island	24,463.85		24,463.85
St. Genevieve, hurdles	47,171.06		47,171.06
Kaskaskia, protection	66,465.62		66,465.62
Liberty Island Dam	5,053.91		5,053.91
Liberty Island, protection	45,129.40		45,129.40
Devils Island, Dike 1	65,871.17		65,871.17
Devils Island, Dams 1 and 2	66,526.88		66,526.88
Minton Point, hurdles	33,436.37		33,436.37
Cape Girardeau, primary hurdles	31,930.18		31,930.18
Cairo, protection	160,439.82		160,439.82
Total	4,030,815.24	268,729.89	4,299,545.13

Property account.

Class of property.	Value July 1, 1892.	Purchases, additions, and repairs.	Expenses and deterioration charged to works of improvement.	Value June 30, 1893.
Steamer General Gillmore	\$12,727.94	\$21,647.84	\$23,503.80	\$10,871.98
Steam launches	5,466.62	688.65	1,572.90	4,582.37
Steam tenders		10,080.38		10,080.38
Barges, model	78,299.35	25,051.38	20,060.22	76,684.51
Barges, with quarters	13,716.81	8,105.75	4,655.75	17,166.81
Quarter boats		1,733.33		1,733.33
Pile-drivers	32,893.68	13,606.73	14,966.86	31,533.55
Machine shop	2,399.51	34.25	490.16	1,943.60
Derrick boat		1,500.00		1,500.00
Small boats	9,663.97	13,593.44	10,987.42	12,269.99
Portable quarters	6,154.05	3,224.24	2,327.71	7,051.18
Tents	190.75			190.75
Supply depot	3,441.00	965.65	1,301.15	3,105.50
Tools and appliances	3,032.56	6,750.99	8,054.76	6,734.79
Boarding outfit	9,314.31	5,513.55	2,930.90	11,896.96
Office furniture	385.63	143.20	77.56	451.27
Survey instruments	613.70	81.75	61.37	634.08
Photographic apparatus	230.16	50.00	23.02	257.14
Total	178,530.64	112,757.13	92,619.58	198,668.19

## Material account.

Class of material.	Value—		Expended and charged to works of improvement.	Value on hand June 30, 1893.
	July 1, 1892.	Purchased.		
Subsistence.....	\$452.43	\$21,323.65	\$21,776.08	.....
Brush.....	765.65	21,210.23	21,975.88	.....
Piles.....	2,123.35	14,398.09	16,250.67	\$270.77
Stone.....	813.34	26,417.48	26,689.16	541.66
Rope.....	7,416.44	7,360.00	3,525.57	11,250.93
Wire.....	156.71	1,466.22	1,575.34	47.59
Iron.....	248.30	3,798.70	683.54	3,361.46
Nails.....	258.08	665.72	381.42	542.38
Spikes.....	838.49	814.99	710.61	442.87
Bolts, screw.....	1,684.63	886.49	1,223.21	1,297.91
Bolts, assorted.....	37.76	40.41	40.75	37.42
Lumber.....	391.51	5,503.24	4,778.81	1,116.44
Oakum.....	36.24	769.50	563.30	242.44
Coal.....	7.00	7,273.19	7,280.19	.....
Coal, blacksmiths.....	15.91	41.93	52.77	5.07
Ice.....	.....	1,720.52	1,720.52	.....
Miscellaneous material.....	376.56	18,921.81	8,718.55	10,581.82
<b>Total.....</b>	<b>15,122.40</b>	<b>132,560.23</b>	<b>117,943.87</b>	<b>29,738.76</b>

2172 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Depth of water in feet upon the

Number of trips.	Date.	Stage above low water by St. Louis gauge.	Name of steamer furnishing report.	Direction.	Arsenal Isl. and.	Quarantine.	Pullticht.	Twin Hol-low.	Fines Bluff.	Marameo River.	Sulphur Springs.
	1892.	Feet.									
1	July 2	24.50	City of New Orleans..	Down..							
2	12	26.40	City of Providence ..	do ..							
3	16	25.50	City of St. Louis ..	do ..							
4	17	25.20	H. M. Hoxie ..	do ..				18			
5	21	23.20	City of New Orleans..	do ..				15			
6	27	18.90	City of Hickman ..	do ..				15			
7	27	18.90	City of Providence ..	do ..				15			
8	29	18.50	City of Monroe ..	do ..				15			
9	31	15.20	Sidney Dillon ..	do ..				13½		24	18
10	Aug. 1	14.80	H. M. Hoxie ..	Up ..				9½		16½	
11	3	13.50	City of Cairo ..	Down..				10½			
12	5	12.50	Arkansas City ..	do ..			12			18	
13	9	10.80	Gen. Gillmore ..	do ..	16½		12			21	
14	10	10.40	City of New Orleans..	do ..							
15	12	60.00	City of Monroe ..	do ..							
16	12	60.00	do ..	do ..							
17	14	60.10	S. H. H. Clark ..	do ..				12		18	
18	15	9.40	Gen. Gillmore ..	do ..	15		9	9		15	
19	16	9.19	City of Cairo ..	do ..	13½		9	9½		12	15
20	17	8.90	City of Hickman ..	do ..	12			8		12	
21	18	8.50	City of Providence ..	do ..				9½			
22	22	7.40	Gen. Gillmore ..	do ..	13½		9			12	
23	22	7.40	Arkansas City ..	do ..							
24	30	5.50	City of Cairo ..	do ..				7½			
25	30	5.50	Jay Gould ..	do ..	10½			8		7	12
26	Sept. 1	5.60	Gen. Gillmore ..	do ..	10½		7½				
27	3	5.40	My Choice ..	do ..	9		6				9
28	4	5.30	Jack Frost ..	Up ..	13½	12		9			10½
29	5	5.20	Gen. Gillmore ..	Down..	12		6½				
30	6	4.80	Arkansas City ..	do ..							
31	8	4.60	City of Providence ..	do ..			5½	5½			
32	9	4.30	City of Hickman ..	do ..	9					9	
33	12	4.40	Gen. Gillmore ..	do ..	9		6			9	16½
34	14	5.00	My Choice ..	do ..				6½			
35	15	4.70	City of Cairo ..	do ..							
36	15	4.70	City of St. Louis ..	do ..	10½		7½				10½
37	19	4.00	Gen. Gillmore ..	do ..	9		5				13½
38	20	3.90	State of Kansas ..	do ..							
39	20	3.00	Arkansas City ..	do ..				6		8	
40	22	3.70	Gen. Gillmore ..	do ..						8	
41	27	3.19	City of Providence ..	do ..				5			
42	28	3.00	A. L. Mason ..	do ..							
43	29		Gen. Gillmore ..	do ..	9		7			8½	15
44	30		do ..	do ..							
45	30		City of Hickman ..	do ..	9					7½	
46	Oct. 3	2.70	Gen. Gillmore ..	do ..	8		5	7½			
47	7	2.00	do ..	do ..							
48	7	2.00	Paul Tulane ..	do ..							
49	8	1.80	State of Kansas ..	do ..	7			8			9
50	10	1.60	Gen. Gillmore ..	do ..	8		4½	7½			
51	11	1.50	do ..	do ..							
52	13	1.20	War Eagle ..	do ..				4½			8
53	17	1.30	Gen. Gillmore ..	do ..	7		4	6		7	
54	18	1.00	do ..	do ..							
55	25	1.00	Grey Eagle ..	do ..				5			
56	27	1.10	Gen. Gillmore ..	do ..	7		4½	7			
57	31	2.10	do ..	do ..	8½		5	7½			
58	Nov. 7	1.30	do ..	do ..	7		5	6		8	
59	10	1.00	do ..	do ..							
60	14	1.00	do ..	do ..	7½		4	7		6½	
61	21	1.10	do ..	do ..	7½		4½			6½	
62	Dec. 14	1.40	Grey Eagle ..	do ..							
	1893.										
63	Feb. 16	4.00	My Choice ..	do ..				9		5½	
64	22	5.40	City of New Orleans..	do ..				9½			
65	Mar. 1	8.00	City of Hickman ..	do ..				10½			
66	29	14.00	City of St. Louis ..	do ..							
67	Apr. 1	13.00	Arkansas City ..	do ..							
68	2	12.70	Hy. Lowry ..	Up ..							
69	7	12.40	City of New Orleans..	Down..				15			
70	8	12.50	H. M. Hoxie ..	Up ..				15		18	
71	10	12.80	Hy. Lowry ..	Down..				13½		15	
72	10	12.80	City of Vicksburg ..	do ..				15			
73	May 20		H. M. Hoxie ..	do ..							16½
74	June 7	22.00	do ..	do ..							16½
75	18	16.90	do ..	do ..							16½
76	21	14.60	City of St. Louis ..	do ..				22½		12	16½
77	21	14.60	City of Hickman ..	do ..							

bars between St. Louis and Cairo.

Harrisonville.	Lucas.	Herculaneum.	Swashin.	Calico Island.	Cornice Island.	Forest Home Landing.	Perry Tow Head.	Rush Tow Head.	Salt Lake Landing.	Brickey Mill.	Fort Char. trees Landing.	Creeks Landing.	Stantons Landing.	St. Genevieve.	Moro Island.
	21						18		16½						
									16½					12	
18	18					16½	16				13½			18	
16½	21					19½	10½		8½		16½		12		
					18	12	9½				9½				
15						12	10½				10½			12	
15						13½	9				8½			7	
					13½	10½		12		7			18		
12					15	16½	9				8				
					12	12	8				7½			13½	
9					12	12	8	12			8			7½	
15					12	10½	8				7				
					12	12	9½				8				
			10½			9½	10½				7½			8	
			8			8	8½				7				
			8			8	8½				6½			10½	
						9	10½				6			10	
					13½					7		16½		7	8
							12				7			6	
10½			7½		6	12	8				6½			8½	10½
5			7			8					6				
					10½		10½				5				
					10½	9					7			7½	
		7½			9		7				6½				
9½					8½	9	8½				8			7	
8					9	9	8				6½			6	
10½						8	9				5½				7
											6				
											5½				
9					10½			8			5½		5½	7	7
			6			10½	8½				5		9		
					9		9½				6			6	
6½			5½		9						5			5½	
8			6				10½				5			5	
0½							8				4½				
											4				
											4½				
											4				
8							12				4½			6	
											4½			5½	
7							9				5				
8							10½				5				
							9				4				
			7							9	5½			7	
											9		12		
					18		16½				10½			16½	
					16½	16½	15				10½				
			10½			16½	15				10½				
			13½			15					13½				
											9½			12½	
	16½					18				12			13		
						21					18			10½	
	15					16½	18				16½			16½	
			19½								15				
											10½			10½	
						15					13½			10½	

2174 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Depth of water in feet upon the

Number of trips.	Date.	Stage above standard low water by St. Louis gauge.	Name of steamer furnishing report.	Direction.	St. Genevieve County.	Blocks.	Manacces.	Liberty Isl. and.	Crawfords Landing.	Neelys Land- ing.	Bambridge.
	1892.	<i>Feet.</i>									
1	July 2	24.50	City of New Orleans.	Down							
2	12	26.40	City of Providence	do							
3	16	25.60	City of St. Louis	do							
4	17	25.20	H. M. Hoxie.	do		24		24			
5	21	23.20	City of New Orleans.	do							
6	27	18.90	City of Hickman	do	12	13½	19½	18			
7	27	18.90	City of Providence	do		13½					
8	29	16.50	City of Monroe	do		15	15	15			
9	31	15.20	Sidney Dillon	do	9	9	13½	13½			
10	Aug. 1	14.80	H. M. Hoxie.	Up	8½	13½		12	19½	18	
11	3	13.50	City of Cairo	Down							
12	5	12.50	Arkansas City	do			15	13½			
13	9	10.80	Gen. Gillmore	do							
14	10	10.40	City of New Orleans.	do		9		15			
15	12	60.00	City of Monroe	do	9½	8	15	10½			
16	12	60.00	do.	do							
17	14	60.10	S. H. H. Clark	do		8	12	9			
18	15	9.40	Gen. Gillmore	do							
19	16	9.10	City of Cairo	do		8	15	10½			
20	17	8.90	City of Hickman	do	9	8½	13½	10½			
21	18	8.50	City of Providence	do	9	9	12½	12			
22	22	7.40	Gen. Gillmore	do							
23	23	7.40	Arkansas City	do	12			9½			
24	30	5.50	City of Cairo	do							
25	30	5.50	Jay Gould	do		6	9½	6½	6½		
26	Sept. 1	5.60	Gen. Gillmore	do							
27	3	5.40	My Choice	do		6	9	9	8		
28	4	5.30	Jack Frost	Up			9	9½			
29	5	6.20	Gen. Gillmore	Down							
30	6	4.80	Arkansas City	do							
31	8	4.60	City of Providence	do		6	8	8	8	8	
32	9	4.30	City of Hickman	do	9	6	8	8½	7½	8	
33	12	4.40	Gen. Gillmore	do							
34	14	5.00	My Choice	do		5½		9	8½		
35	15	4.70	City of Cairo	do							
36	15	4.70	City of St. Louis.	do		7	7½	8	8		
37	19	4.00	Gen. Gillmore	do							
38	20	3.90	State of Kansas	do		0	8	8	6		
39	20	3.90	Arkansas City	do		6	8				
40	22	3.70	Gen. Gillmore	do							
41	27	3.10	City of Providence	do			8		8		
42	28	3.00	A. L. Mason	do		6					
43	29	Gauge covered with mud.	Gen. Gillmore	do							
44	30		do	do		5	8½	8			
45	30		City of Hickman	do		5½	7½	8	7½		
46	Oct. 3	2.70	Gen. Gillmore	do							
47	7	2.00	do	do		5	7	6			
48	7	2.00	Paul Tulane	do							
49	8	1.80	State of Kansas	do		5		6	7	8	
50	10	1.00	Gen. Gillmore	do							
51	11	1.50	do	do		5					
52	13	1.20	War Eagle	do	5		8	8			
53	17	1.30	Gen. Gillmore	do							
54	18	1.00	do	do							
55	25	1.00	Grey Eagle	do	5	5					
56	27	1.10	Gen. Gillmore	do							
57	31	2.10	do	do							
58	Nov. 7	1.30	do	do							
59	10	1.00	do	do	5½						
60	14	1.00	do	do							
61	21	1.10	do	do							
62	Dec. 14	1.40	Grey Eagle	do							
	1893.										
63	Feb. 16	4.00	My Choice	do		6					
64	22	5.40	City of New Orleans	do							
65	Mar. 1	8.00	City of Hickman	do		12		9			
66	29	14.00	City of St. Louis.	do							
67	Apr. 1	13.00	Arkansas City	do		15					
68	2	12.70	Hy. Lowry	Up	16½						
69	7	12.40	City of New Orleans	Down		12		15			
70	8	12.50	H. M. Hoxie.	Up	13½	12	16½	12			
71	10	12.80	Hy. Lowry	Down		15	13½	10½	15		
72	10	12.80	City of Vicksburg.	do							
73	May 20		H. M. Hoxie.	do		10½					
74	June 7	22.00	do	do		15					
75	18	16.90	do	do	15	12	21	13½	19½	18	
76	21	14.60	City of St. Louis.	do			18				
77	21	14.60	City of Hickman	do		12					





2176 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

COMMERCIAL STATISTICS.

Receipts and shipments at St. Louis, Mo., during the years 1889, 1890, 1891, 1892.

Articles.	Receipts.			
	1889.	1890.	1891.	1892.
	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>
Barbed wire and ores and metals (pig and manufactured).....	31,663	21,782	13,741	16,768
Cement.....	6,876	15,802	18,021	1,288
Coal and coke.....	88,845	81,565	55,980	85,547
Cotton (and products).....	4,063	4,230	2,946	1,462
Groceries and dairy products.....	8,815	8,262	7,604	18,382
Hay, seeds, and grain (including flour, meals, etc.).....	96,205	92,914	99,520	76,376
Jute.....	3,473	235		
Live stock and products.....	12,805	17,347	15,217	14,953
Lumber.....	127,695	132,940	142,000	159,140
Merchandise and sundries.....	281,579	284,589	234,817	310,370
Vegetables.....	7,980	3,530	4,110	2,559
White lead, oils, etc.....	756	204	63	12
Wines and liquors.....	102	60	121	64
Wool.....	102	180	304	329
Total.....	671,685	663,780	592,140	687,200

Articles.	Shipments.			
	1889.	1890.	1891.	1892.
	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>
Barbed wire and ores and metals (pig and manufactured).....	5,885	3,945	4,802	3,574
Cement.....				
Coal and coke.....	1,701	734	148	10,504
Cotton (and products).....	200	527	88	22
Groceries and dairy products.....	8,047	7,428	9,675	13,919
Hay, seeds, and grain (including flour, meals, etc.).....	538,329	440,728	377,418	314,336
Jute.....				
Live stock and products.....	15,429	18,379	15,166	10,040
Lumber.....	6,470	8,526	6,245	7,000
Merchandise and sundries.....	131,546	117,806	95,842	138,256
Vegetables.....	2,612	1,739	1,435	2,132
White lead, oils, etc.....	1,799	1,379	1,555	1,786
Wines and liquors.....	647	668	590	631
Wool.....	35	3	18	21
Total.....	712,700	601,862	512,930	592,215

Transferred by ferries across the river at St. Louis.

	<i>Tons.</i>
1889.....	2,717,760
1890.....	3,052,166
1891.....	3,268,773
1892.....	2,760,187

Shipments down the river from landings between St. Louis and Cairo during the years 1889-'92.

Grain, including flour, meals, etc.:

	<i>Tons.</i>
1889.....	29,209
1890.....	34,267
1891.....	20,353
1892.....	18,990

RECAPITULATION.

	1889.	1890.	1891.	1892.
	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>
Receipts and shipments at St. Louis.....	1,384,385	1,265,592	1,105,070	1,189,415
Transferred by ferries at St. Louis.....	2,717,760	3,052,166	3,268,753	2,760,187
Shipped from landings between St. Louis and Cairo.....	29,209	34,267	20,353	18,990
Total.....	4,131,354	4,352,025	4,394,176	3,968,592

*List of steam power boats that arrived at St. Louis during the year 1892.*

Size of boats.	Draft.	Boats.	Times arrived.
	<i>Feet.</i>		
Under 500 gross tons.....	3 to 6.5	80	1,007
Between 500 and 1,000 gross tons.....	4 7.2	25	1,294
Over 1,000 gross tons.....	6 9.5	13	301
Tonnage and size unknown.....		7	16
Total.....		125	2,678

*List of barges and scows that arrived at St. Louis during the year 1892.*

Sizes of barges, etc.	Draft.	Barges and scows.	Times arrived.
	<i>Feet.</i>		
Under 500 tons.....	3.5 to 8	28	184
Between 500 and 1,000 tons.....	5.2 8	19	69
Over 1,000 tons.....	5.3 9	68	306
Tonnage and size unknown.....		271	547
Total.....		386	1,106

*List of steamers and barges permanently and temporarily enrolled at the port of St. Louis on December 31, 1892.*

	Vessels.	Gross tonnage.	Net tonnage.
Permanently enrolled steam (wood).....	101	41,080.83	40,419.55
Permanently enrolled barges (wood).....	89	87,542.09	87,451.25
Permanently enrolled steam (iron).....	4	1,690.29	1,667.09
Temporarily enrolled steam (wood).....	2	82.44	80.50
Permanently licensed steam, under 20 tons.....	8	143.27	115.80
Temporarily licensed steam, under 20 tons.....	1	24.12	13.23
Barges licensed, under 20 tons.....	5	48.71	48.71
Grand total.....	210	130,611.75	129,796.13

## Y 3.

## IMPROVEMENT OF HARBOR AT ST. LOUIS, MO.

St. Louis Harbor has a length of about 18 miles, being divided into two nearly equal parts by the Eads Bridge. The upper portion of the harbor, between this bridge and the northern limits of the city, is about 10 miles in length. About 3 miles above the Eads Bridge is the Merchants Bridge. The lower portion of the harbor, included between the Eads Bridge and River Des Peres, is 8 miles long. A good depth of water and accessible landings exist in this lower part of the harbor, and a sufficient depth is found above the Merchants Bridge. Between the Merchants and Eads bridges, however, there existed middle bars, and also shoals near the Illinois shore, which interfered with navigation.

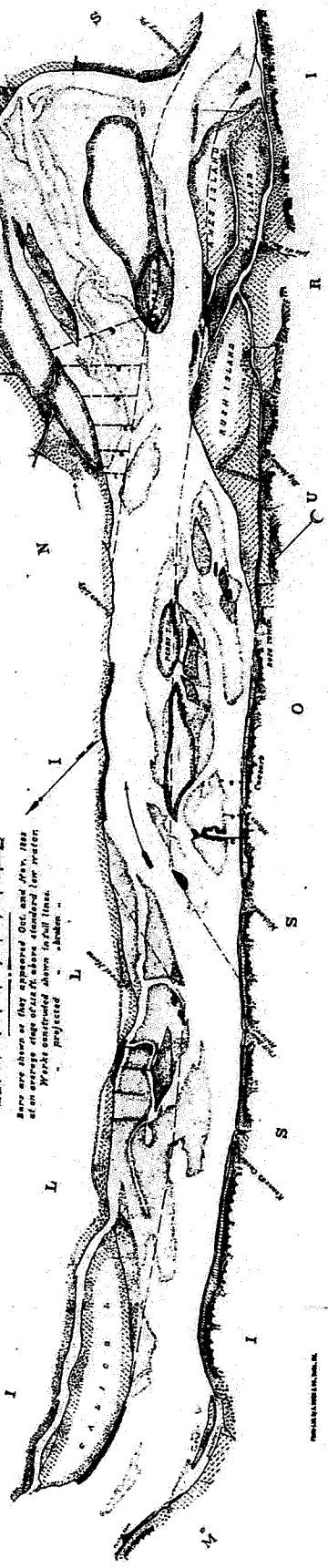
Appropriations for improvement of St. Louis Harbor had been made as early as 1836, and a longitudinal stone dike was built at that time near the head of the present works by Capt. R. E. Lee, Corps of Engineers. Other work, done in later years by the United States, consisted in the building of stone and brush dikes, generally normal to the direction of the current, in the closing of Cahokia Chute, and protection of the bank in Sawyer Bend.

MISSISSIPPI RIVER

CALICO ISLAND to PENITENTIARY POINT,  
Showing Condition of Works of Improvement  
in Rush Tower Reach, June 30, 1893.

Works are shown as they appeared Oct. and Nov. 1882  
at an average stage of water above standard low water.  
Works constructed since in full lines.  
"broken" "broken"

SCALE OF FEET



Transverse Waterway across River about  
1891

(3)





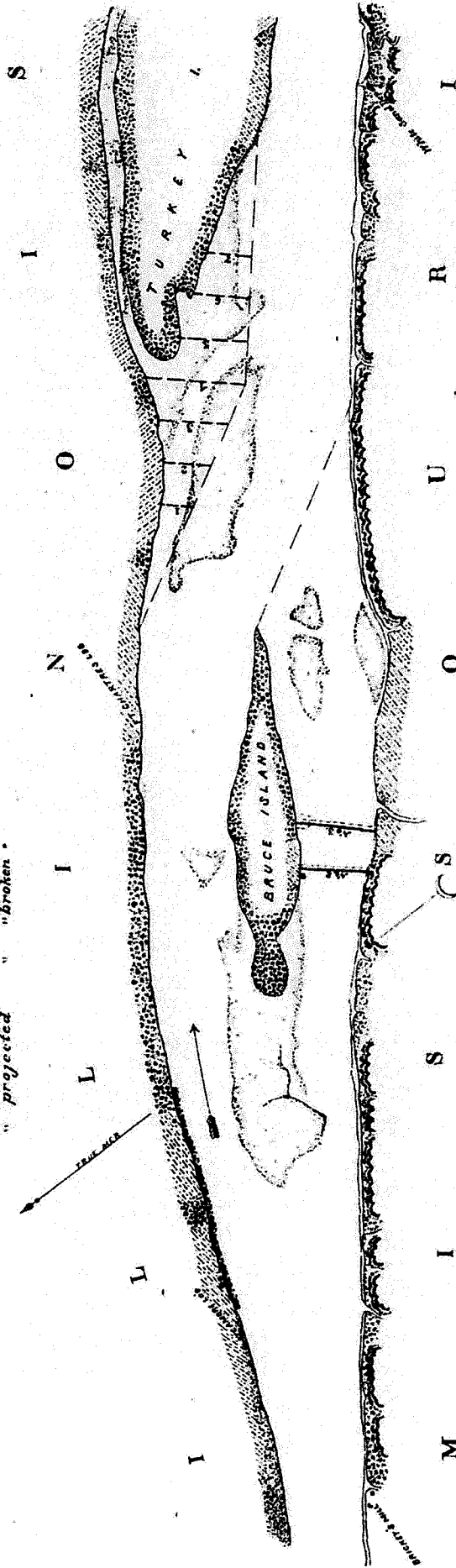
# MISSISSIPPI RIVER

FROM  
BRICKEY'S MILL TO WHITE SAND DEPOT,  
Showing condition of works of improvement

June 30, 1893.



*Bars are shown as they appeared during Oct. 1892,  
at an average stage of 14ft. above standard low water.  
Works constructed shown in full lines,  
"projected" "broken."*



M I S S I S S I P P I R I V E R  
FIG 93 TO ACCOMPANY MAJOR ALLEN'S ANNUAL REPORT JUNE 30, 1893.

REMOVING SNAGS AND WRECKS FROM MISSISSIPPI RIVER; IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE OHIO AND MISSOURI RIVERS, OF HARBOR AT ST. LOUIS, MO., OF GASCONADE AND OSAGE RIVERS, MISSOURI, AND OF KASKASKIA RIVER, ILLINOIS.

This district was in the charge of Maj. Charles J. Allen, Corps of Engineers, with Lieut. Chester Harding, Corps of Engineers, under his immediate orders, since May 3, 1894; Division Engineer, Col. C. B. Comstock, Corps of Engineers.

1. *Removing snags and wrecks from Mississippi River.*—Before this work was inaugurated the navigation of the river was very much interfered with by numerous snags, logs, etc., which had lodged in the channel, and to which a new accession was brought down on each rise of the river, thus constantly adding new and unknown obstructions to those already there. A large number of wrecks, dangerous to navigation, also occupied the channel.

For the removal of these obstructions appropriations were made as early as 1824, and the project adopted consisted in building boats suitable for removing the snags, etc., and operating them whenever the stage of water was favorable for the work, and funds were available.

The total amount expended for this purpose can not be definitely given, as previous to the appropriation made by act of March 3, 1879, a general amount was appropriated to be applied to several streams as their needs required. From March 3, 1879, when the first specific appropriation was made, up to June 30, 1893, \$930,758 had been expended for this purpose. This expenditure materially improved the navigation of the river and lessened the danger to boats. During the fiscal year ending June 30, 1894, the sum of \$88,116.22 was expended upon the improvement. Two snag boats were employed in removing the obstructions to navigation between the mouth of the Missouri River and New Orleans.

The boats worked a total of sixteen months, removing 3,057 snags, cutting down 22,861 trees, removing 19 drift piles, and 5 wrecks, and traveling a total distance of 15,336 miles.

The work accomplished during the year has been of great benefit to navigation and commerce. Formerly the wrecking of steamboats from running against snags was of frequent occurrence, but since the snag boats have been regularly at work such wrecks have been seldom heard of.

The boats were thoroughly overhauled during the past spring, and necessary repairs made to them.

An annual appropriation, not to exceed \$100,000, for carrying on this work, was made by the act of August 11, 1888. Under this appropriation the two snag boats will patrol the river, and remove obstructions whenever necessary for them to do so.

Amount drawn under section 7, act of August 11, 1888.....	\$100,000.00
June 30, 1894, amount expended during fiscal year.....	88,116.22
June 30, 1894, outstanding liabilities.....	136.24
June 30, 1894, amount to revert to the Treasury.....	11,747.54
July 1, 1894, amount available for fiscal year 1894-'95.....	100,000.00

(See Appendix X 1.)

2. *Mississippi River between Ohio and Missouri rivers.*—The original condition of the navigable channel of this portion of the Mississippi River, before the work of improvement was begun, was such that the natural depth at low water was in many places from 3½ to 4 feet. The

channels were divided by islands which formed sloughs and secondary channels, through which a good deal of the volume of flow was diverted to the detriment of navigation.

The first work for improvement began in 1872, and was continued for a number of years as appropriations were made, the works consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to a single channel, and of revetments to hold and preserve the banks where necessary or advisable to do so.

The present project is a continuation of the plan adopted in 1881, and contemplates reduction of the river width approximately to 2,500 feet below St. Louis, the natural width being in many cases from 1 to 1½ miles. The method employed is the building up of new banks, out to the line desired, from the solid matter brought down by the river and which is collected by means of hurdles. The banks, both new and old, are revetted where necessary.

The object of the improvement is to obtain a minimum depth, at standard low water, of 6 feet from the mouth of the Missouri to St. Louis and of 8 feet from St. Louis to the mouth of the Ohio.

The amount expended to include June 30, 1893, was \$4,364,570.32, and the result of the work was that but little difficulty was experienced through the improved portions, and then only at extreme low water. For stages of water above 4 feet on the St. Louis gauge there was generally a depth of at least 6 feet in the channel, excepting at Pulltight, which will be referred to further on.

The amount expended during the past fiscal year was \$825,919.86, which resulted in further improvement of the channel.

A persistent bar at Pulltight, about 9 miles below St. Louis, and upon which in the fall of 1892 there was but 4½ feet depth at standard low water, was improved so as to afford a depth of at least 8 feet at the same stage. The work of improvement carried on during the year was as follows:

*At Horsetail*, just below St. Louis, 2,845 feet of bank protection was partly completed on the west side and a series of 7 hurdles, aggregating 4,340 linear feet, built on the east side.

*Head of Carrolls Island to Jim Smith's*.—This reach of river is about 9 miles long, and embraces the localities known as Carrolls Island; Twin Hollows, east and west; Pulltight; Chesley Island; and Jim Smith's. The work done was as follows:

*At Carrolls Island*, 4 hurdles built, aggregate length 2,160 feet.

*Twin Hollows, east*.—Minor repairs and extensions of the revetment built in 1882 and years following; 9,420 square feet of new revetment built.

*Twin Hollows, west*.—Hurdles were extended and repaired, and 6 hurdles, aggregating 2,410 feet in length, were built.

*Pulltight*.—Seven hurdles, of an aggregate length of 6,645 feet, built, 1 hurdle extended 750 feet, and some extensions made of existing hurdles.

*Chesley Island*.—The new bank formed by hurdles behind the island was protected and the revetment at head of island completed, and that on east bank of island repaired.

*Rush Tower*.—This reach, which extends from the head of Calico Island to Brickey's Mill, 37½ miles below St. Louis, includes a number of detached works, viz: Protection of west side of the island; hurdles on east side near James Landing; hurdles on west side below Kennett's Castle; bank protection from Osborne Field to Durfee's Landing; hurdles below Durfee's, and works projected for regulating the river at Fish Bend. None of these works have been completed.



Work in this reach during the fiscal year consisted in repair of hurdle No. 3, on west side, between Kennett's Castle and Perry Towhead, and in 1,970 feet of extension of the bank protection, Osborne Field to Durfee's, though this extension was not entirely completed.

*Fort Chartres.*—This reach, extending from Brickey's Mill to the head of Turkey Island, 43 miles below St. Louis, includes protection of the left bank below Sycamore Landing and a series of hurdles to close the chute west of Bruce Island.

The work of the season in this reach consisted principally in extension of the bank protection 3,750 feet, and in building 6 new hurdles of an aggregate length of 9,375 feet at Bruce Island.

The total of construction work done during the year is as follows:

	Linear feet.
Hurdle built.....	25,520
Hurdle repaired .....	1,400
Bank protection (revetment) built complete.....	632
Bank protection (revetment) partly built, including extensions and repairs..	21,235
Considerable new floating plant was also built.	

The original estimated cost of the work, as revised in 1883, is \$16,397,500.

Of the works constructed to date it may be said that they have been of great benefit to navigation.

July 1, 1893, balance unexpended.....	\$1,023,763.01
June 30, 1894, amount expended during fiscal year.....	825,919.86
July 1, 1894, balance unexpended.....	197,843.15
July 1, 1894, outstanding liabilities.....	\$28,459.12
July 1, 1894, amount covered by uncompleted contracts....	69,022.07
	97,481.19
July 1, 1894, balance available .....	* 100,361.96
Amount appropriated by sundry civil act of August 18, 1894.....	758,333.33
Amount available for fiscal year ending June 30, 1895.....	858,695.29
{ Amount (estimated) required for completion of existing project....	10,250,833.34
{ Amount that can be profitably expended in fiscal year ending June 30, 1896.....	758,333.33
{ Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

(See Appendix X 2.)

3. *Harbor at St. Louis, Mo.*—St. Louis Harbor is about 18 miles long and divided into two nearly equal parts by the Eads bridge. The upper part, included between the bridge and the northern limits of the city, is about 10 miles in length.

Three miles above the Eads bridge is the Merchants bridge. The lower part of the harbor, included between Eads bridge and River Des Peres, is 8 miles long. The channel in this part of the harbor has sufficient depth and accessible landings at all points. Good depth exists above the Merchants bridge.

Congress, by act approved September 19, 1890, appropriated \$182,000 for this harbor.

The navigable reach between the Eads bridge and Merchants bridge was at that time obstructed by a number of middle bars. The project adopted for improvement of the harbor under the appropriation of 1890 consisted in a contraction of the waterway between those bridges to a

\* Of this amount but \$60,515.22 is at present available for the works now in progress, \$39,846.74 being allotted for special work at Ste. Genevieve, Cape Girardeau, and Cairo.

TABLE NO. 2.—Summary of expenses for operating United States snag boats H. G. Wright and J. N. Macomb, etc.—Continued.

Application.	1894.						
	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
Office expenses.....	\$658.02		\$653.00	\$350.06	\$353.00	\$300.00	\$3,704.21
Supervision.....	410.50		463.52	212.25	228.50	200.00	2,545.09
Expenses of snag boat H. G. Wright:							
Crew.....	4,324.00		3,450.00	232.82	1,325.33	2,810.83	22,804.82
Outfit.....	36.31	\$47.28		91.13		110.80	912.58
Fuel.....	964.35	265.30	1,211.75	693.62		49.56	5,765.95
Subsistence.....	893.93	240.08	701.02	756.72	209.02	752.24	6,678.08
Supplies.....	236.70	22.41	24.34	112.58	1.05	226.51	1,128.93
Repairs.....	60.73		68.24	81.39	922.60	438.14	2,723.39
Miscellaneous.....							41.56
Expenses of snag boat J. N. Macomb:							
Crew.....	4,311.83		4,755.00		1,511.00	2,905.84	23,975.01
Outfit.....	23.15		7.00	34.24	1.26	457.42	709.84
Fuel.....	1,088.13		1,575.00	515.37		76.15	8,112.08
Subsistence.....	396.37		761.41	238.68	449.02	754.53	6,154.89
Supplies.....			149.95	145.54	11.84	592.70	1,216.87
Repairs.....				279.94	116.48	594.33	1,679.35
Miscellaneous.....			12.25				39.81
<b>Total.....</b>	<b>13,404.62</b>	<b>575.97</b>	<b>13,832.48</b>	<b>3,744.34</b>	<b>5,130.10</b>	<b>*10,269.11</b>	<b>*88,252.46</b>

\* Includes \$136.24, liabilities incurred during the fiscal year but remaining unpaid on June 30, 1894.

X 2.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS.

The object of the improvement is to obtain a minimum depth at standard low water of 6 feet from the mouth of the Missouri River to St. Louis, a distance of 16 miles, and of 8 feet at the same stage of water from St. Louis to the mouth of the Ohio River, 178 miles, the natural depth being in many cases from 3½ to 4 feet. The channel is divided at a number of points by islands forming sloughs and secondary channels behind them, through which a good deal of the volume of flow is diverted to the detriment of navigation.

The initial point of the work for the lower portion is St. Louis, the programme being to make the work continuous, proceeding downstream from that city.

The first work for improvement began in 1872 and was continued for a number of years as appropriations were made, the works consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to one channel, and of revetments to hold and preserve the banks where necessary or advisable.

The present project is a continuation of the plan adopted in 1881, and contemplates a reduction of the river to an approximate width of 2,500 feet below St. Louis, the natural width being in many cases from 1 to 1½ miles. The method employed is the building up of new banks out to the line desired from the solid matter brought down by the river and which is collected by means of hurdles. The banks, both new and old, are revetted where necessary.

A hurdle, as the term is here used, is one of many silt-arresting devices that have been experimented upon in this country and elsewhere. The hurdle consists, essentially, of a row, or of parallel rows,

of piling, the piles driven either singly or in clumps, the piling being connected lengthwise of the hurdle by wattling of fine brush, or by curtains composed of brush and lodged against the upstream side of one of the rows of piles, the whole forming a permeable dike through which the silt-laden current can pass, though with greatly diminished velocity, the velocity being so reduced just below the dike as to cause, generally, immediate, rapid, and heavy deposits of silt. These deposits are generally soon overgrown with willows or cottonwood, and after they arrive at sufficient height they can be revetted on their river fronts.

- To guard against loss by scour of the piles a broad, flexible mattress is first sunk on the line of the hurdle; through this mat the piles and clumps of piles are driven.

During the past year the hurdles have been constructed of clumps of piles, three piles and upward to each clump. These piles are driven so that when their upper ends are drawn together by means of a wire rope they form a sort of pyramidal structure, the horizontal distances of the piles from each other at the surface of the river bed being .8 to 10 feet, depending mainly upon the depth of the water.

The wire ropes are made on the work; they are composed of 14 to 18 strands of No. 14 galvanized iron wire. They are drawn taut by means of the pile-driver machinery. At each turn of the rope round the upper end of the clump of piles a spike is driven as an additional guard against the rope slipping, though the wire itself binds or cuts into the piling sufficiently to prevent any slip. This method of drawing the upper ends of the piles together appears to be better than the old one of bolting them.

The tops of the piles are generally at an elevation of 20 feet above extreme low water, excepting that, in the curtain or wattling row, the top of one pile of the clump is at an elevation of about 25 feet above that stage in order to intercept drift at high stages and prevent it from crossing the line of hurdle and dragging the top of the latter with it.

The curtain or wattled row is strengthened by vertical diagonal braces heeled against a row of clumps spaced at such distance below as to make the angle of the braces about 45 degrees.

The heel of the brace is held by a clevis passing around one of the piles of the lower clump with its pin through the brace. At top the brace is bolted to one or more of the piles in the upper clump.

The piling of the hurdle row is so spaced as to represent an equivalent of one pile to the linear foot of hurdle. The piles are driven by means of the hydraulic jet as well as by the hammer, the latter weighing 2,400 pounds, and sometimes by both combined.

The completed curtain or the wattling, whichever may be used, is generally carried finally to a height of 20 feet above extreme low water. The mattress is from 60 to 135 feet in width, depending upon the depth of water and consequent length of piles, as well as upon liability of the bed to suffer from scour. It is fabricated upon floating ways, in place, by wattling brush upon poles spaced about 5 feet apart and in any length desired. Continuity is obtained by lapping the poles and fastening them together with spikes and wire. When additional strength is required, wire cables are used across and in the direction of the length of the mattress. The brush is spiked to the poles at the edges of the mattress and at other points, about one spike to every third rod of brush. In sinking the mat a little less than 1 cubic yard of rock is required to a cord of brush.

The piles used in the hurdles run in lengths from 25 to 60 feet, and

their average penetration in the bottom is about 15 feet. They are driven with the large end down.

At the shore end of the hurdle the bank is revetted for about 300 feet, of which 200 feet are below the axis of the hurdle.

In constructing the shore revetment a mat about 120 feet in width, its inner edge at the surface of standard low water, is sunk. The bank is then eventually graded to a slope of one-half and covered with rip-rap. Where necessary to grade the bank by artificial means the grading is done by the hydraulic method or by means of shovels, etc.

The foregoing is a general description of the work of construction during the past year.

At the beginning of the fiscal year the work for improvement had been extended to the head of Turkey Island, but the construction at a number of points had been left incomplete, especially as to number and extent of works, in order to observe the effect of the hurdles as built. A number of new banks, the result of deposits induced by hurdle work, required revetment to secure their permanency, notably at Horsetail, Twin Hollows, and Jim Smith's.

During the past fiscal year new work was prosecuted at a number of points and as far as Bruce Island, 40 miles below St. Louis, and extensions and repairs of work were also made as follows, the distances all being measured from the River Des Peres, the southerly limit of St. Louis:

#### HORSETAIL BAR, IMMEDIATELY BELOW ST. LOUIS.

At the beginning of the fiscal year a number of depressions in the accretions on the east side formed small channels at high stages of the river, and some erosion had occurred at the lower end of the reach. On the west side the bank protection needed extension.

The work of the fiscal year at this locality consisted in extending the west side protection 2,485 feet, to the lower end of the new bank, with the exception of a short piece below Dike No. 1, which could not be got at on account of the occupation of that piece by a steamer moored at the bank. The owner of the steamer was requested in writing to move her, but no answer was returned, and as cold weather shortly afterwards set in, this particular piece of revetment could not be undertaken.

The protection consisted of the usual revetment for 1,958 feet, to a stage of about 8 feet above standard low water, the rest of the distance being covered by construction and placing of a mat 130 feet wide, the upper edge of the mat on the bank being at the surface of the water at the stage prevailing during October and November, and which was about standard low water. This revetment is not complete.

On the east side a series of hurdles was projected to rebuild the bank which had been eroded, and to extend the contraction works so as to join those at Carrolls Island.

By the close of the year seven lines of hurdles had been built, aggregating 4,340 feet in length.

#### HEAD OF CARROLLS ISLAND TO JIM SMITH'S.

This reach of river is about 9 miles long, and embraces the localities known as Carrolls Island, Twin Hollows (east and west), Pulltight, Chesley Island, and Jim Smith's. Carrolls Island is about 4 miles below St. Louis.

During low-water season of 1892 (calendar year) the depth at Twin

Hollows was only 6 feet, and at Pulltight  $4\frac{1}{2}$  feet, at the stage of standard low water, and was less than the depth found on any other of the bars, where improvement had not been completed, between St. Louis and Fort Chartres.

Of the series of hurdles projected for the west side of Carrolls Island, four, of an aggregate length of 2,160 feet, were built.

At Twin Hollows, west, the repairs, extensions, and construction of hurdles which was in progress at the beginning of the fiscal year, was continued. Six hurdles, aggregating 2,410 feet in length, were built.

At Twin Hollows, east, the work of the year consisted in minor repairs and extensions of the revetment built in 1882 and years following. An aggregate of 9,420 square feet of revetment was placed.

At Pulltight the work which was in progress at the beginning of the fiscal year was continued in repairs, extension of the old hurdles, and building of others required toward completion of the improvement. Seven hurdles of an aggregate length of 6,645 feet were built, and one hurdle, previously built, was extended 750 feet.

To protect the river ends of hurdles 0 and 1 against moving ice buttresses of brush and stone were built, and extra clumps of piles were driven at the end of Hurdle  $0\frac{1}{2}$  for the same purpose.

At Chesley Island the new bank formed by the hurdles behind the island was protected and the revetment at the head of the island was completed, and that on the east bank of the same was repaired in part.

No work was done at Jim Smith's during the year.

For more complete details of the work reference is made to the reports herewith of Messrs. D. M. Currie and Gerald Bagnall, assistant engineers; also to Pl. No. 2 herewith.

#### RUSH TOWER.

This reach, which extends from the head of Calico Island to Brickeys Mill, includes several detached works, viz, protection of the west side of Calico Island, hurdles on the east side near James Landing, hurdles on the west side below Kennetts Castle, bank protection from Osborne Field to Durfees Landing, hurdles below Durfees Landing, and works projected for regulating the river at Fish Bend when the natural changes now in process at that point shall have given an average width of about 2,500 feet to the channel (cut-off) through the chute.

Calico Island is about 22 miles below St. Louis. None of these works have been completed.

The work in this reach during the past fiscal year consisted in the repair of Hurdle No. 3 on the west side between Kennetts Castle and Perry Towhead, in which an equivalent of 400 feet of hurdle was built. The protection from Osborne Field to Durfees was extended 1,970 feet upstream by placing a mattress below standard low water and revetting the bank to a height of about 10 feet above that stage, and the revetment placed during the preceding year was also repaired and extended up the bank.

#### FORT CHARTRES.

This reach, extending from Brickeys Mill to the head of Turkey Island, which is 43 miles below St. Louis, includes a dam of brush and stone at Bruce Island, and which was partly built in 1875, the protection of the left bank below Sycamore Landing, and a series of hurdles to close the chute west of Bruce Island (formerly Fort Chartres Towhead), upon

which work was begun in 1892, at which time the left bank of the river opposite Bruce Island was protected below medium stage of water for a distance of 5,500 feet downstream from Sycamore Landing, and Hurdle No. 2, located on the site of the dam partly built in 1875, and Hurdle No. 3, 1,000 feet below No. 2, were built. These hurdles were partly repaired in the spring of 1893, they having been considerably damaged by ice upon the break-up of the river about the latter part of February of that year.

The work of the past fiscal year in this reach was as follows:

Hurdle No. 2, of the Bruce Island series, was further repaired. The series of hurdles was extended to the head of the bar above the island by building six new hurdles of a total length of 9,375 feet.

The protection on the left bank of the river, opposite Bruce Island, was extended up the bank to an elevation of about 22 feet above standard low water for a distance of 3,750 feet from its upper end.

For more complete details of the work reference is made to the reports, herewith, of Messrs. D. M. Currie and W. S. Mitchell, assistant engineers. Also to Pl. No. 3, herewith.

The total of construction work done during the year is as follows:

	Linear feet.
Hurdle built.....	25,520
Hurdle repaired .....	1,400
Bank protection (revetment) built complete.....	632
Bank protection (revetment) partly built, including extensions and repairs.....	21,235

All of the work was done by hired labor.

MATERIAL USED.

The following quantities of piles, brush (for mattresses), and rock were used in the works during the year:

Piles.....	linear feet..	829,372
Brush in place .....	cords..	31,702.19
Rock in place.....	cubic yards..	83,872.33

UTILIZATION OF DRIFT.

At high stages of the river immense quantities of drift are carried downstream by the flood. A great deal of this drift lodges against the hurdles and sometimes in quantities sufficient to menace their stability either through static pressure or by producing scour about the piling. If the fields of drift thus formed can be sunk in place just above the hurdles they form excellent, permeable dams, often of considerable height, and also serve as protection to the hurdles against which they have rested; but in general the drift must be sunk quickly, otherwise, especially at very high stages of water, it may become dangerous to the hurdles as noted above.

The fields of drift are sunk by laying on top of them, rapidly and as evenly as possible, a sort of mattress of brush and then weighting the whole with stone.

A good deal of drift was utilized in this way during the year.

PROCURING MATERIALS.

The brush used was procured by hired labor. Of the stone used 54,206.30 cubic yards were procured by hired labor at the United States quarry at Little Rock, Mo., a short distance above Ste. Genevieve, and

## 1582 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

29,666.03 cubic yards were purchased in open market. Of the piling, 245,336 linear feet were procured in open market and 584,036 linear feet by contract. Other material, including rope, bolts, wire, spikes, nails, and miscellaneous supplies, were procured in open market.

### PLANT.

At the beginning of the fiscal year the plant available and that provided for by contracts entered into in November, 1892, and in June, 1893, was insufficient for prosecuting the work on a scale that would expend the available funds within the year, and further additions were provided for by contracts entered into early in the fiscal year, as per abstracts of proposals submitted with this report. These contracts provided for constructing and delivering 3 steam tenders, 12 model barges, 4 quarter boats, 11 pile-drivers, complete; 1 office and survey boat, 100 flats, 10 yawls, and 30 skiffs, all to have been delivered not later than April 1, 1894. Twenty-six flats were purchased in open market; 1 floating derrick was procured by hired labor with materials purchased in open market, using for that purpose the hull and boiler of an old pile-driver; and 2 derricks are in process of erection at the quarry by hired labor and purchase of material in open market.

Of the additions provided for by the contracts of 1892 and 1893, all have been procured excepting 2 steam tenders and 1 office and survey boat which have not, at the date of this report, been delivered. The contract for the 30 skiffs and 10 yawls was not completed and those boats were afterwards purchased in open market.

The contract of November, 1892, for the delivery of 6 quarter boats, 7 barges, 21 pile-drivers, and 10 flats was about half completed by November last. The boats to complete the number required were purchased in open market.

The towboat *General Gillmore* was taken out on the ways at Mound City, Ill., last March, and thoroughly overhauled, and the *General T. L. Casey* was taken out on the marine ways of this city for some small alterations. All other repairs to the plant have been made as needed by hired labor at the yard connected with the U. S. Engineer Depot.

Some needed repairs to storehouses at the depot were also made, and a line of pipe, connecting with the water mains of the city, was laid and fire plugs and hose provided, with a view to guarding against fire. Ways were also established at the depot yard last fall upon which a large portion of the fleet was hauled out of the water, with a view to safety from ice break-up in the spring and also to have them ready for calking when they should be required.

For further details of repairs, etc., at the Engineer Depot, reference is made to the report, herewith, of Mr. C. D. Lamb, superintendent.

The details of the work of quarrying and of procuring brush are given in the accompanying reports of Mr. E. D. Libby, assistant engineer.

### PLATES.

Four plates are herewith. Pl. No. 1, on a scale of 1:100000, is a general map of the river from the mouth of the Missouri to Chester, Ill., 63 miles below St. Louis. This map is from the annual low-water survey made last fall below the Merchants bridge, St. Louis, and from the latest available map and sketches of the river above that bridge. Pl. No. 2, on a scale of 1:25000, shows the river from the southern limits of the city to the foot of Chesley Island. Pl. No. 3,

also on a scale of 1:25000, shows the river from Forrest Home to Fort Chartres. Pl. No. 4, a profile, shows surface slopes at flood, high, and low stages of the river. This profile is from gauge readings as explained on the plate. In 1892, eight gauges were established from Jefferson Barracks to Jones Point in order to determine, if possible, whether any change in slope of water surface results from the works for regulation of the river channel.

These gauge observations have not been continued long enough to enable the extent of changes in surface slopes to be determined, but they indicate that the water surface has been lowered at all stages wherever the bars have been removed.

#### VALUE OF PROPERTY.

The present value of property belonging to this work is shown in the following table:

Class of property.	Value July 1, 1893.	Purchases, additions, and repairs.	Expenses and deterioration charged to works of improvement.	Value June 30, 1894.
Steamer Gen. Gillmore .....	\$10,871.98	\$25,650.11	\$22,810.20	\$13,711.89
Steamer Gen. T. L. Casey .....		36,346.97	11,421.27	24,925.70
Steam launches (2) .....	4,582.37	2,039.03	6,621.40	
Steam tenders (3) .....	10,060.38	12,649.92	2,383.39	20,326.91
Barges, model (49) .....	76,684.51	80,475.89	18,462.59	138,697.81
Barges, quarter (11) .....	17,166.81	4,957.98	5,948.16	16,176.63
Quarter boats (10) .....	1,733.33	51,996.81	2,025.55	51,104.59
Office and survey boats (3) .....		13,686.50	1,360.50	12,326.00
File drivers (34) .....	31,533.55	102,097.35	15,052.15	118,578.75
Derrick boats (2) .....	1,500.00	4,212.90	839.25	4,873.65
Derrick .....		1,011.50		1,011.50
Small boats (105) .....	12,289.99	69,498.95	20,192.97	61,575.97
Portable quarters .....	7,051.18	2,634.03	3,783.00	5,902.21
Tents .....	180.75		180.75	
Supply depot .....	3,105.50	3,564.04	2,389.29	4,280.25
Ways (supply depot) .....		4,421.27	836.29	3,584.98
Machine shop .....	1,948.60	437.03	790.50	1,595.07
Tools and appliances .....	6,734.70	12,685.49	6,076.36	13,343.92
Boarding outfit .....	11,806.96	19,132.33	5,655.26	25,274.03
Office furniture .....	451.27	175.50	93.29	533.48
Survey instruments .....	634.08	1,387.40	111.22	1,910.26
Photographic apparatus .....	257.14			257.14
Total .....	198,668.19	449,061.00	127,643.45	520,085.74

#### CONDITION OF THE RIVER.

The stages of water ranged from extreme low to standard low water (4 feet above extreme low) from the middle of September to the latter part of February. The gauge registered extreme low water on the 9th of December, 1893. During a part of this time depths of 4½ feet were found at Sulphur Springs and Fort Chartres crossings, both within the reach under improvement but the works for which were incomplete. The indications are that increased depth will hereafter be found at the Fort Chartres crossing (Bruce Island). Further work will probably be required at Sulphur Springs crossing.

At Pullticht, where 4½ feet depth existed during the low-water season of the year 1892, no depth less than 8 feet was found during the navigation periods of the past fiscal year.



**1584 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.**

**STATISTICS.**

Attention is respectfully invited to the tables of statistics of the commerce of the river hereto appended. These, as well as the statistics for the other works of improvement reported upon were compiled by Mr. Elliott Jones, chief clerk.

**HISTORICAL SKETCH OF THE WORKS.**

The report of Mr. D. M. Currie, assistant engineer, already referred to, contains an interesting résumé of the different methods of construction pursued at times upon the works since 1872.

**ESTIMATE.**

The amount that can be profitably expended during the year ending June 30, 1896, is \$758,333.33, which is the sum estimated in the last annual report for the fiscal year ending June 30, 1895. It is proposed to expend this sum in carrying out the programme heretofore adopted; that is, to carry on the work of improvement continuously from St. Louis downstream, reclaiming land by building up new banks, thus reducing the river to an approximate width of 2,500 feet, alluvial banks to be protected from erosion. It is proposed to obtain by this means a channel of at least 8 feet at low water. The depth is now liable to become as small as 4 feet or even less in some places, and less at every locality where the width is more than 2,500 feet.

This general statement of the proposed application of the appropriation is as specific as the nature of the case admits. The changeable character of the river renders it impracticable to give in advance the exact locality where works will be required.

The original estimated cost of this improvement of the river between the mouth of the Ohio and the mouth of the Missouri River, as revised in 1883, is \$16,397,500.

The aggregate amount from appropriations available for this work, to June 30, 1893, is \$5,388,333.33, and as follows:

**APPROPRIATIONS.**

By act of—		By act of—	
June 10, 1872 .....	\$100,000.00	August 2, 1882.....	\$600,000.00
March 3, 1873.....	200,000.00	July 5, 1884 .....	520,000.00
June 23, 1874 .....	200,000.00	August 5, 1886.....	375,000.00
March 3, 1875.....	200,000.00	August 11, 1888.....	300,000.00
August 14, 1876.....	200,000.00	September 19, 1890 .....	400,000.00
June 18, 1878.....	240,000.00	July 13, 1892.....	525,000.00
March 3, 1879.....	200,000.00	March 3, 1893.....	658,333.33
June 14, 1880.....	250,000.00		
March 3, 1881.....	600,000.00	Total .....	5,568,333.33

Of these amounts, \$180,000 were allotted by acts and projects for improvement between the Illinois and Missouri rivers, including Alton Harbor, leaving amount applicable for general improvement between the mouth of the Ohio and Missouri rivers \$5,388,333.33.

Amount expended to include June 30, 1893, \$4,364,570.32.

Amount expended during the fiscal year ending June 30, 1894, \$825,919.86.

The balance available, \$60,515.22, will be expended in prosecuting work according to the approved project. Funds having become low,

the expenses were considerably reduced in June, and it is proposed, on account of the necessity of having some funds available to meet contingencies and also to enable the plant to be cared for, to keep a reasonable reserve of funds until a new appropriation shall be made.

Recurring to the expenditures to include June 30, 1893, and to the expenditure for the past fiscal year, it must be said—although the improvement is far from being completed, in fact, being but little more than fairly begun—that the river between the mouths of the Ohio and Missouri is much better for navigation than it was before the work of improvement began, and that the difficulties and dangers to navigation are much less than they were twenty years ago. In giving credit to the work for improvement of the river, the operations of the snag boat in freeing the river of snags must not be overlooked.

*Money statement.*

July 1, 1893, balance unexpended .....	\$1,023,763.01	
June 30, 1894, amount expended during fiscal year.....	825,919.86	
		197,843.15
July 1, 1894, balance unexpended.....		197,843.15
July 1, 1894, outstanding liabilities .....	\$28,459.12	
July 1, 1894, amount covered by uncompleted contracts....	69,022.07	
		97,481.19
July 1, 1894, balance available.....		* 100,361.96
{ Amount (estimated) required for completion of existing project.....	11,009,166.67	
{ Amount that can be profitably expended in fiscal year ending June 30, 1896 .....	758,333.33	
{ Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.		

*Abstract of proposals received in response to advertisement dated June 16, 1893, and opened July 17, 1893, by Maj. Chas. J. Allen, Corps of Engineers, St. Louis, Mo., for furnishing 3 steam tenders, 4 quarters boats, 1 office and survey boat, 12 barges, 11 pile-drivers, 100 flats, 30 skiffs, and 10 yawls.*

Amount available .....	\$843,000
Amount of awards .....	152,506

No.	Name and address of bidder.	One large steam tender.	Two small steam tenders.		Four quarter boats.		One office and survey boat.	
			Price for each.	Amount.	Number proposed to be furnished.	Price for each.		Amount.
2	Ed. J. Howard, Jeffersonville, Ind.....	\$7,425.00	\$4,425.00	\$8,850.00	4	\$5,390.00	\$21,560.00	\$4,770.00
3	M. A. Sweeney Co., Jeffersonville, Ind.....	6,990.00	4,400.00	8,800.00	4	5,498.00	21,992.00	4,340.00
5	The Davis Boat and Car Co., Detroit, Mich.....	10,900.00	7,400.00	14,800.00	4	8,950.00	35,800.00	8,400.00
10	Samuel W. Skinner, Wilmington, N. C.....				4	5,964.30	23,857.20	.....
12	Geo. T. Nelles, Leavenworth, Kans.....				4	6,170.00	24,680.00	4,500.00

\* Of this amount but \$60,515.22 is at present available for the works now in progress, \$39,846.74 being allotted for special work at Ste. Genevieve, Cape Girardeau, and Cairo.

**1586 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.**

*Abstract of proposals received in response to advertisement dated June 16, 1893, and opened July 17, 1893, by Maj. Chas. J. Allen, etc.—Continued.*

No.	Name and address of bidder.	Twelve barges.			Eleven pile-drivers.		
		Number proposed to be furnished.	Price for each.	Amount.	Number proposed to be furnished.	Price for each.	Amount.
1	David S. Barmore, Madison, Ind.	6	\$3,590.00	\$21,540.00	11	\$4,150.00	\$45,650.00
2	Ed. J. Howard, Jeffersonville, Ind.	6	3,650.00	21,900.00	11	4,248.00	46,728.00
3	M. A. Sweeney Co., Jeffersonville, Ind.	6	3,990.00	23,940.00	11	4,248.00	46,728.00
4	The Davis Boat and Oar Co., Detroit, Mich.	12	6,350.00	76,200.00	12	6,495.00	77,940.00
9	Sanford S. Holbrook, Cincinnati, Ohio.	6	4,400.00	26,400.00	11	4,188.40	46,072.40
10	Samuel W. Skinner, Wilmington, N. C.	12	3,950.00	47,400.00	11	3,590.00	39,490.00
11	Clements Bros., Paducah, Ky.	12	3,950.00	47,400.00	11	3,590.00	39,490.00
12	Geo. T. Nelles, Leavenworth, Kans.	12	3,950.00	47,400.00	11	3,590.00	39,490.00
13	Geo. T. Nelles, Leavenworth, Kans.	12	3,950.00	47,400.00	11	3,590.00	39,490.00
14	J. N. Wright and H. S. Brown, Quincy, Ill.	12	3,950.00	47,400.00	11	4,445.00	48,895.00

No.	Name and address of bidder.	One hundred flats.		Thirty skiffs.		Ten yawls.	
		Number proposed to be furnished.	Price for each.	Price for each.	Amount.	Price for each.	Amount.
1	David S. Barmore, Madison, Ind.	100	\$426.64				
2	Ed. J. Howard, Jeffersonville, Ind.			\$60.00	\$1,800.00	\$120.00	\$1,200.00
4	T. G. Isherwood, Davenport, Iowa	100	263.00				
5	The Davis Boat and Oar Co., Detroit, Mich.	100	948.50	29.50	885.00	70.00	700.00
6	Wm. Schlicht, Cincinnati, Ohio.	100	948.50	36.00	1,080.00	125.00	1,250.00
7	R. C. Arnold, Leavenworth, Ind.	50	284.50				
8	Robt. G. Brown, Quincy, Ill.			40.00	1,200.00	100.00	1,000.00
10	Samuel W. Skinner, Wilmington, N. C.	100	314.45				
12	Geo. T. Nelles, Leavenworth, Kans.	100	317.00				
13	Wigzel Bros. & Co., Elizabeth, Pa.	100	425.00				
15	Kahlke & Bro., Rock Island, Ill.	25	427.50				
16	The Truscott Boat Manufacturing Co., St. Joseph, Mich.			34.75	1,042.50	96.00	900.00
17	Geo. W. McAdams, Columbia, Ohio.			36.00	1,080.00	120.00	1,200.00
18	Thos. Drien & Son, Wilmington, Del.			90.00	2,700.00	125.00	1,250.00
19	Jas. P. Sinima, St. Louis, Mo.			33.00	990.00	90.00	900.00

- No. 1.—Guarantee not dated.
- No. 2.—Proviso attached in regard to skiffs.
- No. 5.—Bids on 12 pile-drivers instead of 11, the number required.
- No. 6.—Proposal not dated and no guarantee attached.
- No. 8.—Guarantee not dated.
- No. 11.—Guarantee not dated.
- No. 13.—Price given is for flats delivered at Cairo, Ill. Telegram accompanying adds \$23 to price of each flat delivered at St. Louis, Mo.
- No. 14.—Proviso for delivery of pile-drivers in Quincy Bay, Ill. Letter and blue prints accompanying No. 14.
- No. 15.—Signatures of guarantors not witnessed. Justification of guarantors not executed.
- No. 17.—One copy of proposal only received. Specifications not attached and no guarantee given.
- No. 18.—One copy only of proposal received. Specifications not attached and no guarantee given. Accompanied by letter qualifying bid.
- No. 19.—No guarantee given. In price for skiffs words and figures do not agree. Certificate of justification of guarantors signed by notary public.

**AWARDS.**

Proposal No. 1.—David S. Barmore, Madison, Ind.:	
6 barges, at \$3,590 each.....	\$21,540
Proposal No. 2.—Ed. J. Howard, Jeffersonville, Ind.:	
4 quarter boats, at \$5,300 each.....	21,500
6 barges, at \$3,650 each.....	21,900

Proposal No. 3.—M. A. Sweeney Co., Jeffersonville, Ind.:

1 large steam tender, at \$2,900 .....	\$2,900
3 small steam tenders, at \$4,400 each .....	13,200
1 office and survey boat, at \$4,340 .....	4,340

Proposal No. 4.—T. G. Isherwood, Davenport, Iowa:

100 flats, at \$233 each .....	23,300
--------------------------------	--------

Proposal No. 5.—The Davis Boat and Oar Co., Detroit, Mich.:

30 skiffs, at \$29.50 each .....	885
10 yawls, at \$70 each .....	700

Proposal No. 12.—George T. Nelles, Leavenworth, Kans.:

11 pile-drivers, at \$3,500 each .....	39,490
----------------------------------------	--------

Abstract of proposals received in response to advertisement dated November 11, 1893, and opened December 11, 1893, by Maj. Charles J. Allen, Corps of Engineers, St. Louis, Mo., for furnishing piles.

Amount available from appropriation of March 3, 1893, for improving Mississippi River, between mouths of Ohio and Missouri rivers .....	\$460,000.00
Amount of award .....	\$2,162.69

No.	Name and address of bidder.	25 to 30 feet long.		31 to 35 feet long.		36 to 40 feet long.	
		No.	Price per foot.	No.	Price per foot.	No.	Price per foot.
1	St. Louis Refrigerator and Wooden Gutter Co., St. Louis, Mo .....	1,500	Cents. 6.725	6,500	Cents. 6.725	8,000	Cents. 6.725
2	Huse & Loomis Ice and Transportation Co., St. Louis, Mo .....	1,500	6½	6,500	6½	8,000	6½
3	Sterling Fort, Memphis, Tenn .....	1,500	5.90	6,500	6.24	8,000	6.48
4	Charles Gaertner, St. Louis, Mo .....	1,500	6½	6,500	6½	8,000	7
5	John Cleary, Chester, Ill .....	1,500	5½	6,500	5½	8,000	5½
6	Whitney Gilbreath, Ava, Ill .....	500	6½	2,233	6½	2,334	6½

No.	Name and address of bidder.	41 to 45 feet long.		46 to 50 feet long.		51 to 60 feet long.		Amount.
		No.	Price per foot.	No.	Price per foot.	No.	Price per foot.	
1	St. Louis Refrigerator and Wooden Gutter Co., St. Louis, Mo .....	6,500	Cents. 6.725	4,500	Cents. 6.725	3,000	Cents. 6.725	\$82,162.69
2	Huse & Loomis Ice and Transportation Co., St. Louis, Mo .....	6,500	6½	4,500	6½	3,000	6½	82,805.21
3	Sterling Fort, Memphis, Tenn .....	6,500	6.74	4,500	7	3,000	7.74	82,430.67
4	Charles Gaertner, St. Louis, Mo .....	6,500	7	4,500	7	3,000	7	84,883.13
5	John Cleary, Chester, Ill .....	6,500	5½	4,500	5½	3,000	5½	14,805.03
6	Whitney Gilbreath, Ava, Ill .....	2,233	6½	1,500	6½	1,000	6½	28,976.37

No. 1.—Lowest; acceptance recommended.  
 No. 5.—Incomplete; a portion of each size not being bid upon, as required by specification 24.  
 No. 6.—Less than one-third bid upon. If total number were bid upon at rate here given, the total bid would amount to \$82,468.12.

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

UNITED STATES ENGINEER OFFICE,  
 St. Louis, Mo., June 30, 1894.

MAJOR: I have the honor respectfully to submit the following report upon the improvement of the Mississippi River between the Ohio and Missouri rivers for the fiscal year ending June 30, 1894, including as part of it the accompanying reports of assistants in local charge.

The general improvement of the Mississippi River between the Ohio and Missouri rivers has been prosecuted for the purpose of obtaining at standard low-water depths not less than 6 feet above and 8 feet below the city of St. Louis, the depths being no more than 3½ feet at many points in the natural state of the river.

Improvements have been made at several points in local interests, in compliance with special appropriations and mandatory provisions of river and harbor acts supplemented by allotments from the general funds.

Referring to dates by fiscal years, the work was begun in 1873 and prosecuted at several detached localities through the following years, to include 1890, upon a plan which contemplated confining the river at low stages to a single stream having a

1538 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

width of about 2,500 feet. During the period low solid dikes and dams to contract excessive widths and close secondary branches and of revetments to prevent erosion of alluvial banks were used.

In 1881, solid dikes and dams were abandoned, and the plan which is still the basis of projects was adopted. It contemplated proceeding with the general improvement continuously downstream from St. Louis, reclaiming land by inducing deposits of silt with hurdles and other permeable structures and protecting alluvial banks to contract and confine the river to a single stream about 2,500 feet wide.

A summary of the work done at each locality by the United States since the improvement was begun, whether under appropriations for local or general improvement, is given below, as follows:

*Sawyer Bend.*—The bank was protected to a distance of 4,474 feet upstream from Grand avenue, St. Louis. The work was begun in 1873 and continued as appropriations were available to 1879.

The work consisted of a foot wall of brush and stone placed in a trench excavated throughout its entire length for low-water protection, and of revetment from that to the top of the bank to a distance of 1,118 feet above Grand avenue, while cross dikes at intervals of about 120 feet, extending from the top of the bank to the foot wall, completed the protection on the remainder of the distance.

This protection has been damaged to a certain extent by driftwood and floating ice, but still prevents erosion of the bank.

*Venice Bend.*—Four dikes in Venice Bend were designed and partly built by local authorities to improve St. Louis Harbor. As found in 1872, the upper or Bischoff's Dike was 1,390 feet long, the others 120, 387, and 1,360 feet, respectively. The last, known as "Long Dike," was raised to about 14 feet above low water and extended 600 feet in accordance with the recommendations of a board of engineers convened February, 1872.

Prior to the beginning of the general improvement in 1872, appropriations for the improvement of St. Louis Harbor had been made as far back as 1836, and a longitudinal dike was built from Kerrs Island to Bloody Island, with cross dikes connecting it with the Illinois shore. In 1891 and 1892 a series of 12 hurdles was built at Venice Bend, which lies between Eads Bridge and Bissells Point, under the project for the expenditure of the appropriation of \$182,000, for the improvement of St. Louis Harbor, by the river and harbor act approved September 19, 1890. The project consisted in contracting the river to about 2,000 feet average width, to remove middle bars, and improve landings.

This work has been very successful; the middle bars have been removed to a great extent, and the landings have been improved.

No work has been done since 1892.

*Cahokia Chute and Arsenal Island.*—Cahokia Chute was closed first by a stone dam built to the stage of 5 feet above standard low water prior to the adoption of the permeable system, and afterwards by hurdles to the stage of 16 feet above the same plane. At higher stages a small stream of water still finds an outlet through the chute, and has eroded the bank near the head of Arsenal Island.

In connection with the closing of the chute, the west face of the island was protected to the top of the bank near its head, but on the lower part only to the medium stage, or about 15 feet above low water. This medium stage protection has been damaged by the erosion of the bank during higher stages of several years, but chiefly during the long flood stage of 1892.

No work was done at this locality during the year just closed.

The works from Sawyer Bend to Arsenal Island, inclusive, are within the limits of St. Louis Harbor.

*Horsetail Bar.*—At this locality extending from the River Des Peres to the head of Carrolls Island a series of 5 dikes, one on the west side, the others on the east side, with a training wall connecting the ends of those on the east side to contract the width and consolidate the river into a single stream about 2,400 feet wide, was projected in 1873 and constructed during that and the years following to 1880. Dike No. 1 was located below the mouth of River Des Peres; No. 2, below Prairie Du Pont Creek, and below that was 3, 4, and 5 in the order named, No. 5 being located with a view of closing the chute east of Carroll's Island. These had a measure of success, but in the interest of economy they were abandoned in 1881 and hurdles were substituted for them. The river was reduced to the desired width and the obstructing bars removed by 1884, when the last work prior to that of this year was done and there has been no obstruction to navigation since that date. The protection of new banks and other work to secure permanency had been done in part only, however.

At the beginning of this year several depressions in bars on the east side gave outlets to small streams of water during high stages of the river and some erosion had occurred in the lower end of the reach; while on the west side the protection of the bank needed extension.

During this year the low-water protection on the west side was extended 2,485 feet to the lower end of the new bank, with the exception of a short section under

Dike No. 1, by placing a mattress 130 feet wide below the surface of the water at the stage prevailing during October and November, which was about standard low water.

The bank was revetted to about 8 feet above standard low water upon a distance of 1,958 feet, located as shown on the accompanying sketch, Pl. No. 2.

On the east side a series of hurdles was projected to reestablish the bank which had been eroded and to extend the contraction down to Carrolls Island. At the close of the year 7 lines had been built, Nos. 20½, 230 feet long; 22½, 750 feet long; 24½, 670 feet long; 27½, 950 feet long; 29½, 880 feet long; 30½, 670 feet long, and 31½, 520 feet long.

See Pl. No. 2 and the report of Mr. Gerald Bagnall, assistant engineer, for further details.

*Head of Carrolls Island to Jim Smith's.*—Formerly divided for purposes of administration into Carrolls Island, Twin Hollows, east and west, Beards Island, Chesley Island, and Jim Smith's.

The work in this reach was begun during the year 1882 upon a project of which the present one is a continuation and which included a series of works on the west side extending down to the foot of Fines Bluff, the protection of the bank on the east side from the foot of Carrolls Island to Pulltight Landing, afterwards known as Pulltight; a series of hurdles from that point, to include one behind Beards Island, followed downstream by the protection of the west bank of Beard's Island; hurdles at Jim Smith's; hurdles at Chesley Island to close the Meramec Chute, and protection of the bank on the head and channel side of the island. During that and succeeding years, to include the year 1884, the bank protection below medium stages and hurdles on the east side were completed, the series of hurdles on the west side was extended down to include No. 4, as shown on Pl. No. 2, when on account of a persistent effort of the channel to make a crossing to the west bank at a point near the mouth of White House Creek, the project was revised in 1888, and the Pulltight hurdles, Nos. 1, 2, and 4 were extended, and No. 5 was built, when work was again suspended to await developments. During low-water seasons the depth has been very small in the channel crossing to the west bank near White House Creek, while hurdles Nos. 1, 2, 4, and 5, Pulltight, were seriously damaged by ice, driftwood, and floods, and further work was projected during the year 1893, having for its object the reduction of the reach from the head of Carrolls Island to Jim Smith's to an average width of 2,500 feet to secure a minimum depth of not less than 8 feet at standard low water. This included hurdles on the west side of Carrolls Island, the protection of new bank, repairs to hurdles Nos. 2 to 5, inclusive, and the construction of additional hurdles at Twin Hollows, and the repairs and extension of hurdles Nos. 1 to 5, inclusive, and the construction of No. 6 at Pulltight. (For the location and extent of all these, reference is made to Pl. No. 2.)

During the low-water season of 1893 the depth at Twin Hollows was only 6 feet, and at Pulltight 4½ feet, and was less than that found on any other bars within the reach from St. Louis to Fort Chartres, which had been partly improved.

#### CARROLLS ISLAND.

Of the series projected on the west side of Carrolls Island, four hurdles, Nos. 2, 800 feet long; 3, 570 feet long; 4, 450 feet long; and 5, 340 feet long, were built this year. (See Pl. No. 2 and the report of Mr. Bagnall for further details.)

*Twin Hollows, west.*—The repairs, extensions, and construction of hurdles which were in progress at the beginning of this year were continued, and Nos. 2½, 240 feet long; 3, 450 feet long; 3½, 710 feet long; 4, 520 feet long; 4½, 330 feet long; 6, 160 feet long, were built. The protection of the new bank, which was begun in 1886, when a low-water mattress was placed to a distance of 2,633 feet with revetment to the top of bank to a distance of 900 feet, both measured from its upper end and repaired in 1888, was during this year extended 2,180 feet farther downstream and the old revetment repaired to a distance of 750 feet from its lower end. (See Pl. No. 2, and the report of Mr. Bagnall for further details.)

*Twin Hollows, east.*—Such minor repairs and extensions to higher stages, as were urgently needed, were made to the revetment placed in 1882 and succeeding years, in aggregate 9,420 square feet were placed. (See Pl. No. 2 and the report of Mr. Bagnall for further details.)

*Pulltight.*—The work in progress at the close of last year was continued upon repairs, extension of the old hurdles and the construction of others projected to complete the improvement. Hurdles Nos. 0, 550 feet long; 0½, 1,060 feet long; 0½, 1,400 feet long; 1, 550 feet long; 6, 650 feet long; 7, 1,200 feet long, and 8, 1,235 feet long were built, and 750 feet in length of No. 1, was repaired. To protect the river ends of the hurdles, buttresses of brush and stone were built on Nos. 0 and 1 and extra clumps of piles were driven on No. 0½. (For further details see Pl. No. 2 and the report of Mr. Bagnall.)

1590 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

*Chesley Island.*—The bank protection placed below medium stage of river on the east side of Chesley Island during the years 1883 and 1884 was considerably damaged by erosion above it; the hurdle closing Meramec Chute was also damaged during the long flood stage of 1892. This protection was repaired during the year 1893, and upon a part of the island the protection was extended to the top of the bank. During this year the new bank formed by the hurdle behind the island was protected and the revetment of the head of the island was completed and that on the east bank was repaired in part.

Work on the revetment was suspended on account of urgency at other localities after it was put in condition to withstand another flood season. (See Pl. No. 2 and report of Mr. Bagnall for further details.)

*Jim Smith's.*—This work was begun in 1882 and prosecuted through to 1883, in accordance with the plans adopted in the original project, which contemplated a series of hurdles on each side of the river to reduce its width to 2,500 feet, but before that portion on the west side could be built the channel changed and crossed to the west bank below the foot of Chesley Island instead of to Waters Point, and upon a revised project hurdles on the east side were extended to reduce the river to the average width of 2,500 feet.

At high stages a small channel remains open through the hurdles near their eastern ends, and the channel returned to Waters Point during this year.

A short section of the bank between hurdles Nos. 0 and 1, has been protected.

No work was done during this year.

*Sulphur Springs.*—The work in this locality was begun in 1887 and a series of hurdles was built extending from the foot of Jim Smith's to the head of Fosters Island. Some of the hurdles have been seriously damaged by ice, driftwood, and floods, and several small streams remain open through them at high stages.

No work has been done during this year.

*Fosters Island.*—The protection to the medium stage of the west bank of Fosters Island was placed during the years 1882 and 1884 and has been damaged by the erosion of the bank above during the flood stages, notably during that of 1892.

No work was done during this year.

*Lucas.*—The construction of hurdles in this reach, which extends from the foot of Fosters Island to the head of Calico Island, was begun in 1888 and continued to the close of the year ending June 30, 1890. Hurdles were built, as shown on Pl. No. 1, and the construction of others was deferred to await developments. The upper one has been seriously damaged by ice, driftwood, and floods; others have sustained some injuries.

No work was done during this year.

*Buck Tower.*—In this reach, which extends from the head of Calico Island to Brickey's Mill, are included several detached works, the protection of the west side of Calico Island, hurdles on the east side near James Landing, hurdles on the west side below Kennett's Castle, bank protection from Osborne Field to Durfees Landing, and hurdles below Durfees, upon which works have been prosecuted under the projects for the expenditure of appropriations approved September 19, 1890, July 13, 1892, March 3, 1893, and other works were indicated in outline in the chute cutting off Fish Bend when developments shall have reached a stage which will give average width of 2,500 feet to the channel through the chute.

None of these works have been completed.

During this year Hurdle No. 3, on the west side, below Kennetts Castle, was repaired, in which an equivalent of 400 feet of hurdle was built. The protection from Osborne Field to Durfees was extended 1,970 feet upstream by placing a mattress below standard low water and revetment to about 10 feet above that, or as high as the bank had a grade suitable to receive, and the revetment placed during the preceding year was repaired and extended as required. (For further details reference is made to Pl. No. 3 and to the accompanying report of Mr. William S. Mitchell, assistant engineer.)

*Fort Chartres.*—This locality, extending from Brickeys Mill to the head of Turkey Island, includes: A dam of brush and stone partly built in 1875, the protection of the east bank below Sycamore Landing, and a series of hurdles to close the chute west of Bruce Island (formerly Fort Chartres Towhead), upon which work was begun during 1893, when the bank was protected below medium stage to a distance of 5,500 feet downstream from Sycamore Landing, and Hurdle No. 2, located on the site of the dam, and No. 3, 1,000 feet below were built, and partly repaired after they were considerably damaged by ice upon the breaking up of the gorges.

During this year Hurdle No. 2 was further repaired; the series was extended to the head of the bar above the island by building six new hurdles: Nos. 1, 1,400 feet long; 1, 1,700 feet long; 0, 1,600 feet long; -1, 1,900 feet long; -2, 550 feet long, and -3, 1,225 feet long; and the protection on the east side was extended up the bank to about 22 feet above standard low water upon a distance of 3,750 feet from its upper end. Reference is made for further details to Pl. No. 3 and the accompanying report of Mr. W. S. Mitchell, assistant engineer in local charge.

*Turkey Island.*—A dam of brush and stone was begun during the spring of 1875 and was partly built during that and the years 1876 and 1877. When work was suspended, the chute was closed at stages below 3 feet above standard low water. No work has been done since October, 1876, and no water passes through the chute at low and medium stages of the river.

*Ste. Genevieve.*—The project for the improvement of this locality was adopted in 1890, and consisted in the construction of a series of hurdles on the Illinois side of the river, designed in accordance with the requirements of the river and harbor act approved September 19, 1890, to prevent the channel leaving Little Rock, the landing for Ste. Genevieve, and to contract the river to a width of 2,500 feet, and to be incorporated in and form part of the general improvement of the river when the work shall be extended to the locality in its progress continuously downstream in accordance with the plan adopted in 1881.

The series contemplated four hurdles, but the bar below Turkey Island had moved downstream, so that the upper one was not necessary. The work was begun in May, 1891, and the other three hurdles were completed the July following, and during the spring of 1892 minor repairs were made.

No further work has been done and the channel remains at Little Rock.

*Kaskaskia Bend.*—A project for the protection of this bend was adopted in 1876 and modified in 1880 to stop the caving in of the bend, which was 23,000 feet long.

The work was continued as funds were available until 1881. After direct revetment had been applied to about 6,000 feet of bank and a hurdle 1,140 feet long had been built to deflect the current away from the bank, the work was almost wholly destroyed by ice and flood. The flood, pouring into the Kaskaskia River through a depression in the bank with a fall of 6 feet, opened the way for a deep but narrow stream, which has since become the navigable channel.

No work has been done since 1881.

*Liberty Island.*—The original project at this locality contemplated closing the chute on the Missouri side of Liberty Island to concentrate the water in the channel, which had passed at low stages for a number of years by the village of Rockwood, Ill., opposite the island.

Work on the project was begun in July, 1875, but after the high water of August of that year the channel was found on the west side, while that via Rockwood was nearly closed, and the project was changed and the Missouri bank was revetted with stone, from 1876 to 1879, to a distance of 7,325 feet above the site of the projected dam.

No work has been done since 1879. The downstream end of this revetment remains in serviceable condition, but has been seriously damaged by caving of the bank from above.

*Devils Island.*—Work was begun at this locality during the fiscal year 1875 in accordance with a project which contemplated the closing of the Illinois and Picayune chutes by dams, and further contraction to the desired width by a dike from the west side of Devils Island.

The work was begun during the year 1875 when the low-water channel was in the Illinois chute, though the larger body of water flowed on the west side. The work was prosecuted as funds were available until 1877, when it was practically completed.

The channel has been very much improved.

*Cape Girardeau and Minton Point.*—During the year 1881 a project was prepared and adopted to remove a bar in front of Cape Girardeau Landing and to secure not less than 8 feet at low water between the landing and Minton Point, Illinois, in accordance with requirements of special appropriations by the river and harbor acts of June 14, 1880, and March 3, 1881, and for the general improvement of the river from the Illinois to Ohio rivers.

A hurdle was built to a distance of 2,256 feet from the foot of Devils Island downstream, making a considerable angle with the current, and a series of five cross hurdles at intervals of 400 feet was projected and partly built, connecting with the bar below Devils Island. Of the 5,329 feet thus projected 2,100 feet was practically completed. Another hurdle inclined to the current was built from the Illinois shore near Wahoo Landing to distance of 3,100 feet. These were repaired after the high water of 1882, and the object for which the work was designed was obtained in part. The bar was removed and the desired depth secured, but to render the result permanent would require extension of the hurdles.

No further work has been done.

An appropriation of \$22,500 was made by river and harbor act of 1884, but remains unexpended, waiting further appropriations.

*Cairo protection.*—Between 1859 and 1868 the Cairo Land Company built a series of spur dikes at Eliza Point, in rear of Cairo, Ill., to check the erosion of the bank. Two dikes at the upper end of the series had been undermined by the current and had disappeared when the protection was begun by the United States in 1877, in



accordance with requirements of the river and harbor act approved August 14, 1878. The project contemplated protection of the spur dikes which remained in serviceable condition and the bank to a distance of 11,500 feet above them by revetment. The work was continued as funds were available during 1877 and the following years to include 1880, when the protection had been extended to a distance of 10,700 feet and the eddies between the spurs had been broken up. The channel changed to the west side of Eliza Towhead, and that on the east side silted up and covered the revetment by a bar and growth of willows. During the year 1885, in accordance with the requirements of river and harbor act approved July 5, 1884, the protection was extended to a distance of 4,628 feet downstream from the lower end of the revetment by placing a continuous mattress 120 feet long to protect the spurs and the bank below as far as the current followed it. During the following year repairs were made as needed.

This entire work remains in such condition that there has been no necessity to expend the balance which remains available and located there by the act making the appropriation.

*Procuring materials.*—The full quantity of brush used was procured by hired labor. The stone was procured in part by hired labor and the balance by purchase in open market. The pile timber was procured in part by contract and the remainder by purchase in open market.

Other material, including rope, bolts, wire, spikes, nails, and miscellaneous supplies, was procured in open market.

*Plant.*—At the beginning of the year the plant available and that provided for during the year 1893 was insufficient for prosecuting the work on a scale that would expend the available funds within this year, and further additions were provided for by contracts entered into last summer, by purchase in open market, and by building by hired labor with materials purchased in open market. The contracts provided for 3 steam tenders, 12 model barges, 4 quarter boats, 11 pile-drivers (complete), 1 office and survey boat, 100 flats, 10 yawls and 30 skiffs, all to have been delivered not later than April 1, 1894. Twenty-six flats were built after receiving sealed proposals on ten days' notice in open market. One floating derrick was procured by hired labor, with materials purchased in open market, using for that purpose the hull and boiler of an old pile-driver; and 2 derricks at quarry are in progress of erection by hired labor and purchase of material in open market.

Of the additions provided for during the years 1892 and 1893 all have been procured except 2 tenders and 1 office and survey boat, but 4 of the quarter boats have not been outfitted and 9 pile-driver hulls and cabins still need their machinery set up to complete them as pile-drivers.

The towboat *Gen. Gillmore* was taken out on the ways at Mound City, Ill., and thoroughly overhauled, and the *Gen. Casey* was taken out on the marine ways of this city for small alterations. All other repairs to the plant have been made as needed at the yard connected with the supply depot.

Reference is made to the report of Mr. Lamb, superintendent of supplies, for further details of repairs made at the supply depot.

*Plates.*—Plate No. 1 is a general map of the river from the mouth of the Missouri River to Chester, Ill., from the annual low-water survey made last fall below the Merchants bridge, St. Louis; and above that point from the latest available charts and sketches recently taken in St. Louis Harbor above Sawyer Bend. Plates 2 and 3 show the river from the southern limits of the city of St. Louis to foot of Chesley Island, and from Fort Forest Home to Fort Chartres Landing, respectively, the localities at which work has been done during this year. Plate 4 shows surface slopes at flood, high, and low stages from gauge readings, as explained thereon.

*Gauges.*—The eight gauges established in 1892 between Jefferson Barracks and Jones Point, to determine whether any change in slope of the water surface results from the improvement, were read daily, and their readings, together with such other authentic readings as were available, have been plotted. Surface slopes, with river at flood stage and averages of high and low stages, are shown on Plate 4.

These readings have not been kept up long enough to determine the extent of the changes in surface slopes which may be expected to result from the improvement, but they indicate that the surface has been lowered at all stages wherever the bars which obstructed the flow of water have been removed.

The lowering of the water surface is notable in St. Louis Harbor below to Jefferson Barracks, and in a less degree at other points within the reach under process of continuous improvement.

*Condition of the river.*—The stages ranged from extreme low to standard low water from the middle of September to the latter part of February. Zero stage was reached December 9, 1893. During part of this period depths of only 4½ feet were found at Sulphur Springs and Fort Chartres, both within the reach under process of improvement, but with works incomplete. Recent changes effected by the works indicate that greater depths will hereafter be found at the latter point. At Sulphur Springs further work will be required to secure the desired depth.

At Pullticht, where only 4½ feet was found during the low-water season of 1893, no depth less than 8 feet was found while navigation was open during this year.

*Forms of construction.*—During the latter half of the year a form of hurdle differing in some respects from any of those previously used was adopted for experimental tests. It consists (1) of a mattress to protect the bottom within the ordinary limits of scour above and below the line of hurdle. The width adopted for the mattress is about 100 feet, but is subject to increase or decrease as necessity may require. The mattress is placed from clumps, single piles, or other anchorages suitable to hold it during construction and sinking. (2) The piles in the hurdles are driven in clumps about 8 feet between centers, with elevation the same as in other forms, on a line passing centrally through and parallel to the direction of the mattress. The clumps consist of 3 to 7 piles, as may be necessary to resist the destructive forces to which the line may be exposed. The clumps are further strengthened where necessary by driving another line of piles or clumps below them and connecting the two lines by cross-stringers and diagonal braces heeled against the lower line. (3) A curtain is placed against the clumps in lieu of wattling. (4) The drift when collected in sufficient quantities above the upper line is sunk.

This form has not been sufficiently tested to fully determine its relative value, but the statement may be made that it possesses the elements of strength of the others and avoids some of their defects.

Other forms of contraction works used since 1872 have been tried experimentally also, and although they have proved successful in a greater or less degree, they have been changed from time to time in the effort to obtain the desired results at the least cost.

The two principal systems of contraction works which have been used, briefly described, are as follows:

1. *Dikes and dams.*—Solid stone dikes and dams were built in several localities from 1872 to 1879.

They were usually constructed on foundations of brush placed in layers alternately parallel to and across the current, and extending below the structure to protect the bottom against scour from overfall.

The dams at Cahokia Chute, Bruce, Turkey, Devils, and Picayune islands, the training walls and dikes at Horsetail Bar and a dike at Devils Island were built upon this system.

The results were satisfactory at first. The structures did not, however, build up new banks, and their continued success depended upon the obstruction that they offered to the flow of water without the channel limits, which in time created such disturbances, boils, whirls and eddies as to practically destroy their usefulness as works of improvement and they were abandoned. (See Report of the Chief of Engineers for 1880, p. 1362 *et. seq.*)

2. *Hurdles.*—This form of construction was adopted in 1879, at first in connection with the training wall which was retained as a solid structure, but built in cheaper form, wooden gates attached to a row of braced piles having been substituted for solid stone wherever in the line the depths were not too great for piles to be driven and made efficient by bracing; in greater depths, curtains, weeds and other light open structures were anchored by attaching one edge to a foundation mattress while afloat and then sinking the mattress, the other edge being held at the water surface by buoys. (See Report of the Chief of Engineers, 1880, p. 1362 *et. seq.*)

1. A hurdle at first consisted of a single row of piles driven 5 feet apart, with brush wattled upon them, pushed well down to the bottom and extending up to the stage of 15 feet above extreme low water, or, if the depths were excessive, a curtain was placed against the piles, instead of wattling, to retard the bottom current and prevent scour.

These hurdles were usually placed 300 feet apart, but the distance between lines was determined by currents, velocities, depths, etc. These gave results much more satisfactory than the solid dikes, though frail and often destroyed by ice on the breaking up of gorges in the spring and by drift accompanying floods. They induced heavy deposits of sediment within the space inclosed and formed a solid bank to concentrate the flow, at medium stages, in the channel.

Yet, from their frailty and small elevation, 15 feet above extreme low water, they did not completely reclaim the land and build to the height of the old banks within the time that they remained in efficient working condition.

2. In 1881 the hurdles were strengthened by driving the piles in two rows, braced in pairs and in clumps.

The upper end of the braces were framed into the piles and fastened to them by drift or screw bolts or wire strands.

The spaces between the hurdles were enlarged to compensate for the extra cost of strengthening, at first by gradually increasing the distance between them from the head of the series downstream until about 1,000 feet was reached. Afterwards

## 1594 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

spaces were made experimentally 2,000 feet, but this distance having been found too great it was reduced to 1,000 feet.

A series of hurdles spaced at 1,000 feet, driven in clumps or braced rows, consumes about as many piles as one covering the same river frontage spaced at 800 feet between lines with piles driven in single rows.

The height of the hurdles remained about 15 feet above extreme low water, and a mattress was used to protect the bottom against scour when deemed necessary, but in working at high stages the piles were of necessity left above the water surface, which in one notable instance, Horsetail Bar, west, was at flood stage. The result was very satisfactory, a single flood being sufficient to complete the reclamation of the inclosed space nearly to the height of the natural bank. After this the height of hurdles was increased to 20 feet above extreme low water, and a foundation mattress to protect against scour became part of the usual form. Bracing was continued and stringers were added both in the direction of the hurdles and across it.

A third row of piles was also added, called the drift row, and intended to keep the heavy drift away from the hurdle or wattled row. (See sketch in Report of Chief of Engineers, 1885.)

This form was very strong, and seemed all that could be desired against horizontal static pressure, but, when sufficiently submerged, drift was carried over it and the hurdles were seriously damaged, requiring extensive repairs after floods and after the breaking up of gorges accompanied by considerable rises. Also owing to the sequence of construction serious damages frequently occurred while the hurdles were incomplete; the piles being first driven, the mattress was built afloat around them and then sunk, thus leaving considerable portions of incomplete work exposed to the action of floods and drift. The driving of the drift row in clumps followed, at least one pile in each clump extending up to the 25-foot stage, the mattress was constructed ordinarily only on the lower side of the drift row with its upper edge attached to the lower piles of the clumps, but when currents parallel with the line indicated the necessity another mattress was placed above the clumps with its lower edge against them, and drift whenever accumulated in sufficient quantity above the piling was sunk. The stringers and tops of diagonal braces remained at the stage of 20 feet above extreme low water.

This form gave better results than any previously tried, but showed weakness during flood stages when the rising river brought large fields of drift under the braces and stringers and finally over the hurdles.

All these forms of hurdles gave satisfactory results in securing deposits and building up solid banks to concentrate the flow of water within the channel, but they also showed want of strength to resist the forces tending to destroy them.

The reports show that better results might have been attained, provided their serviceable life could have been lengthened; with that object in view hurdles with piles in single rows and anchored curtains and other light structures were replaced by braced hurdles with mattresses to protect the bottom, the elevation of the hurdles was increased from 15 to 20 feet above extreme low water and the distance between the hurdles was increased to compensate in part for extra cost (See Report of the Chief of Engineers, 1882, p. 1601.)

After experimenting with several forms of bracing and widths of mattress, the form shown in the report of the Chief of Engineers, 1885, was developed. (See p. 1655 *et seq.*, and plates of that report.)

In this the mattress was still built around the piles of the upper or drift row, which offered little resistance to heavy fields of drift during construction when floods carried fields of drift against or over it.

There was also evidence of destruction from buoyancy of ice and driftwood. Carrolls Island had a section about 1,000 feet long lifted out of place and carried away by ice in 1886. (See Report of Chief of Engineers, 1887, p. 1557.) Many hurdles showed the effect of the buoyancy of drift after the flood of 1892, which still may be seen at Lucas and other localities.

Scour, which has been the cause of considerable damage to hurdles, presents one of the most difficult problems connected with contraction works. It may be caused by currents parallel and in close proximity to the hurdles, by channeling under the mattress where it does not closely conform to the inequalities of the bed, by overfall or by rushing around the end of the obstruction. A wide mattress protects for a time against the first, vigilance may prevent the second, but against overfall or head of water the only adequate means is to make the obstruction permeable. An obstruction made by sinking driftwood composed of trees, their branches, and other smaller drift seems to meet the case.

The form of construction now undergoing experimental test was designed to resist all of these destructive agents.

*Bank protection.*—In bank protection the forms used have undergone but slight modifications since 1881, when the form adopted consisted of a mattress to protect

the bank below low water and a revetment of stone from low water to the 20-foot stage, leaving the zone above that level to be protected by willow growths.

At first a line of guide piles was driven to insure the correspondence of the shore edge of the mattress with the curve of standard low water, but that has been changed, and now the mattress is so placed that its shore edge corresponds with the curve marked by the water surface at the stage at which the work is done, and such additional width is given it as may be necessary to keep its river edge 120 feet from the curve of standard low water, while the revetment of stone extends to the top of the bank. This latter, however, may be placed in zones, as the bank is graded by the action of the river, except in special cases where the bank is composed of materials that will not grade to suitable slopes under exposure to the weather and the river. Such banks should be graded artificially and revetted without delay.

Prior to 1881 several other forms were tried.

1. That used at Sawyer Bend, 1872 to 1878, consisted of a foot dike with its crest 6 feet above low water, built upon a foundation of brush placed in a trench dredged to a depth of 8 feet below low water, and above the crest of the dike the bank was graded to a slope of 2 to 1 and revetted with stone.

On part of the reach stone spur dikes were built about 150 feet apart as a temporary protection, and being found efficient were adopted instead of the revetment.

2. A form consisting of loose brush in alternate longitudinal and transverse layers, and in widths from 40 feet to 60 feet placed below low water with a revetment of stone above, was used first at Devils Island and afterwards at Cairo, Kaskaskia Bend, and Arsenal Island.

3. Still another form was used at Liberty Island, which consisted entirely of a stone covering of the bank placed as riprap below low water and as a revetment above. This was carried only to the level of the medium stage of river.

These forms have been exposed to the action of the river from ten to twenty years, and though they have been more or less damaged, no finished protection has been destroyed or injured sufficiently to impair its efficiency.

Very respectfully, your obedient servant,

D. M. CURRIE,  
Assistant Engineer.

Maj. CHAS. J. ALLEN,  
Corps of Engineers, U. S. A.

#### REPORT OF MR. GERALD BAGNALL, ASSISTANT ENGINEER.

*On works at Horsetail Bar, Carrolls Island, Twin Hollows, Pulltight, and Chesley Island.*

HORSETAIL BAR, EAST, June 30, 1894.

MAJOR: I have the honor to make the following report of operations at Horsetail Bar, east and west, Carrolls Island, Twin Hollows, east and west, Pulltight, and Chesley Island, for the fiscal year ending June 30, 1894:

Mr. William S. Mitchell, assistant engineer, was in local charge of the work at Carrolls Island, Pulltight, and Chesley Island previous to September 1, 1893.

*Horsetail Bar, west.*—Work was commenced on bank protection at this locality on October 9, 1893, and continued until the 22d of November following. It had been intended that this work should be a continuation of the revetment already constructed from the river Des Peres to Dike No. 1, but owing to the space immediately below the dike being occupied as a winter harbor by the steamer *Grand Republic*, the new work was commenced a short distance below and carried to the end of the made ground, a distance of 2,500 feet.

This protection consists of a continuous mat 130 feet wide, extending up to a 4-foot stage. For a distance of about 1,958 feet from the upper end the bank was graded and a stone revetment placed to a 12-foot stage. (For amount of work done see Table No. 1.)

*Horsetail Bar, east.*—Work was commenced at this locality on May 18, 1894, and continued to June 26, 1894, when work was suspended.

Seven new hurdles were built between the old ones and were numbered 20½, 22½, 24½, 27½, 29½, 30½, and 31½. Hurdle No. 32½ was commenced but not completed. With the exception of Nos. 20½ and 32½ these lines were all curtained to a 12-foot stage. Nos. 20½, 22½, and 24½ were braced diagonally and Nos. 27½ and 29½ were strengthened by a second row of clumps and stringers. (For amount of work done see Table No. 2.)

*Carrolls Island.*—Work was commenced at this locality, on July 11, 1893, and suspended on August 11, 1893. During that period hurdles Nos. 2, 3, 4, and 5 were com-

## 1596 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

structed and curtained to a 20-foot stage. Owing to shoal water the construction of Hurdle No. 1 projected at the head of the island, and of a hurdle across the chute just east of the island, was abandoned.

On May 1, 1894, a small force was moved to Carrolls Island and commenced strengthening Hurdle No. 5 by driving a second row of clumps of piles close up behind the first one. Owing to shoal water this was the only line that could be strengthened. (For amount of work done see Table No. 3.)

*Twin Hollows, east.*—At intervals during the first half of the fiscal year a small amount of scattered repair work was done on the revetment at this locality. (For amount of work done see Table No. 4.)

*Twin Hollows, west.*—Work was continued at this locality from the beginning of the fiscal year until November 20, when it was suspended for the winter. During that period hurdles Nos. 2½, 3, 3½, 4, 4½, 6, and 7 were constructed and with the exception of Nos. 2½ and 7 were curtained to a 12-foot stage. A considerable amount of bank protection work was also constructed. Much difficulty was experienced in building the hurdles at this locality on account of the shoal water at their outer ends, which practically made the conditions as regards the movement of plant and material the same as if the lines crossed a chute. The bank protection was also carried on under difficulties due to inaccessibility and soft, muddy banks. A considerable quantity of drift was sunk on these lines with the exception of on No. 6.

Work was resumed at Twin Hollows, west, on March 26, 1894, and continued until April 26, 1894, during which period lines Nos. 2½, 3, 3½, and 4 were braced diagonally and some drift was sunk on lines Nos. 2½, 3, and 4. (For amount of work done see Table No. 5.)

*Pulltight.*—Work was continued at this locality until July 12, 1893, when it was suspended. It was resumed on August 12 following and continued with an interval of 6 days until November 17, when it was again suspended for the winter. During these periods work was done on hurdles Nos. 0, 0½, 0¾, 1, 6, 7, and 8, the total amount being 4,675 linear feet of new work, 650 feet of old lines extended, and 750 linear feet of old work repaired.

With the exception of line 0, which consisted of three rows of clumps, and line 0¾ these lines were all curtained to heights of from 12 to 20 foot stages. Hurdles Nos. 0 and 1 had their ends protected by buttresses built of brush and stone and 0¾ by a cluster of clumps of piles.

On March 16, 1894, a force of pile-drivers commenced bracing the hurdles at Pulltight and repairing the gap which had been broken through No. 0. Lines Nos. 0 and 0¾ were braced diagonally; 0¾ was completed and had 270 feet on the outer end braced diagonally; No. 8 was extended 260 feet and had 1,085 feet of its length strengthened by a second row of clumps. (For amount of work done see Table No. 6.)

*Chesterley Island.*—The work of reveting the head of the island was continued until September 25, 1893, when it was suspended for want of material.

Part of this work consists of a mattress built over a mass of drift and sand on the north side of the hurdle line; this has been considered as bank protection in the accompanying table of work done. The revetment here was very heavy in places and had a layer of spalls under the riprap where the bank was of soft material. (For amount of work done see Table No. 7.)

### GENERAL METHOD OF CONSTRUCTION.

*Hurdles.*—The method of constructing a hurdle is as follows: A continuous woven mat, 112 feet wide, is built on way flats and sunk according as it is launched until the entire length has been completed. This mat is attached to clumps of piles, driven 100 feet above, by means of wire cables and is held floating in position by them until sunk, when the cables are taken up. A row of drift clumps of 4 piles each is driven along this mat at a distance apart of 10 feet from center to center of clumps. This row of clumps forms what is termed the drift row or hurdle proper, and is driven, as nearly as conditions permit of, to a 25-foot stage. It is sometimes strengthened by diagonal bracing or by another row of clumps driven close up behind.

At the outer end of the hurdle a T-head mat is constructed and sunk up and down stream; this has a width of 112 feet and a length of from 300 to 400 feet, and commences 100 feet above the upstream edge of the other mat. When this is completed and sunk the hurdle row of clumps is extended out 30 feet on it, and then a drift catcher consisting of about 8 clumps is driven upstream. This T-head mat acts as an apron to prevent scour from the channel end of the hurdle.

A mat about 350 feet long is also constructed on the shore end of the hurdle in order to prevent the bank from scouring, and above this is placed a stone revetment to about a 20-foot stage. This shore mat is usually built before the others. As soon as a hurdle is completed a curtain is usually built on the upper side and sunk in a

perpendicular position against the clumps in order to further check the current and cause a deposit.

At the ends of some of the hurdles at Pulltight ice-breakers were constructed. These were of two kinds. One consisted of a solid brush and stone buttress built by sinking one mattress on top of another until the desired height had been obtained, the other of a cluster of about 60 clumps of piles in triangular shape pointing upstream. In the first case the mattresses decreased in size from the bottom up.

*Bank protection.*—Bank protection usually consists of a continuous woven mat, from 120 to 130 feet wide, built alongshore in way flats, and sunk as built. It is sunk so that the inshore edge will come where the plane of a 4-foot stage of water intersects the bank, and above that is then revetted with rock. Sometimes, when it is necessary to protect a flat, soft bank, a mattress is built in place as a foundation for the stone, and this may be either a woven or grillage mattress.

At Twin Hollows, west, three kinds of mattresses were used in such a place, i. e., woven willow, grillage, and willows woven with wire cables.

*Drift mats.*—Drift mats are built over bodies of drift in order to sink them. They are always grillage mats, and are built of such thickness as is required to bear the weight of the stone necessary to sink the drift below.

#### DETAILS OF CONSTRUCTION.

*Foundation mattress.*—The way flats being made fast together, a header built up of a number of pieces of heavy brush is constructed on the lower end of the ways. To this are fastened at right angles weaving poles at a distance of from 4 to 6 feet apart, depending on the size of the weaving brush to be used; a second pole like the first is then fastened on top of these, and the whole well fastened with wire and spikes. The weaving then commences by working the brush under and over every other weaving pole and alternating across the mat so as to give it strength against tearing apart lengthwise in sinking. As the brush is placed it is fastened to the weaving poles with 20-penny nails, one being put in every third piece of brush. As soon as the length of the ways is completed in this manner extra poles are fastened along the second weaver from the upper edge and thoroughly fastened to it; the cable is then made fast to this, the upper end having been previously fastened around one of the piles of a clump driven 100 feet above by means of a chain and allowed to sink to the bottom.

Small cables are put in across the mat where the sinking cables come, and are fastened with a hitch around every alternate weaving pole. Sometimes several extra poles are fastened on a mat, and also wire cables running longitudinally, this depending on the current and the depth of water the mat is to sink in. As soon as the section of mattress on the ways is completed it is launched by pulling the flats from under it until only the edge remains unlaunched. New poles are then spliced to the ones in the section already built and the same process is gone through again and repeated until the mat is finished, when another header is put on and it is launched clear of the flats. When the mat is of considerable length it is sunk as the construction progresses. Before sinking, the upper edge of the mat is made fast by slip lines to flats, so hung from the piling as to float just above it. These slip lines are let go as soon as there is sufficient stone on the mattress to make it sink quickly. In weaving, the butts of the brush are always placed pointing out from the center of the mat.

*Shore-protection mattress.*—This is constructed in a similar manner to the foundation mattress, but is fastened either to piling along the inshore edge by means of yokes or to dead men buried in the bank by means of lines.

*Clumps of piles.*—These usually consist of 4 piles to the clump, driven at such distance apart as will give the greatest spread without causing them to break when drawn together. The piles are pulled together by a pile-driver and then bound securely with a wire rope wrapped three or four times tightly around, and fastened to them by 6-inch and 8-inch spikes driven nearly home and then turned over the wire so as to clinch it.

*Curtains.*—The construction of a curtain is as follows: A stringer of single poles is first fastened along a hurdle line at convenient height; then a number of poles are fastened to this at right angles and of such length as to reach the bottom of the river when sunk and leaving several feet extending up above. Outside of these poles a second row of stringers is placed over and fastened to the first. The ends of the poles rest on flats, and crosspieces of light saplings are nailed to them at intervals, beginning with 3 inches at the bottom and increasing to 6 inches at the top, and this is carried up to such distance on the poles as will bring the curtains to the desired height when sunk. A sufficient quantity of stone is then fastened by wire to the lower end of the curtain, the flats are pulled out from under it, and it sinks, being drawn down against the piling by the current. The fastenings connecting the perpendicular poles with the stringers are then cut, allowing the former to slide down between the latter should a scour occur.

1598 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

*Diagonal bracing.*—Two diagonal braces inclined at from 35° to 45° with the horizontal are placed against each drift clump of the hurdle.

To hang these braces, three piles for a brace clump are first driven opposite and below each drift clump in triangular form, the apex being upstream and the base running in line parallel with the hurdle. A clevis is then fastened through the end of the brace, which is lifted up by a pile-driver and hung over one of the piles in the base of the pile clump. The brace is worked down until the butt rests on the mat, and the head is then lowered against the clumps, to be braced where it is bolted to one or two of the piles of same by 1-inch bolts. The brace from the right-hand pile of the base of brace clumps is hung over to the drift clump on the right of the one directly above, and the brace from the left-hand pile of same base to the clump on the left of the one above, so that when the bracing is finished each clump in the drift row or hurdle proper has its braces spread at the butts and crossing the braces to the clumps on its right and left, thus getting support against side as well as against direct pressure. The piles of brace clumps are then drawn together and wired. The distance between the upstream pile of the brace clump and the other two depends on the depth of water, and the distance between the piles in its base is from 3 to 5 feet.

*Strengthening clumps.*—These are driven from below a hurdle line as close up to the center of the spaces between the drift clumps as the pile-driver can get, and of the same construction as the latter, but usually left out to a lower stage of river.

The upper piles of these clumps enter the ground above the downstream piles of the drift clumps, but when they are clumped they cross the latter. A stringer is then placed above the intersection of these piles and bolted to the back row, so that the hurdle row gets immediate support when any strong pressure comes against it.

RESULTS AND OBSERVATIONS.

There has been considerable filling all along the hurdles during the past year, especially at the upper end of Pulltight, where it amounts to 25 feet in places. At Twin Hollows, west, there has been a deposit of from 6 to 12 feet, and at Horsetail Bar, east, during the past two months, while the work was in progress, there has been a filling of from 4 to 8 feet. The quickest and heaviest deposits have been on the Illinois side of the river, but the material is entirely different on the two sides of the river, it being principally silt on the Missouri side and sand on the Illinois. The filling is greatest on the outer ends of the hurdles, but is fairly uniform in to shore. The greatest deposit at the beginning of the season was found below the cluster of clumps at the outer end of line 0½, Pulltight, which were driven late last fall.

The following tables show the work done in detail:

TABLE NO. 1.—Work done at Horsetail Bar, west.

Bank-protection mattress constructed and sunk (2,485 by 130 feet) ..sq. feet..	323,050
Bank revetted above mattress (1,958 linear feet) ..do....	48,950
Bank excavated ..cubic yards..	1,400
Piles driven ..	19

TABLE NO. 2.—Work done at Horsetail Bar, east.

	At Hurdle No.—				
	20½.	22½.	24½.	27½.	29½.
Hurdle completed ..linear feet..	220	430	670	950	800
Hurdle braced ..do.....		430	625		
Hurdle strengthened ..do.....	200			880	820
Foundation mattress constructed and sunk.....	325×112 112×90	615×110	745×110 105×112	40×90 205×110 1015×112	1220×110 110×112
Shore mattress constructed and ballasted ..	325×30				
Curtain constructed ..		420×19	632×12.3	853×11.6	850×9.7
Revetment at end of hurdle ..sq. feet..	14,625	4,622	14,760	15,036	14,665
Excavation ..cubic yards..			1,110	1,208	
Piles driven ..number..	203	427	528	855	795
Braces placed ..do.....		79	113		
Stringers placed ..do.....	6			26	15

**APPENDIX X—REPORT OF MAJOR ALLEN. 1599**

**TABLE NO. 2.—Work done at Horstall Bar, east—Continued.**

	At Hurdle No.—			Total.							
	20½.	31½.	32½.								
Hurdle completed.....linear feet..	670	520		4,340							
Hurdle braced.....do.....				1,055							
Hurdle strengthened.....do.....				1,900							
Foundation mattresses constructed and sunk.....	995×112	<table border="0"> <tr><td>40×80</td></tr> <tr><td>990×112</td></tr> <tr><td>70×50</td></tr> <tr><td>108×40</td></tr> <tr><td>135×65</td></tr> </table>	40×80	990×112	70×50	108×40	135×65	550×112	<table border="0"> <tr><td>*7,450</td></tr> <tr><td>†804,485</td></tr> </table>	*7,450	†804,485
40×80											
990×112											
70×50											
108×40											
135×65											
*7,450											
†804,485											
Shore mattress constructed and ballasted.....				<table border="0"> <tr><td>*325</td></tr> <tr><td>†9,750</td></tr> </table>	*325	†9,750					
*325											
†9,750											
Curtain constructed.....	600×0.1	520×7		<table border="0"> <tr><td>*3,819</td></tr> <tr><td>†40,424</td></tr> </table>	*3,819	†40,424					
*3,819											
†40,424											
Revetment at end of hurdle.....square feet..	3,520	24,576	9,190	100,424							
Excavation.....cubic yards..				2,376							
Piles driven.....number..	366	291	47	3,536							
Braces placed.....do.....				197							
Stringers placed.....do.....				61							

\* Linear feet. † Square feet.

**TABLE NO. 3.—Work done at Carrolls Island.**

	At Hurdle No.—				Total.		
	2.	3.	4.	5.			
Hurdle completed.....linear feet..	800	670	450	340	2,200		
Hurdle strengthened.....do.....				280	280		
Foundation mattresses constructed and sunk.....	1,030×85	1,000×100	900×100	650×100	<table border="0"> <tr><td>*3,480</td></tr> <tr><td>†332,550</td></tr> </table>	*3,480	†332,550
*3,480							
†332,550							
Curtain constructed.....linear feet..	800	670	450	340	2,200		
Revetment at end of hurdle.square feet..	3,000	3,600	4,000	8,400	19,000		
Piles driven.....square feet..	289	303	189	263	1,044		

\*Linear feet. †Square feet.

**TABLE NO. 4.—Work done at Twin Hollows, east.**

Bank revetted (scattered in repairing old work)..... Square feet. 9,420

**TABLE NO. 5.—Work done at Twin Hollows, west.**

	At Hurdle No.—															
	2½.	3.	3½.	4.	4½.											
Hurdle completed.....linear feet..	270	425	705	650	425											
Hurdle braced.....do.....	240	425	685	630												
Foundation mattresses constructed.....	<table border="0"> <tr><td>290×100</td></tr> <tr><td>385×60</td></tr> </table>	290×100	385×60	<table border="0"> <tr><td>390×60</td></tr> <tr><td>410×90</td></tr> </table>	390×60	410×90	<table border="0"> <tr><td>600×100</td></tr> <tr><td>180×60</td></tr> <tr><td>250×94</td></tr> </table>	600×100	180×60	250×94	<table border="0"> <tr><td>607×100</td></tr> <tr><td>395×60</td></tr> </table>	607×100	395×60	<table border="0"> <tr><td>422×70</td></tr> <tr><td>400×100</td></tr> </table>	422×70	400×100
290×100																
385×60																
390×60																
410×90																
600×100																
180×60																
250×94																
607×100																
395×60																
422×70																
400×100																
Foundation mattress sunk.....	<table border="0"> <tr><td>290×100</td></tr> <tr><td>385×60</td></tr> </table>	290×100	385×60	<table border="0"> <tr><td>390×60</td></tr> <tr><td>410×90</td></tr> </table>	390×60	410×90	<table border="0"> <tr><td>600×100</td></tr> <tr><td>180×60</td></tr> <tr><td>250×94</td></tr> </table>	600×100	180×60	250×94	<table border="0"> <tr><td>607×100</td></tr> <tr><td>395×60</td></tr> </table>	607×100	395×60	<table border="0"> <tr><td>422×70</td></tr> <tr><td>400×100</td></tr> </table>	422×70	400×100
290×100																
385×60																
390×60																
410×90																
600×100																
180×60																
250×94																
607×100																
395×60																
422×70																
400×100																
Shore mattress constructed and ballasted.....	170×30			<table border="0"> <tr><td>150×60</td></tr> <tr><td>60×40</td></tr> <tr><td>80×30</td></tr> </table>	150×60	60×40	80×30	100×50								
150×60																
60×40																
80×30																
Drift mattresses constructed and ballasted.....	<table border="0"> <tr><td>215×60</td></tr> <tr><td>165×30</td></tr> <tr><td>240×50</td></tr> </table>	215×60	165×30	240×50	60×40	235×50	<table border="0"> <tr><td>230×50</td></tr> <tr><td>246×40</td></tr> </table>	230×50	246×40	<table border="0"> <tr><td>270×35</td></tr> <tr><td>76×30</td></tr> <tr><td>125×25</td></tr> </table>	270×35	76×30	125×25			
215×60																
165×30																
240×50																
230×50																
246×40																
270×35																
76×30																
125×25																
Curtain constructed.....		420×15	640×16.7	626×16.8	427×12.4											
Revetment at end of hurdle.....square feet..	8,000	6,500	8,000	16,150	12,410											
Piles driven.....number..	180	306	500	408	196											
Braces placed.....do.....	47	33	117	97												
Excavation for hurdles.....cubic yards..					1,000											
Excavation for bank protection.....do.....																
Bank protection mattresses constructed and sunk, square feet.....																
Bank revetted and protected.....																



1600 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

TABLE NO. 5.—Work done at Twin Hollows, west—Continued.

	At Hurdle No.—			Total.
	5½.	6.	7.	
Hurdle completed.....linear feet.....		165	260	2,900
Hurdle braced.....do.....				1,980
Foundation mattress constructed.....		{ 185×100 250×60 67×50 }	{ 170×60 145×85 }	* 5,146 † 420,015
Foundation mattress sunk.....		{ 185×100 250×60 67×50 }	{ 170×60 205×85 }	* 5,208 † 425,115
Shore mattress constructed and ballasted.....		105×100	100×68	* 720 † 38,500
Drift mattress constructed and ballasted.....			530×50	* 2,402 † 107,080
Curtain constructed.....		230×3		* 2,352 † 83,515
Revetment at end of hurdle.....square feet.....	6,643		2,893	60,596
Piles driven.....number.....		91	102	1,783
Braces placed.....do.....				294
Excavation for hurdles.....cubid yards.....	256			1,256
Excavation for bank protection.....do.....				800
Bank protection mattress constructed and sunk, square feet.....				241,710
Bank revetted and protected.....				* 2,030 † 64,149

\* Linear feet.

† Square feet.

TABLE NO. 6.—Work done at Pulltight.

	At Hurdle No.—				
	0.	0½.	0¾.	1.	4.
Hurdle completed.....linear feet.....	550	1,060	1,400	550	
Hurdle repaired.....do.....	75			750	
Hurdle braced.....do.....	550	1,060	270	1,040	
Hurdle strengthened.....do.....	550				
Foundation mattress constructed.....	750×06	{ 1,100×96 500×112 }	{ 1,360×100 260×112 90×50 }	{ 550×100 250×112 }	
Foundation mattress sunk.....	750×06	{ 1,100×96 500×112 }	{ 1,360×100 260×112 90×50 }	{ 700×100 250×112 }	
Shore mattress constructed and ballasted.....				225×100	
Buttress mattress constructed and ballasted.....	{ 80×50×6 65×50×6 50×40×4 }			{ 79×60×2 87×50×3 55×51×3 }	
Curtain constructed.....		1,000×12	1,400×11.5	1,780×15.7	1,170×16.5
Revetment at end of hurdles.....sq. ft.....	27,930	27,700	19,685	5,280	
Piles driven.....number.....	808	813	608	716	
Braces placed.....do.....	83	256	43	163	
Bank revetted.....					

	At Hurdle No.—			Total.
	6.	7.	8.	
Hurdle completed.....linear feet.....	650	1,200	1,235	6,645
Hurdle repaired.....do.....				825
Hurdle braced.....do.....	610			3,530
Hurdle strengthened.....do.....			1,085	1,635
Foundation mattress constructed.....	700×95	2,000×100	1,100×110	* 8,060 † 873,720
Foundation mattress sunk.....	770×95	2,000×100	1,100×110	* 8,880 † 895,370
Shore mattress constructed and ballasted.....	150×65		300×110	* 675 † 65,250
Buttress mattress constructed and ballasted.....				* 9,400 † 3,013.6
Curtain constructed.....	1,650×7	1,400×20	1,000×25	* 9,400 † 139,931
Revetment at end of hurdles.....square feet.....			11,100	91,755
Piles driven.....number.....	459	540	845	4,840
Braces placed.....do.....	119			664
Bank revetted.....				* 450 † 23,240

\* Linear feet.

† Square feet.

‡ Cubic yards.

TABLE NO. 7.—Work done at Chesley Island.

	Linear feet.	Square feet.
Revetment placed .....	632	88,375
Drift mattress constructed.....	200	26,750
Drift mattress ballasted.....	200	26,750
Curtain constructed.....	60	450

TABLE NO. 8.—Summary and distribution of work done during fiscal year ending June 30, 1894.

	Hurdles.	Bank protection.
	Lin. ft.	Sq. feet.
Total work done.....	16,145	785,644
Work done at Horsetail Bar, west.....		372,000
Work done at Horsetail Bar, east.....	4,340	
Work done at Carrolls Island.....	2,260	
Work done at Twin Hollows, east.....		9,420
Work done at Twin Hollows, west.....	2,900	305,859
Work done at Pulltight.....	6,645	33,240
Work done at Chesley Island.....		65,125
Hurdle repaired at Pulltight.....	825	

The ruling channel depths during the low water of 1892 and 1893 are shown in the following table, all being reduced to standard low water:

	Sept. 25, 1893.	Sept. 28, 1893.	Sept. 26, 1892.
	Feet.	Feet.	Feet.
At Arsenal.....	6.9		5.8
At Quarantine.....	9.4		
At Pulltight.....	8.4		3.8
At Meramec.....	9.4		5.3
At Sulphur Springs.....	4.4		11.8
At Waters Point.....		6.4	
At Bushberg.....		9.4	

Very respectfully, your obedient servant,

GERALD BAGNALL,  
Assistant Engineer.

Maj. CHAS. J. ALLEN,  
Corps of Engineers, U. S. A.

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

On works at Fort Chartres and Rush Tower.

RUSH TOWER WORKS, June 30, 1894.

MAJOR: I have the honor to submit the following report on the progress of the works for the improvement of the Mississippi River near Fort Chartres and Rush Tower during the fiscal year ending June 30, 1894.

FORT CHARTRES WORKS.

*Revetment.*—The revetment placed on the Illinois bank below Sycamore Landing in the fall of 1892 is in excellent condition and has performed its office most satisfactorily.

During the high-water season of 1893 the river graded the bank above the mattress to a slope favorable for the reception of stone, which, in September and October, was placed between the levels of the 10 and 22 foot stages of the river (St. Louis

## 1602 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

gauge) over 3,750 feet of the bank from the upper end of the mattress, leaving 1,750 feet yet to be revetted, although in this portion of the work slight repairs were made to the narrow riprap placed in 1892.

The stonework should be extended to the end of the mattress, as the bank is now ready to receive it. Below the mattress, for 9,000 feet to Fort Chartres Landing, the heavily wooded bank is caving rapidly and needs protection.

Opposite the landing 3,500 feet of its east bank to the foot of Bruce Island is also undergoing severe erosion, although the upper half of this stretch has not yet been cut back to the 2,500-foot channel limit. The outside of the bar above the island is also cutting.

This general erosion is evidence that the system of hurdles next the Missouri shore, although too recently constructed to be silted up to the desired level, is having a very appreciable effect in contracting and on the direction of the channel.

### HURDLES.

During the year 6 hurdles, Nos. -3, -2, -1, 0, 1, 1½, have been added to the Fort Chartres system. Of these, 5, Nos. -3 to 1, inclusive, were begun last fall and are spaced as follows: 2,200 feet between Nos. 1 and 2, 1,800 feet between Nos. 1 and 0, and 1,500 feet between the others. In May, Hurdle No. 1½ was constructed halfway between Nos. 1 and 2.

These hurdles all begin within 100 to 200 feet of the Missouri shore, or as close as piles could be driven to the rock ledge projecting under the bed of the river from the adjacent bluff, and they extend out 1,200 to 1,900 feet to the west limit line for the channel. The outer ends of Nos. -3 to 0, inclusive, are on this line, but Nos. 1 and 1½ end at the high banks of Bruce Towhead and Island, respectively, the former bank being protected with a mattress and heavily revetted with stone to the top.

The main shore connections for all lines but No. 1 consists in part of low stone dikes brought to the 5-foot stage, and founded on each of these dikes, except in line No. -2, is a series of heavy stone piers 25 feet between centers, raised to a 23-foot level. There are 9 piers in line No. -3, 5 each in Nos. -1 and 0, and 6 in No. 1½. Similar connections will be made in lines Nos. -2 and 1 should they be needed. The use of such piers is thought to be preferable to solid stone dikes for permeable works, especially at high stages of water exerting maximum pressures.

Above all lines, except No. 1½, drift has been sunk in one or two tiers 35 to 50 feet in width, and in some instances supplemented with heavy brush mattresses up to the level of a 12-foot stage. Above hurdles Nos. -3 and -1 enormous masses of drift remain unsunk.

At the outer ends of Nos. -3 and -2 T-head mattresses, 300 by 100 feet, have been sunk, and heavy triangular buttresses, 50 by 50 feet, of brush and stone, raised to 12 and 15 foot levels and surrounded by clumps of piles, have been placed.

All of the hurdles are founded on the usual brush mattresses, about 100 feet in width, woven continuously on flats and sunk, except for 3,155 feet (combined length) in lines Nos. -1, 0, and 1, which were fabricated last fall in place on the dry sand bar. It was impracticable to weave this portion of the mattress, so they were made in two cross layers of brush bound between top and bottom grillage, and were ballasted with stone, all materials being hauled to place on trucks running on tracks of willow poles laid on the sand, a pile-driver furnishing the necessary power. This construction was tried as an experiment, but is not recommended for general use, for the reasons that it is inferior in strength to the woven mattress; its top grillage renders it easily liable to injury from passing drift, and when torn it quickly breaks up; it is loose and does not hold stone well, especially on steep slopes or banks caving under one edge of the mattress, as is often the case. Could the mattress be woven on the dry sand bar for a commensurate cost, the advantage would be great, but the ultimate gain with a loosely laid mat is not apparent.

The woven mattresses were sunk on ¼-inch wire cables leading to the bases of anchor piles driven 100 feet above the upper edge of the mattress. The anchor piles were spaced 15 to 100 feet (average 30 feet) apart, corresponding to the strength of current in which the sinking had to be done. The cables were recovered by special releasing devices and used repeatedly, 12 cables with chains, trippers, and shackles making a full complement for one mattress gang.

For clumping the piles which were all driven through the foundation mattresses, bolts were rejected altogether because of their tendency to split the piles under strain and the slow rate at which the latter could be bored for them. Cables were used instead, 18 to 30 feet in length. They were made on the ground of 18 strands No. 14 galvanized wire, and cost about 1 cent per linear foot at present prices for labor and material. In use from 3 to 5 full turns of cable were taken around each clump, each turn being drawn taut by a pile-driver engine and caught to each pile with a 6-inch by ½-inch boat spike driven well in above the cable, the head of the spike being clamped hard down on it. Above the top turn on each pile an 8-inch

by  $\frac{1}{2}$ -inch spike was driven and turned down over all. The eyes at the cable ends were also secured to the piles.

This fastening is cheaper than bolts, is much more quickly placed, is more flexible under strain, and has no tendency to injure the piles; in fact, the reverse is the case. The attempt was made to pull several of them off, but the Mundy hoisting engine on the pile-driver was not able to loosen them except one strand at a time. So far as known not a single cable has given way, although huge fields of drift have lodged against the hurdles.

Bolts, 1-inch diameter, were used with all cross braces and as top fastenings for the braces, although a few of the latter at the west end of line No.  $1\frac{1}{2}$  were secured with cables as an experiment. Clevises of  $1\frac{1}{2}$ -inch iron were used to secure the lower ends of all braces.

The distribution of the piling and the condition of the various hurdles at the close of the year, beginning with the hurdle furthest upstream, are as follows:

*Hurdle No. 3.*—This is the head line, and strongest in the system. It is 1,225 feet in total length, of which 22 feet next shore are occupied by the stone dike and nine piers described.

The piling consists of a principal row of clumps, 8 feet between centers, of 7 piles each, driven in pairs, with the odd pile upstream. The latter pile carries a brace running to the top of a pile 10 feet above the clump, and 10 feet above this line of single piles is a second similar row, the space between the two being filled to the 5-foot stage with brush and stone. This low dike extends from the shore connection on the west to the buttress into which it spreads at the east end of the line. A brush curtain to the 12-foot stage was placed above the dike.

Below the clumps (10 feet) a third row of single piles was driven, from which braces lead to the clumps, and over the tops of the braces cross braces were placed, reaching from the third to the first row of single piles, to both of which, as well as to the clumps, they were bolted.

The hurdle was entirely completed during the fall season and contains  $1\frac{1}{2}$  sticks of pile timber per linear foot of line. In the spring the drift which had collected above it was sunk and the tops of the piers, which at first had been raised to the 17-foot level only, were raised to 22 feet after having been slightly damaged at a 23-foot stage of river by drift dragging over them.

The hurdle is in excellent condition and a large quantity of drift remains unsunk along its entire front.

The remaining hurdles were constructed alternately with (lines Nos. —2, 0, and  $1\frac{1}{2}$ ) and without (lines Nos. —1 and 1) braces or cross braces, to determine the relative efficiency of these methods of construction, of which the second seems the cheaper and quicker to build, and it being thought also that a brace heeled against its back pile, with a loose clevis and with the tendency of its top bolt to split out under strain, might prove an inferior element in the strength of the structure to the same stick well driven as a pile.

To aid in the comparison each hurdle was constructed with an allowance of one stick of pile timber for each foot in length of line. This necessitated a slight difference in the spacing of the clumps, 10, 9, and 8 feet all being used when the same number of sticks were called for in the construction of the bent as the combination of the unit of structure in both rows may be called. The arrangements are given in the following table:

	Distance between rows of clumps.	Piles in clump in upstream row.	Piles per clump in downstream row.	Braces placed.	Cross braces placed.	Total sticks pile timber per bent.	Space between bents.	Remarks.
	Feet.						Feet.	
Hurdle No. —2 .....	25	5	3	1	1	10	10	
Hurdle No. —1 .....	5	4	4	0	0	8	8	Clumps staggered.
Hurdle No. 0 .....	25	4	3	1	1	8	8	
Hurdle No. 1 .....	5	4	4	0	0	8	8	Clumps staggered same as No. —1.
Hurdle No. $1\frac{1}{2}$ .....	25	4	3	2	0	8	8	

At least one pile in each clump in the upstream row reaches to the 25-foot level, and none of the other piles are below 20 feet. The cross braces are placed at about the latter level and rest on the heads of the braces, which were never set at a higher angle than 45 degrees. These levels and the arrangement of braces and cross braces apply also to Hurdle No. —3.

1604 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

*Hurdle No. — 2.*—This line is 1,550 feet in length, 150 feet of which consists of a low stone dike, above which piers were omitted, since at no time has the current been at all swift through this gap, owing to the thorough protection afforded by Hurdle No. —3, although the river rose to a 23-foot stage.

The piling consists of a row of 5-pile clumps (odd pile above), spaced 10 feet between centers, and supported by braces and cross braces from a row of 3-pile clumps, 25 feet below. The latter were driven with the odd piles downstream, to carry the braces which pass between the upper two piles in each clump, which were purposely driven close together to prevent the heels of the braces from slipping to either side of the lower piles.

This line is entirely completed with T-head mattress and buttress at east end and sunken drift along its front.

*Hurdle No. — 1.*—The total length of the line is 1,900 feet, of which 225 feet consists of a low stone dam, on which have been raised five stone piers, the former having been placed in the fall and the latter in May, on account of the heavy flow of water over the dike, due to the draw toward the Missouri shore of the current around the outer end of Hurdle No. —2, and between that hurdle and the bar at the outer end of this line.

One row of 3-pile clumps, 10-foot centers, was driven over a portion of the line and the mattress was extended full length in the fall. The piling was also curtained to a 12-foot stage. During the winter the piling was broken by ice near the Missouri shore, and the bar mattress was damaged by drift. Both of these injuries were repaired in the spring, the latter by weaving a section of mattress above it and carrying the hurdle around the injured place to avoid the deep water immediately below and due to it, and the former by restoring the piling with heavy 4-pile clumps, 8-foot centers, supported by a second similar row, close below, in which the clumps were driven in the spaces between (were staggered with) those in the upper row. All of the fall work was strengthened in this manner, the upper row was extended to the end of the line, and the lower row to within 500 feet of that point, when it was abandoned on account of water too shoal to float the drivers.

For the same reason the T-head mattress and the buttress could not be constructed.

Drift has been sunk above the hurdle to the 12-foot stage and there yet remains a field 250 feet wide along its entire length.

*Hurdle No. 0.*—The total length of this hurdle is 2,150 feet, of which 150 feet at the west end are occupied by a stone dike and 5 piers; 450 feet of the hurdle at its east end on the sand bar is void of piling, although the foundation mattress was laid there during the fall, when also the piling, begun as a single row of curtained 3-pile clumps, was driven from the Missouri shore to the bar. During the winter the west half of this work was badly damaged by ice, but it was repaired in the spring with 4-pile clumps, 9-foot centers, strengthened with braces and cross braces from a second row of 3-pile clumps driven 25 feet below. The double row was extended to the new bar line 1,000 feet from the outer end of the mattress, and the front row was carried 550 feet farther. Beyond this point a high-water stage (27 feet, St. Louis gauge) will be required to complete the work.

The T-head and buttress, of course, are lacking.

The drift above the line was sunk to the usual level.

*Hurdle No. 1.*—The hurdle is 1,700 feet in length, but in 200 feet of this next the rock shore piles could not be driven, as in the case of the piers for No. —2 a dike does not yet seem necessary, as the hurdles above seem to check the current here effectually, the only additional water entering the pool above this hurdle coming from the main river running upstream across the bar and around the upper end of the tow-head at stages over 12 feet. The piling extends complete to within 75 feet of the tow-head; part of it was driven last fall, was broken by ice in the winter, and was repaired, strengthened, and extended in the spring. It consists of a double row of 4-pile clumps, staggered as in No. —1.

The tow-head bank at which the hurdle ends was protected by a mattress and heavily revetted with stone for 175 feet on each side of the line.

*Hurdle No. 1½.*—The length of this line is 1,600 feet between the high banks of the Missouri shore and Bruce Island. At its west end 175 feet are taken up with the dike and piers made necessary in part by the inflow of water between the tow-head and island from the main river. At the east end the same space is vacant, owing to the elevation of the dry bar there next the island. Between these two spaces the hurdle is entirely completed, having been built May 1 to 31.

The piling is driven in a row of 4-pile clumps, 9-foot centers, each clump supported by 2 braces leading back diagonally, one on either side, to 3-pile clumps driven opposite the spaces (staggered) in the upper row and in a line 25 feet below it.

Cross braces were not used, nor was there drift enough above the line to sink.

To protect the west half of the line, which was driven through a top layer of soft silt, a thick mattress of rough brush loosely laid, 750 by 36 by 3 feet, was sunk. Stone was used very freely, especially around the piles, throughout this soft section.

*Hurdles Nos. 2 and 3.*—Constructed in 1892. The smaller gap reported last year at the west end of the line was closed. No other work was attempted on either of these lines owing to the excessive depths still found through their main gaps.

The location of the hurdles and the depths of water found throughout this reach are shown on the chart accompanying the report for May.

It will be seen that a very considerable deposit has been gained by the hurdles and that the bars below the series have been augmented, with lessened depths along the west shore of Bruce Island, despite the general low water of the year, the spring rise (to 23 feet only) affording the only opportunity to collect sediment, as the June flood has not yet appeared.

The present state of the hurdles insures during the low-water season the concentration of the entire flow of the river at this point in the channel between Bruce Island and the Illinois shore, which can only result in at least a partial relief from the obstructing bar. Much greater effect might have been expected had the usual June rise occurred.

The work of the year was begun September 1 and continued until November 24, under Mr. J. O. Holman, assistant engineer.

It was resumed March 15 and carried on until the close of the year.

At the end of May the force was reduced from 350 men and 12 pile-drivers, to 30 men at Fort Chartres for stonework done in June, and 75 men and 2 pile-drivers for work at Rush Tower. The remainder of the force was discharged and the plant was placed in harbor at the latter work.

RUSH TOWER WORKS.

During October and November the revetment of the Illinois bank between Osborne Field and Durfecs Landing was extended upstream 1,970 feet, with a protection mattress to low-water mark and with stone to the level of a 10-foot stage. In addition, about 3,000 linear feet of the stonework placed in 1892 above the old mattress, was repaired and raised to the 16-foot contour.

The repair of Hurdle No. 3 of this system began May 29 and continued until June 30.

A foundation mattress was laid anew in both gaps in this hurdle. The piling was entirely restored in the east gap, 275 feet wide, and for the west gap, 330 feet wide, a screen of 4-pile clumps was driven entirely across it, but 175 feet above the old line to avoid the deep water encountered there. The end connections between this screen and the old work have not yet been made.

The work is too recent to have exerted any influence upon the channel in the vicinity.

The amount of the various kinds of work done on each hurdle, the expenditures in labor and materials, and the service of plant, are given in the following tables:

TABLE NO. 1.—Work done at Fort Chartres.

HURDLES, WEST SHORE.

	No. -3.	No. -2.	No. -1.	No. 0.	No. 1.	No. 1½.	No. 2.	Total.
Hurdles.....linear feet..	1,225	1,550	1,000	1,600	1,700	1,400	175	9,550
Piles driven.....number..	1,240	1,312	1,405	1,237	1,108	1,005	133	7,500
Piles driven.....depth, feet..	15,573	17,109	20,817	17,435	14,882	17,410	1,532	104,758
Braces.....number..	210	130	.....	81	.....	270	.....	691
Cross braces.....do..	127	142	.....	114	1	.....	.....	384
Foundation mattress.linear feet..	1,005	1,505	2,105	2,270	1,885	1,468	.....	10,298
Foundation mattress...sq. feet..	100,500	156,650	196,075	218,600	182,320	165,880	.....	1,020,025
T-head mattress.....linear feet..	200	285	.....	.....	.....	.....	.....	485
T-head mattress.....square feet..	20,000	31,350	.....	.....	.....	.....	.....	51,350
Drift mattress.....linear feet..	1,951	1,208	2,600	1,959	1,972	804	.....	9,954
Drift mattress.....square feet..	84,740	43,370	82,535	92,982	92,657	22,464	.....	418,748
Curtain.....linear feet..	1,000	.....	550	750	.....	.....	.....	2,300
Revetment.....do..	170	.....	.....	.....	340	.....	.....	510
Revetment.....square feet..	4,080	.....	.....	.....	4,700	.....	.....	8,840
Shore dikes with piers above, linear feet.....	225	.....	150	150	.....	150	.....	675
Shore dikes with piers above, number.....	9	.....	5	5	.....	6	.....	25

BANK PROTECTION, EAST SHORE.

	Linear feet.	Square feet.
Station 0 to 37 + 50, extension of revetment.....	3,750	203,370
Station 37 + 50 to 55, old revetment repaired.....	300	5,400

1606 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

TABLE NO. 2.—Work done at Rush Tower.

HURDLE No. 2, WEST SHORE.

Length of hurdle .....	linear feet..	400
Piles driven .....	number..	881
Piles driven, depth.....	feet..	14, 495
Foundation mattress.....	{ linear feet.....	872
	{ or square feet..	80, 183

BANK PROTECTION, EAST SHORE.

	Linear feet.	Square feet.
Protection mattress.....	1, 970	236, 400
Revetment above new mattress .....	1, 970	48, 079
Revetment, extension of old .....	2, 985	90, 170

Very respectfully, your obedient servant,

WM. S. MITCHELL,  
Assistant Engineer.

Maj. CHAS. J. ALLEN,  
Corps of Engineers.

REPORT OF MR. E. D. LIBBY, ASSISTANT ENGINEER, ON PROCURING BRUSH.

STE. GENEVIEVE, MO., June 30, 1894.

MAJOR: I have the honor to submit the following report of operations at procuring brush for the fiscal year ending June 30, 1894:

At the beginning of the fiscal year the brush party, consisting of 14 teams and 52 laborers, was engaged in procuring brush at upper Jim Smith's.

In order to supply the brush that was needed during the first half of the year, frequent changes of location were necessary, partly on account of the soft condition of the ground due to the high water of June, and partly from the small amount of brush that could be found at any one place.

The entire quantity of brush that was procured in the first half year was obtained at various points between Lower Horsetail Bar (East side) and Chesley Island.

The force remained the same as at the beginning of the year until August 21, when the number of teams was increased to 25 on account of the long haul. From this time to the close of the working season of 1893 frequent changes were made in the number of teams, in order to accommodate the force to the demand for brush and to the nature of the localities at which it was obtained. The greatest number employed during the fall season was 32, while procuring brush at Lower Horsetail Bar.

No material change was made in the number of laborers.

The force was disbanded for the winter on November 6, and the outfit was taken to Winter Harbor, at Chester, Ill.

Active operations for the season of 1894 were commenced at Turkey Island on March 15, the force consisting of 17 teamsters with teams and 40 laborers. This force was increased or reduced as the demand for brush and the conditions, at the various localities from which it was obtained, required.

The largest force during the spring season consisted of 32 teamsters with teams, and 49 laborers with their foreman and boarding crew.

During the last half year brush was procured at the following localities:

Turkey Island, Rush Tower Towhead, Lee's Island, Liberty Island, Hat Island, Grand Tower Towhead, Wittenberg, and Hamburg Island.

The force was disbanded on June 16 at Hamburg Island, and on June 19 the outfit was towed to Little Rock, Mo., and laid up, a few men being retained to care for the property.

Quarter barges with portable shanties were in use until September 21, on which date quarter boat No. 1 was received and put in service, and barge No. 25, with quarters, was sent to the engineer depot.

Derrick boat No. 1 was in service for loading brush during the larger part of the year. On the 8th of May derrick boat No. 2 was received and put in service, but

its use was discontinued after loading one barge, and it was sent to the engineer depot for repairs. It was received again on May 29, and was in service until the work closed.

There were procured during the year 32,691.89 cords of brush.

Very respectfully, your obedient servant,

E. D. LIBBY,  
*Assistant Engineer.*

Maj. CHAS. J. ALLEN,  
*Corps of Engineers, U. S. A.*

REPORT OF MR. E. D. LIBBY, ASSISTANT ENGINEER, ON PROCURING RIPRAP AT LITTLE ROCK, MO.

STE. GENEVIEVE, MO., June 30, 1894.

MAJOR: I have the honor to submit the following report of operations at procuring riprap at Little Rock, Mo., during the fiscal year ending June 30, 1894:

At the beginning of the year work was in progress at the lower quarry by a small force of men, the drilling being done by hand and the loading by a pile-driver fitted up as a derrick boat.

On July 27 one steam drill was put in service, and another on September 28.

Steam for operating these drills was at first taken from the boiler of the derrick boat, but this arrangement, besides being inconvenient on account of the long lines of pipe required to reach the drills, made too great a demand upon the boiler, and a self-propelling engine with boiler was hired, as a temporary expedient, to run the drills, and with so good success that it was kept in service during the remainder of the fall season. By its use much better results were obtained, as the boiler could at all times be kept in the immediate vicinity of the drills, thus doing away, in a great measure, with condensation of steam, and avoiding frequent changes of long leads of pipe.

With a few short delays for repairs the steam drills were in use until the work was closed for the winter.

The very low water that prevailed during the latter part of the working season of 1893 made it necessary to lower the track approaches to the derrick in order for the boom to reach the stone boxes. With this change, and some additions to the tracks in the quarry, loading by steam was carried on until active field work was closed for 1893.

In order to permit working at the upper quarry, the force was considerably increased and the shore parties put in service on July 10.

During the first half of the year the work at the upper quarry consisted largely in clearing away the earth in front of the ledge and in forming a terrace from which the work can be carried on at high stages of the river.

Late in September the demand for riprap became greater than could be filled by the force at the lower quarry, and in order to supply the amounts needed, quarrying was begun at the upper quarry, drilling and loading being done by hand.

On the 1st of October, barge No. 25, with quarters, was received for temporary service at the upper quarry, and the force at that locality was increased so as to give a capacity of about 300 cubic yards of riprap per day, and from this time on the procuring of riprap was carried on at both quarries until the close of the season of 1893.

On December 1 the force was reduced to about 20 men, who, during the winter and until active field work was resumed on March 17, were employed in clearing away spalls, stripping the earth from the top of the ledge, and constructing a stone pier for a site for steam derrick.

The force was increased on March 17 by the employment of 20 laborers, and active work for the season of 1894 was begun at the lower quarry. A small derrick with a boat crab for a hoist was used for loading the barges, but this arrangement proved only indifferently successful, as the derrick, designed for other purposes, was too light for the heavy service of loading. Its use was discontinued on April 6, and the force being further increased was transferred to the upper quarry, where drilling by hand and loading by barrows could be best carried on, but not with the same economy in cost as with steam power.

On the 23 of April a steam boiler and derrick, to be used with a steam hoist, were received from the engineer depot, and a small force was detailed to put them in position in the lower quarry, and fit them up for service. This work had so far advanced by May 9 that the boiler was ready for use, and one steam drill was started, and with slight interruptions was kept running as long as there was any demand for riprap.

The derrick was set up and made ready for loading by steam power, but pending the arrival of a steam hoisting engine was not immediately put into service.



## 1608 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

On June 7 the force was considerably reduced. Work which up to this time had been continued at the upper quarry was suspended, and the force was transferred to the lower quarry, where the small quantity of riprap still required could more readily be obtained. The new derrick was employed for loading purposes, a boat crab being used as a temporary expedient for the hoisting.

The work was thus continued until June 22, when active operations were suspended, and the force, with the exception of a few of the monthly men, were discharged.

During the year there were procured 54,206.3 cubic yards of riprap, of which quantity 31,066.4 cubic yards were from the lower quarry and 23,139.9 cubic yards from the upper quarry.

Quarter boat No. 6 was received on April 26 and was immediately put in service, the shore quarters being vacated. On June 11 barge No. 9 with office quarters, was also received.

During July, 1893, a magazine was constructed at a safe distance from both quarries, to be used in storing dynamite. The old magazine is used in storing exploders and caps.

Considerable work for the improvement of the quarries has been done during the year, the cost of which has been charged against the riprap procured during the year, and without an immediate return for the outlay, but the result of this work will be to lessen the cost of the riprap that shall be taken from the quarries, since the improvements are of a general character and their results lasting.

With the appliances used for loading by steam, in the first half year, 400 cubic yards of riprap were readily loaded in a day of eight hours.

During the latter part of the year, when the loading was done by the new derrick with a hand power hoist, 280 cubic yards of riprap was a day's work.

Employing the same force and loading by barrows 250 cubic yards could be loaded in ten hours.

When the steam hoisting engine shall be put in service, it is confidently expected that two fully-loaded barges, 580 cubic yards, per day will be easily loaded.

The advantages of steam drilling over hand drilling are very marked. The cost of drilling is very much reduced, and, as a matter of economy alone, all holes for blasting should be driven by steam drills.

Very respectfully, your obedient servant,

E. D. LIBBY,  
*Assistant Engineer.*

Maj. CHAS. J. ALLEN,  
*Corps of Engineers, U. S. A.*

### REPORT OF MR. C. D. LAMB, SUPERINTENDENT, ON OPERATIONS AT U. S. ENGINEER DEPOT.

UNITED STATES ENGINEER DEPOT,  
*St. Louis, Mo., June 30, 1894.*

MAJOR: I have the honor to submit the following report of operations at the engineer depot during the fiscal year ending June 30, 1894:

The construction and repairing of equipment was continued throughout the year, though the force was largely reduced during the month of May.

This work is divided into two classes: First, that which increases the value of plant, and, second, ordinary repairs required to keep the plant in a serviceable condition.

#### CONSTRUCTION AND EXTRAORDINARY REPAIRS.

*Towboats.*—The repairs upon the towboat *Gen. Gillmore*, which were begun at the Mound City ways in February, were completed at the engineer depot in March. The wheel, rudders, fire box, roof, chocks, nosing, and plank-sheer were renewed, a new set of brass packing rings fitted to the cylinders, and the deck and top sides calked.

The towboat *Gen. T. L. Casey* was received from Jeffersonville, Ind., January 3, and was outfitted and made ready for service.

Changes were made in the machinery during May, including the relining of the engines and cams and fitting a set of gun-metal packing rings to the cylinders.

*Pile-drivers.*—The construction and repairs of pile-drivers was continued during the year until the force was reduced in May, important changes being made in all the drivers except No. 15.

The boilers of Nos. 1 to 6 and 12 were found unsafe and retired, and those of Nos. 9 and 13 used for derrick boats Nos. 1 and 2, respectively.

The hulls of Nos. 2, 5 to 13, 16, 18, 19, and 20, built in 1881, were found unserviceable and retired.

The 21 new hulls which were under contract at Cincinnati at the beginning of the year were all delivered.

These hulls were each 68 by 20 by 3½ feet, the cabin 34 by 13 feet and 9 feet high, with a skylight. One of these hulls was used, with the boiler of No. 9, for derrick boat No. 1, and 14 for pile-drivers as follows: Nos. 8, 9, 10, 11, 12, 13, 14, 16, 19, 20, 21, 22, 23, and 24.

Fourteen new boilers were bought for pile-drivers during the year, of which 8 were expended in building pile-drivers Nos. 9, 12, 13, 14, 21, 22, 23, and 24.

These boilers were each 18 feet by 36 inches, with two 13-inch flues.

These pile-drivers were also equipped with Mundy hoisting engines and Gordon force pumps.

The other 6 boilers are 14 feet by 42 inches, with 4 flues, each 10½ inches diameter, and are designed to replace the boilers retired from drivers Nos. 1 to 6.

The hoisting engines have two 7½-inch by 10-inch cylinders, a 14-inch drum with wood frictions, foot brake, and 3 independent winch heads.

The pumps have 10 by 10 inch steam and 6 by 10 inch water cylinders with a 5-inch supply pipe.

The 5 pairs of steel leads prepared for setting up during the spring of 1893 were used on drivers Nos. 8, 11, 17, 20, and 22. They were 42 feet high, of 3-inch by ½-inch Z-bars, with a 9-inch by ½-inch plate between them riveted together, thus:

The lined space being filled with yellow pine.

The pair built the previous year on No. 17 were put together without the 9-inch web plate and were so badly bent by the hammer that they were taken down and replaced by a pair with the web.

Seven other pairs were also riveted and set up on drivers Nos. 9, 12, 13, 14, 21, 23, and 24, all with side braces of 3½-inch gas pipe and rear braces of 7-inch by ½-inch channel beams, while the platforms are supported by 3 by 4 inch angle irons.

These leads were also stiffened by yokes of 12-inch by ½-inch iron riveted to the leads on each of the 3 lower platforms.

The effective plant was increased during the year by the purchase of 11 new pile-drivers, numbered, consecutively, from 25 to 35. These were built by contract in St. Louis and delivered early in January, 1894. They were outfitted and prepared for service at the engineer depot during January and February. These drivers are similar to those fitted up at the engineer depot during the year, except that the jet pump is a Hooker No. 12.

The condition of the drivers at present is as follows:

Six (Nos. 1 to 6) dismantled.

Three (Nos. 10, 16, 19), old machinery moved to new hulls, but not complete.

Three (Nos. 7, 15, 18), old machinery, wooden leads on hulls, built in 1891.

One (No. 17), old machinery, steel leads on hull, built in 1891.

Three (Nos. 8, 11, 20), old machinery, steel leads on new hulls.

Eight (Nos. 9, 12, 13, 14, 21, 22, 23, and 24), with new hulls, steel leads, Mundy hoisting engines, and Gordon jet pumps.

Eleven (Nos. 25 to 35), same as the above, but with Hooker pumps.

This list shows 26 drivers available for service, which will be increased to 35 by using the hulls and machinery now on hand.

*Derrick boats.*—The hull of derrick boat No. 1 was retired and replaced with one of the new hulls built for pile-drivers, and the boiler, which was that of pile-driver No. 5, was replaced by that taken from No. 9.

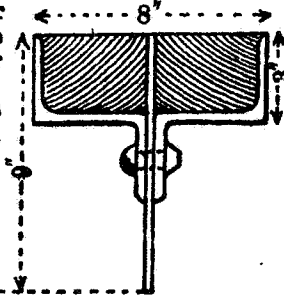
Derrick boat No. 2 was built during the winter, the hull of pile-driver No. 4, built in the spring of 1891, being docked and repaired during the winter for that purpose. It has a double-drum Crook hoisting engine with two 7 by 10 inch cylinders, the boiler from pile-driver No. 13, and a derrick 48 feet high, set up with sheer and stiff legs of 5-inch gas pipe, and a boom 42 feet long of two 7-inch channel beams.

*Barges.*—Two out of the 6 model barges built under contract by Clements Bros., of Paducah, Ky., were received during June of last year, and the other 4, Nos. 116 to 119, were received during the summer.

There were also received during the fiscal year 7 barges, Nos. 120 to 126, built by Coffin & Son at Cincinnati, Ohio.

Six barges, Nos. 127 to 132, built by D. S. Barmore, at Madison, Ind., and 6 barges, Nos. 133 to 138, built by the Howards at Jeffersonville, Ind. These barges are all 135 feet long, 28 feet wide, 5 feet deep, built full model. They were all equipped at the engineer depot with iron pumps and overflow pipes.

*Quarter boats.*—Quarter boats Nos. 1 to 6 were received from Cincinnati during the first half year.



## 1610 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

These were all 135 feet long, 30 feet wide, and 3 feet 11 inches deep, with cabins 105 feet long, 24 feet wide, and two stories high, furnishing quarters for 144 laborers besides 28 foremen and kitchen crew.

They were equipped with iron pumps, cross bulkheads, lockers, coal boxes, and hatch hoods. Nos. 1, 2, and 3 were supplied with the necessary outfit and sent out for service in the fall, but Nos. 4, 5, and 6 were not outfitted until March, 1894.

Four more quarter boats of the same size (Nos. 7 to 10) were received during the spring from the Howards at Jeffersonville and were supplied with iron pumps, but had not been put into service at the end of the year.

*Office and survey boats.*—Three office and survey boats, Nos. 1, 2, and 3, built by the Diamond Jo Line Steamers Company at Dubuque, Iowa, were received at the engineer depot during August and September.

They are 135 feet long, 26 feet wide, and 3½ feet deep, with a cabin 109 feet long and 9½ feet high. They were provided with pumps, hatch hoods, lockers, etc., and sent out for service in September.

*Quarter barges.*—Quarter barges, Nos. 25, 26, and 27, were pulled out on the ways at the depot in December. Nos. 25 and 26 were repaired during the winter and launched in March, but No. 27 had not been calked at the close of the year.

The work done upon these barges consisted in renewing the top sides, stems, chocks, nosing, and plank-sheer.

*Machine shop.*—The machine shop was supplied during the year with a 20-inch drill press and a machine cutting and threading pipe from ½ to 4 inches in diameter.

*Small boats.*—The plant was increased during the year by the purchase of 229 flats. Of this number 179 were decked flats 40 feet long, 16 feet wide, and 2½ feet deep. Forty were decked flats 35 feet long, 10 feet wide, and 23 inches deep, and the other 10 of the same size, without decks.

Twenty-eight of the large flats were equipped with ways for building mattresses, and 16 of these with Providence power capstans, size A.

Thirty new skiffs and 10 yawls purchased during the spring were painted.

*Derricks.*—A derrick 50 feet high for the quarry was prepared for setting up, and a fire-bed boiler put together ready for use and shipped to Ste. Genevieve.

*Tools and appliances.*—Tools and appliances were constructed as required, including 25 truck and 36 stone boxes for use at the quarry.

*Boarding outfit.*—This outfit was increased during the year by the construction of 5 ice chests, 2 large ice boxes, 25 by 9 by 7 feet, built on pile-driver hulls, 58 laundry boxes, 65 mess tables, 114 benches, and 50 meat boxes.

*Engineer depot.*—The value of grounds and buildings at the depot was increased by the following work done under contract during the fall. The Arsenal street water main, which terminated at the Iron Mountain Railroad, was extended down through the yard to within 150 feet of its lower end, a distance of 870 feet. The main used for this extension was 6 inches diameter, with 3 fire plugs so located that a stream of water can be thrown over any building in the yard with 100 feet of hose, which, with a nozzle attached, is kept coupled to each plug.

The fence on the west side of the yard was covered with corrugated iron, No. 20 gauge, and No. 27 gauge was used to cover the west sides and ends of all the permanent buildings near the railroad.

*Ways.*—Ways for pulling out plant were built during the fall, the bank being graded for this purpose for a distance of 140 feet, beginning about 160 feet below the platform.

The slope adopted was about 1 on 4, and the dirt was removed by scrapers to the depression next the wall, which was filled to a 34-foot stage.

The way pieces were of 8 by 8 inches yellow pine, 12 feet apart, on posts set 4 feet deep and 6 feet apart. The way pieces extended from a 32-foot stage to 4 feet below the low water of 1863, a distance of 174 feet.

Tilting tables were also put in at the top of the bank, and north and south ways 12 feet apart from within 30 feet of the platform to within 50 feet of the lower end of the yard.

The ways were used for docking 2 steam tenders, 3 quarter barges, the machine boat, derrick boat No. 2, and 2 pile-driver hulls.

### ORDINARY REPAIRS.

*Towboats.*—Small repairs were made upon both towboats during the year.

The guards and outriggers of the steamer *General Willmore* were calked during the fall and new swinging fenders hung during the spring.

The pilot house and furnace of the steamer *General Casey* were repaired.

*Steam tenders.*—The roofs, wheels, and boiler tubes of tenders Nos. 1 and 2 were renewed during the fall and a set of rocking grate bars put in the furnace of each. They were docked in the fall and were calked and painted before launching in the spring.

The top sides of Nos. 3 and 4 were calked and painted in the spring, and their wheels repaired.

*Pile-drivers.*—The top sides of all the pile-drivers available for service at the beginning of the season (25 in number) were calked. The leads of pile-driver No. 28 were straightened and the side braces renewed.

*Barges.*—The top sides of barges Nos. 2, 6, 8, 11, 101, 114, and 122 were calked in the fall and all the barges available for service (46 in number) in the spring. These are numbered as follows:

Eight, Nos. 2, 6, 7, 8, 29, and 30, built in 1885.

Thirteen, Nos. 101 to 113, built in 1891.

Thirteen, Nos. 114 to 126, built in 1893.

Twelve, Nos. 127 to 128, built in 1893.

*Quarter boats.*—The rakes of quarter boats Nos. 1 to 10 were calked at the winter harbor during the month of March.

*Office and survey boats.*—The rakes of office and survey boats Nos. 1, 2, and 3 were calked at the winter harbor during the month of March.

*Quarter barges.*—The quarters on barges Nos. 17, 18, 19, 21, 22, and 24 were removed and the barges retired from service, the office and quarters on Nos. 17 and 19 were set up on Nos. 9 and 29, those on No. 21 were left at St. Genevieve quarry, the kitchen and quarters on No. 18 were set up on the bank at the depot, while the old quarter-boat cabins on Nos. 22 and 24 were removed to barges Nos. 11 and 28. The top sides of all the barges carrying quarters (8 in number), Nos. 1, 3, 4, 5, 9, 11, 28, and 29, were calked in the spring.

*Machine shop.*—The machine shop was pulled out upon the ways at the engineer depot in the fall, remained out all winter, and was calked thoroughly in the spring.

*Small boats.*—A pair of temporary ways were put in on the bank and 181 flats were pulled out and blocked up in November. Eighty-four of these flats were calked and launched during the spring.

The rakes of 49 flats were also calked while in the river.

Of the 107 flats now on the bank at this place, 26 have been retired on account of age.

Twenty-three yawls and 40 skiffs were pulled out upon the bank during the fall. Thirteen of the yawls and all of the skiffs were calked and launched in the spring. Ten skiffs were also repaired during the year by renewing one or both sides.

Tools and appliances and boarding outfit were repaired and kept in serviceable condition.

*Portable buildings.*—Small repairs and alterations were made upon portable buildings when required.

A shanty of 6½ sections was set up and repaired under the wall at the depot for storing boarding outfit.

*Engineer depot.*—A barbed wire fence was built from the wall to the river at both ends of the yard.

The blacksmith shop and both warehouses were repaired and supplied with large sash.

The shipping platform was extended about 60 feet during the fall for greater convenience in shipping.

Four clumps, of 3 piles each, were driven for moorings along the river front.

*Coal.*—Three large flats containing about 41,000 bushels of coal were unloaded upon United States barges during May and June.

*Clevises.*—Clevises were fabricated as required upon the works of construction, 854 being made during the year. A large number were also purchased when they were required faster than they could be made here.

Material of all kinds and subsistence stores were received and shipped as required.

Very respectfully, your obedient servant,

C. D. LAMB,  
Superintendent.

Maj. CHAS. J. ALLEN,  
Corps of Engineers, U. S. A.

# 1612 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

## DETAIL CONSTRUCTION ACCOUNT.

*Cost of works at Horsetail, Carrolls Island, Twin Hollows (east and west), Pulltight, Chesley Island, Rush Tower, and Fort Chartres during fiscal year ending June 30, 1894.*

Labor, plant, and material.	Hurdles.	Protection.	Total.
Labor, superintendence, etc.....	\$117,322.36	\$18,383.01	\$135,605.37
U. S. Engineer Office.....	10,402.92	1,386.21	11,789.13
General expense.....	9,128.68	1,002.69	10,129.37
Surveys.....	7,743.79	2,056.88	9,800.67
Care of plant.....	11,557.91	637.98	12,195.89
Care of material.....	1,882.66	236.31	2,118.97
Steamer Gen. Gillmore.....	2,498.02	770.50	3,268.52
Steamer Gen. T. L. Casey.....	3,163.43	.....	3,163.43
Steam tenders.....	3,087.48	245.75	3,333.23
Quarter barges.....	4,254.80	642.51	4,897.31
Quarter boats.....	1,725.81	48.51	1,774.32
Office and survey boats.....	1,161.87	39.69	1,201.56
Pile-drivers.....	13,041.53	493.68	13,535.21
Small boats.....	18,046.22	616.57	18,662.79
Portable quarters.....	1,040.28	365.04	2,005.32
Supply depot.....	2,064.87	324.42	2,389.29
Ways (supply depot).....	335.50	104.65	440.15
Machine shop.....	261.60	81.58	343.18
Tools and appliances.....	2,967.68	395.76	3,363.44
Boarding outfit.....	4,013.53	384.26	4,397.79
Office furniture.....	82.33	10.96	93.29
Subsistence.....	37,517.29	4,400.65	41,926.94
Brush.....	36,431.71	6,446.71	42,878.42
Piles.....	57,774.16	.....	57,774.16
Stone.....	62,254.52	29,542.96	91,797.48
Rope.....	2,351.00	217.00	2,568.00
Wire.....	3,080.64	431.67	3,512.31
Iron.....	33.94	.....	33.94
Nails.....	496.62	71.50	568.12
Spikes.....	1,150.49	106.00	1,256.49
Bolts.....	666.58	.....	666.58
Clevises.....	1,098.80	.....	1,098.80
Lumber.....	301.39	20.00	321.39
Oakum.....	11.72	1.30	13.02
Coal.....	7,077.00	352.80	7,429.80
Coal, blacksmith's.....	2.09	.....	2.09
Ice.....	3,134.44	561.33	3,695.77
Miscellaneous material.....	1,870.30	120.71	2,000.10
<b>Total.....</b>	<b>431,644.10</b>	<b>70,408.59</b>	<b>502,052.69</b>

Distributed as follows:

Locality.	Hurdles.		Protection.		Total.
	Linear feet.	Amount.	Square feet.	Amount.	
Horsetail.....	4,340	\$69,413.60	372,000	\$20,348.40	\$89,962.00
Carrolls Island.....	2,260	36,250.40	.....	.....	36,250.40
Twin Hollows, west side.....	2,900	46,516.00	305,859	16,730.49	63,246.49
Twin Hollows, east side.....	.....	.....	9,420	515.27	515.27
Pulltight.....	7,470	119,818.80	33,240	1,818.23	121,637.03
Chesley Island.....	.....	.....	65,125	3,562.33	3,562.33
Rush Tower.....	400	6,416.00	293,640	16,062.11	22,478.11
Fort Chartres.....	9,550	153,029.30	208,770	11,371.76	164,401.06
<b>Total.....</b>	<b>26,920</b>	<b>431,644.10</b>	<b>1,288,054</b>	<b>70,408.59</b>	<b>502,052.69</b>

APPENDIX X—REPORT OF MAJOR ALLEN.

1618

Construction account, showing cost of work to June 30, 1894.

Name of work.	Expended.		Total cost to June 30, 1894.
	Prior to July 1, 1893.	During fiscal year ending June 30, 1894.	
Sawyer Bend, protection.....	\$96,803.03		\$96,803.03
Venice Dikes.....	36,341.85		36,341.85
St. Louis Harbor.....	145,048.94		144,048.94
Arsenal Island, protection.....	42,599.06		42,599.06
Closing Cahokia Chute.....	119,958.21		119,958.21
Channel opposite St. Louis.....	58,455.54		58,455.54
Horsetail Bar, dikes 1 to 5 inclusive.....	225,068.31		225,068.31
Horsetail Bar, training wall.....	81,253.28		81,253.28
Horsetail Bar, hurdles.....	548,834.08	\$69,613.60	618,447.68
Horsetail Bar, bank protection.....	40,993.55	20,348.40	61,341.95
Carrolls Island, hurdles.....	4,093.58	36,250.40	40,343.98
Twin Hollows, west side, hurdles.....	269,095.64	49,510.00	318,611.64
Twin Hollows, west side, bank protection.....	81,370.55	16,730.49	48,101.04
Twin Hollows, east side, bank protection.....	128,620.30	515.27	129,435.57
Pulltight, hurdles.....	394,279.35	119,818.80	514,098.15
Pulltight, bank protection.....		1,818.23	1,818.23
Beards Island, primary hurdle.....	7,166.24		7,166.24
Beards Island, bank protection.....	84,258.76		84,258.76
Chesley Island, hurdles.....	27,808.61		27,808.61
Chesley Island, bank protection.....	70,354.22	3,562.33	73,916.55
Jim Smith's, hurdles.....	365,803.33		365,803.33
Jim Smith's, bank protection.....	7,569.58		7,569.58
Sulphur Springs, hurdles.....	177,964.24		177,964.24
Foster Island.....	44,296.02		44,296.02
Lucas, hurdles.....	128,056.65		128,056.65
Rush Tower, hurdles.....	211,851.90	6,416.00	218,267.90
Rush Tower, bank protection.....	66,250.72	16,062.11	82,312.83
Fort Chartres Dam.....	36,812.86		36,812.86
Fort Chartres, west side, hurdles.....	72,851.09	153,029.30	225,883.99
Fort Chartres, east side, bank protection.....	28,475.12	11,371.76	39,846.88
Turkey Island.....	24,461.85		24,461.85
Ste. Genevieve, hurdles.....	47,171.06		47,171.06
Kaskaskia, bank protection.....	66,465.62		66,465.62
Liberty Island Dam.....	5,053.91		5,053.91
Liberty Island, bank protection.....	45,129.40		45,129.40
Devils Island, Dike No. 1.....	65,871.17		65,871.17
Devils Island, Dams 1 and 2.....	66,526.88		66,526.88
Minton Point, hurdles.....	33,436.37		33,436.37
Cape Girardeau, primary hurdles.....	31,930.18		31,930.18
Calro, bank protection.....	160,439.82		160,439.82
Total.....	4,098,125.07	502,052.69	4,600,177.76

Property account.

Class of property.	Value July 1, 1893.	Purchases, additions, and repairs.	Expenses and deterioration charged to works of improvement.	Value June 30, 1894.
Steamer Gen. Gillmore.....	\$10,871.98	\$25,050.11	\$22,810.20	\$13,711.89
Steamer Gen. T. L. Casey.....		36,340.97	11,421.27	24,925.70
Steam launches.....	4,582.37	2,039.03	6,621.40	
Steam tenders.....	10,060.38	12,049.92	2,393.39	20,326.91
Barges, model.....	76,684.51	80,475.89	18,402.59	138,697.81
Barges, quarter.....	17,166.81	4,957.98	5,948.16	16,176.63
Quarter boats.....	1,733.33	51,996.81	2,625.55	51,104.59
Office and survey boats.....		13,086.50	1,360.50	12,326.00
Pile-drivers.....	31,533.55	102,097.35	15,052.15	118,578.75
Derrick boats.....	1,500.00	4,212.90	839.25	4,873.65
Derrick.....		1,011.50		1,011.50
Small boats.....	12,209.99	69,498.95	20,192.97	61,575.97
Portable quarters.....	7,051.18	2,634.03	3,783.00	6,902.21
Cots.....	190.75		190.75	
Supply depot.....	3,105.50	3,564.04	2,389.29	4,280.25
Ways (supply depot).....		4,421.27	836.20	3,584.98
Machine shop.....	1,943.60	437.03	790.56	1,590.07
Tools and appliances.....	6,734.79	12,685.49	6,078.86	13,343.92
Loading outfit.....	11,896.96	19,132.87	5,655.26	25,374.03
Office furniture.....	51.27	175.50	93.29	533.48
Survey instruments.....	634.08	1,367.40	111.23	1,910.26
Photographic apparatus.....	257.14			257.14
Total.....	198,668.19	449,061.00	127,643.45	520,085.74

1614 REPORT OF THE CHIEF OF ENGINEERS, U. S. ARMY.

Material account.

Class of material.	Value.		Expended and charged to works of improvement.	Value on hand June 30, 1894.
	July 1, 1893.	Purchased.		
Subsistence.....		\$58,586.22	\$57,100.27	\$1,485.99
Brush.....		45,032.82	42,878.42	2,154.40
Piles.....	\$270.77	58,641.10	58,121.10	790.97
Stone.....	541.66	92,375.29	91,823.10	1,093.85
Rope.....	11,250.93	5,594.20	2,740.80	14,104.33
Wire.....	47.59	8,974.62	3,521.31	500.80
Iron.....	3,361.46	1,877.84	3,083.33	2,155.97
Nails.....	542.38	471.83	696.08	318.13
Spikes.....	442.87	1,873.05	1,363.59	952.33
Bolts, screw.....	1,297.91	445.91	1,113.95	629.87
Bolts, assorted.....	37.42	208.78	183.31	62.89
Clevises.....		1,731.92	1,098.80	623.12
Lumber.....	1,116.44	8,003.34	6,493.31	2,626.47
Oakum.....	242.44	1,141.20	753.49	630.15
Coal.....		20,560.03	17,695.90	2,864.13
Coal, blacksmith's.....	5.07	313.94	257.64	61.37
Ice.....		5,250.78	5,250.78	
Material miscellaneous.....	10,581.82	28,723.38	32,240.18	7,065.07
Total.....	29,738.76	334,816.25	326,415.27	38,139.74

COMMERCIAL STATISTICS.

Receipts and shipments at St. Louis, Mo., during the years 1890, 1891, 1892, 1893.

Articles.	Receipts.				Shipments.			
	1890.	1891.	1892.	1893.	1890.	1891.	1892.	1893.
Barbed wire and metals (pig and manufactured).....	Tons. 21,782	Tons. 13,741	Tons. 16,768	Tons. 11,357	Tons. 3,945	Tons. 4,802	Tons. 3,574	Tons. 7,912
Cement.....	15,892	18,621	1,238	13,429				
Coal and coke.....	81,565	55,980	85,547	23,180	734	148	10,504	28,874
Cotton (and products).....	4,230	2,946	1,462	903	527	38	22	19
Groceries and dairy products.....	8,202	7,604	18,382	22,868	7,428	9,675	13,919	11,789
Hay, seed, grain, flour, meals, etc.....	92,914	96,526	76,376	77,709	440,728	377,416	314,336	274,201
Jute.....	17,347	15,217	14,953	13,392	18,379	15,166	10,040	7,631
Livestock and products.....	132,940	142,090	159,140	123,510	8,526	6,245	7,000	6
Lumber.....	284,589	234,817	310,370	304,099	117,806	95,842	138,250	95,609
Merchandise and sundries.....	3,530	4,110	2,559	5,440	1,739	1,435	2,132	3,210
Vegetables.....	204	63	12	68	1,379	1,555	1,780	1,513
White lead, oils, etc.....	60	121	64	181	698	590	631	6,038
Wines and liquors.....	180	304	329	269	3	18	21	8
Wool.....								
Total.....	663,730	592,140	687,200	599,405	601,862	512,930	502,215	436,900

Transferred by ferries across the river at St. Louis.

	Tons.
1890.....	3,052,166
1891.....	3,268,753
1892.....	2,760,187
1893.....	2,829,053

Shipments down the river from landings between St. Louis and Cairo during the years 1890, 1891, 1892, 1893.

Grain, including flour, meals, etc.:	Tons.
1890.....	34,267
1891.....	20,353
1892.....	18,990
1893.....	21,294

RECAPITULATION.

	1890.	1891.	1892.	1893.
Receipts and shipments at St. Louis.....	<i>Tons.</i> 1,265,592	<i>Tons.</i> 1,105,070	<i>Tons.</i> 1,189,415	<i>Tons.</i> 1,036,306
Transferred by ferries at St. Louis.....	3,052,166	3,268,758	2,760,187	2,820,053
Shipped from landings between St. Louis and Cairo.	34,287	20,353	18,990	21,294
Total.....	4,352,025	4,394,176	3,968,592	3,884,653

List of steam-power boats that arrived at St. Louis during the year 1893.

Size of boats.	Draft.	Boats.	Times arrived.
	<i>Feet.</i>		
Under 500 gross tons.....	2.5 to 6	65	1,042
Between 500 and 1,000 gross tons.....	4 8	21	1,200
Over 1,000 gross tons.....	6.7 9.5	14	355
Tonnage and size unknown.....		17	35
Total.....		117	2,632

List of barges and scows that arrived at St. Louis during the year 1893.

	Draft.	Barges and scows.	Times arrived.
	<i>Feet.</i>		
Under 500 tons.....	3.5 to 8	28	133
Between 500 and 1,000 tons.....	5.2 8	15	43
Over 1,000 tons.....	5.3 9	64	368
Tonnage and size unknown.....		164	598
Total.....		271	1,142

List of steamers and barges permanently and temporarily enrolled at the port of St. Louis on December 31, 1893.

	Vessels.	Gross tonnage.	Net tonnage.
Permanently enrolled:			
Steam (wood).....	97	40,274.52	39,646.26
Barges (wood).....	84	81,188.01	81,097.17
Steam (iron).....	4	1,660.29	1,639.83
Permanently licensed:			
Steam, under 20 tons.....	7	138.47	99.10
Barges, under 20 tons.....	3	35.72	35.72
Yachts, under 20 tons.....	1	5.24	5.24
Grand total.....	196	123,332.25	122,528.41

X 3.

IMPROVEMENT OF HARBOR AT ST. LOUIS, MISSOURI.

St. Louis Harbor has a length of about 18 miles, being divided into two nearly equal parts by the Eads bridge. The upper portion of the harbor, between this bridge and the northern limits of the city, is about 10 miles in length. About 3 miles above the Eads bridge is the Merchants bridge. The lower portion of the harbor, included between the Eads bridge and River Des Peres, is 8 miles long. A good depth of water and accessible landings exist in this lower part of the harbor, and a sufficient depth is found above the Merchants bridge.



Between the Merchants and Eads bridges, however, there existed middle bars, and also shoals near the Illinois shore, which interfered with navigation.

Appropriations for improvement of St. Louis Harbor had been made as early as 1836, and a longitudinal stone dike was built at that time near the head of the present works by Capt. R. E. Lee, Corps of Engineers. Other work, done in later years by the United States, consisted in the building of stone and brush dikes generally normal to the direction of the current, in the closing of Cahokia Chute, and protection of the bank in Sawyer Bend.

The river and harbor act of Congress approved September 19, 1890, contained an appropriation of \$182,000 for improving harbor at St. Louis, Mo., and the officer in charge, in submitting a project for its expenditure, recommended that the money be applied to the portion of the harbor between the Eads and Merchants bridges. The approved project consisted in the contraction of the river by a system of hurdles along the Illinois shore for a distance of 13,000 feet to a width of 2,000 feet, with a view to removing the bars which then existed and which interfered with navigation at low stages of the river, and also to improve the ferry landings on the Illinois shore. The object of the hurdles was to cause deposits of sediment, and thus build up a new bank out to the line desired. They were 12 in number, and spaced 1,000 feet apart. The hurdles were from 325 to 2,075 feet in length, each, and were constructed as follows:

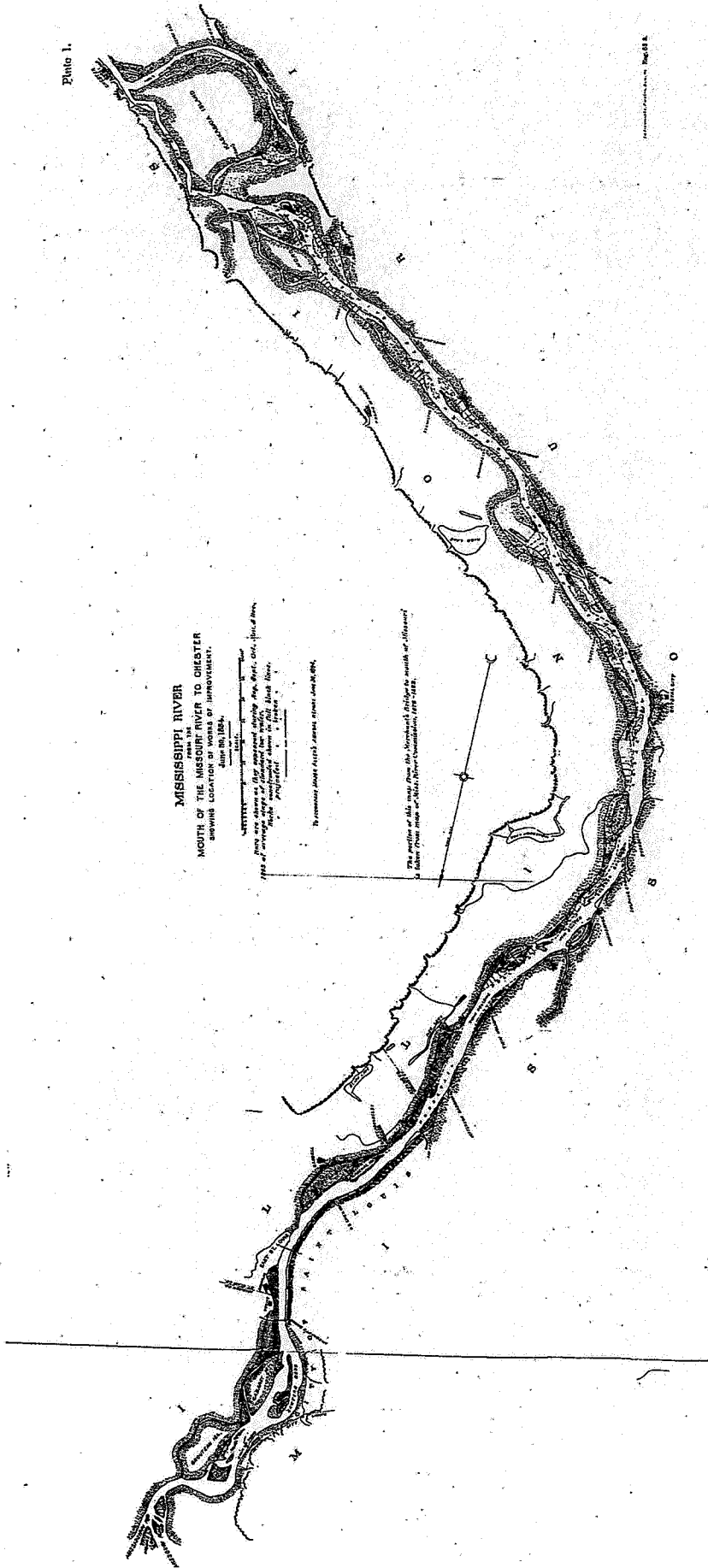
The piles were driven in two rows 20 to 27 feet apart, the distance varying with the depth of water. The upper or drift row was composed of three pile clumps spaced 12 feet apart with a stringer bolted to them on the downstream side. The piles in the lower or hurdle row were driven 6 feet apart with a stringer bolted to them on the upstream side. Brace piles for this row were driven every 12 feet with their tops bolted to the stringer. The river ends of the hurdles were further strengthened by cross stringers bolted to the stringers of each row.

The drift row was carried to the 25 and the hurdle to the 20 foot stage above low water at St. Louis, rising, however, with the river above the 20-foot stage. For a length of 1,900 feet at the shore ends of Nos. 1, 9, 10, and 11 only the hurdle row was driven, the depth of water not requiring the drift row.

The woven foundation mattress of willows was 65 feet in width, extending that distance below the drift row by which it was supported during construction. It was placed before the hurdle row was driven. Mattresses 200 feet long by 80 in width were placed at each end of the hurdles for protection against scour. Riprap was also used at the shore ends. Wattling the hurdle row with willows and sinking the drift wood where collected completed the construction of the hurdles.

The hurdles, which were built in depths of 2 feet to 36 feet of water, were all completed by July 1, 1892. The extent of accretion produced by them may be judged by the following:

Soundings taken June, 1892, showed a fill of 8 feet by a width of 400 feet at No. 1 hurdle, 15 feet by a width of 600 feet at No. 6 hurdle, 10 feet by a width of 600 feet at No. 11 hurdle, or an average of about 12 feet over an area of about 160 acres. The filling has increased yearly; by December, 1893, it covered the outer half of the areas inclosed by the hurdles; the depth of fill at No. 1 was 10 feet; at No. 11, 15 feet; between hurdles 6 and 7 it was 26 feet. The areas near to the original shore line have also been filled, but not to such an extent as have the outer areas.



**MISSISSIPPI RIVER**

**MOUTH OF THE MISSOURI RIVER TO CHESTER**

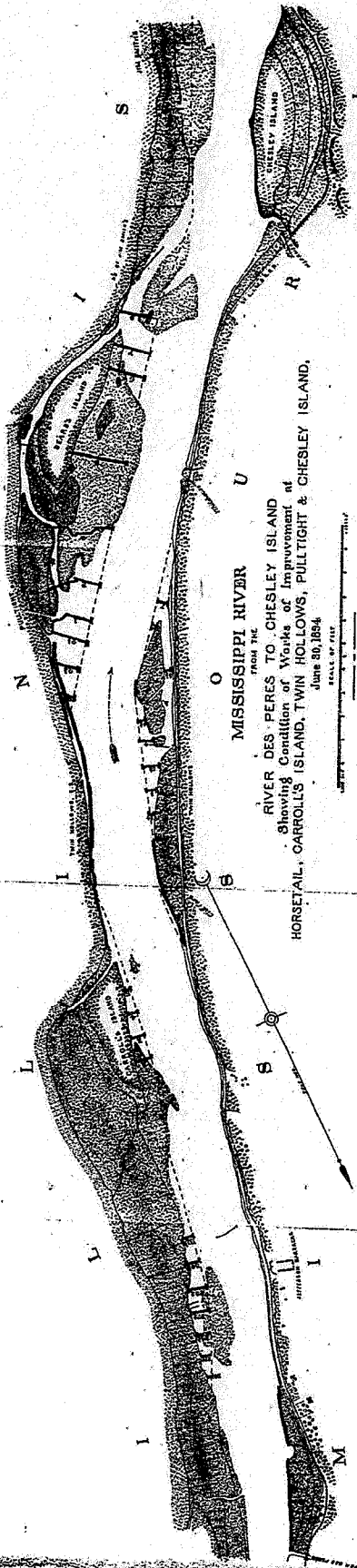
SHOWING LOCATION OF WORKS OF IMPROVEMENT.

Scale 100, 1884.

From a plan of the Mississippi River, from the mouth of the Missouri to the mouth of the Ohio, as shown on the map of the Mississippi River, published by the U.S. Army, 1884.

The names of the works of improvement are given in the text.

The plan of the Mississippi River, from the mouth of the Missouri to the mouth of the Ohio, as shown on the map of the Mississippi River, published by the U.S. Army, 1884.



MISSISSIPPI RIVER  
 FROM THE  
 RIVER DES PERES TO CHESLEY ISLAND  
 Showing Condition of Banks of the river at  
 HORSETAIL, CARROLL'S ISLAND, TWIN HOLLOW, PULLTORT & CHESLEY ISLAND.  
 June 30, 1864

See map shown at New Orleans at the following date and place.  
 River des Peres to Adams, Memphis Oct. 1863 at standard low water.  
 Adams to New Orleans, July 1864, at standard low water.  
 and at Chesley Island Oct. 1864, at standard low water.

To return to the original map, see page 68.



MISSISSIPPI RIVER

FOREST HOME TO FORT CHARTRES LANDING  
Showing Condition of River, of Improvement at  
RUSH TOWER AND FORT CHARTRES REACHES  
June 30, 1899.

These maps show as they appeared Sept. 20, 1872, and Jan. 2, 1881, at an  
average stage, for the better period, of water. Higher stages shown in full lines,  
lower stages in dotted lines.

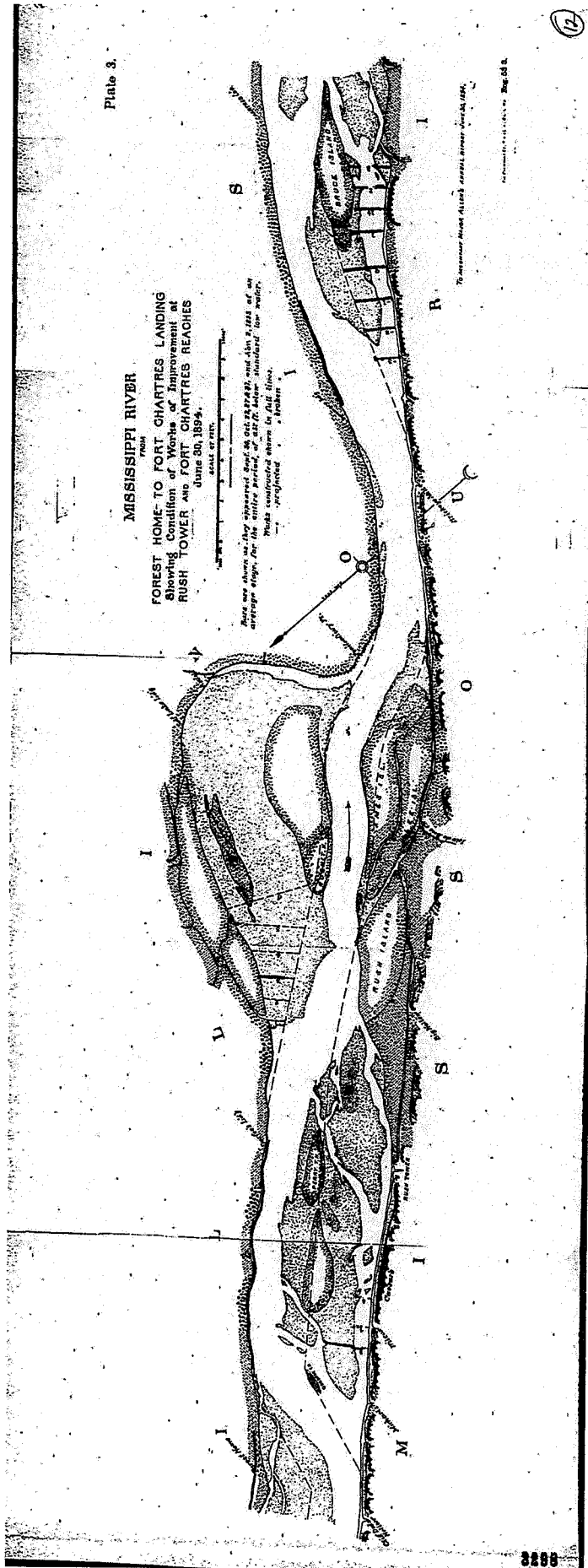


Plate 4.

**SLOPES OF  
MISSISSIPPI RIVER  
CHAIN OF ROCKS TO BISHOP'S LANDING**  
at  
**FLOOD, HIGH AND LOW STAGES**  
from  
**GAUGE RECORDS OF 1880 TO 1923**

To accompany Major A. S. Allen's Annual Report, 1924, p. 147.

**DATA:**  
Gauges at Bush Tower and Cliff 1884 from 'Stage of Mississippi River', M.R.C. 1881.  
Gauges at Alvin's Point and Chain of Rocks from Alvin's Point Commission.  
Gauges at St. Louis from Signal Service Dept.  
Other gauges from office records.  
Note—Arrows show indications of reading at that gauge.

