there was a hole over 70 feet deep, and there was a gap in dike 4. After partially filling the gaps in dike 5, it was decided to discontinue work upon these dikes and to rely upon the training-wall, with some supplementary works, to accomplish the contraction of the river. Beginning at a dry sand-bar nearly half a mile above dike 2, this wall has been carried down stream a distance of 5,950 feet, at a cost of $9.75 per foot, exclusive of engineering and contingencies, or, including these items, $10.16 per foot.

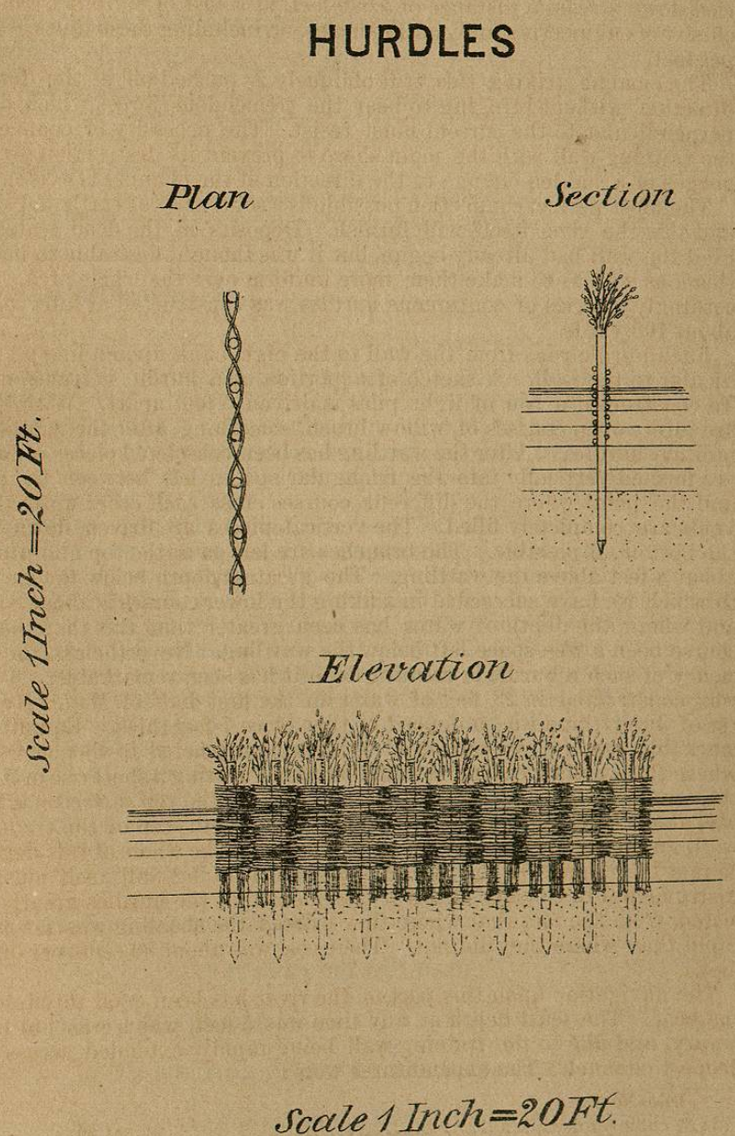
The current striking this wall obliquely is pushed off in the desired direction, without bringing to bear the tremendous forces which dikes perpendicular to the current must resist. The necessity of connecting the training-wall with the main shore to prevent its destruction by ice-gorges or a sudden change in the direction of the channel is evident.

The most perfect connection possible is a solid mass of earth and sand, and this the river itself will furnish. Deposits in the dead water behind the wall had already begun, but it was thought desirable to hasten them, as well as to make them more uniform over the whole area. Accordingly a series of continuous hurdles was constructed at intervals of about 100 yards.

Each hurdle runs from the wall to the high bank upon a line perpendicular to the wall. A sketch of a portion of a hurdle is transmitted. To construct it a row of light piles is driven 5 feet apart. With these are interwoven courses of willow brush, something after the manner of military hurdles. After the wattling has been completed pieces of brush are pushed vertically into the triangular spaces left between the piles and the point where the different courses cross each other until these voids are completely filled. The vertical pieces are driven down into the bottom, if possible. The branches are left on at the top and project about 8 feet above the wattling. The greatest depth below the surface to which we have succeeded in sinking the lower courses is about 8 feet, and where the depth of water has been greater than this there has of course been a free space left below the wattling. Nevertheless, the efficiency of such a hurdle in creating deposit has been remarkable. A line was constructed in 23 feet of water in the first half of May. By the 1st of June there was a deposit at that place 7 feet thick. Equally remarkable results were achieved by those constructed in shoaler water where the wattling extended to the bottom. During a short rise in April the completed hurdles collected a mass of mud, the top surface of which was about level and flush with and extending to the top of the training-wall, and to a depth in some places of 6 feet. The whole of this deposit cannot be claimed for the hurdles, since the training-wall itself must be instrumental in causing it, but it is evident that the hurdles greatly assisted, from the fact that where they existed the shoaling was far more rapid than where they did not. Their cost was about 80 cents per linear foot.

The navigation upon this part of the river has been good throughout the year. The least depth at any time was 5 feet, which was but temporary, and due to the training-wall being rapidly extended across the deepest channel. The expenditures were:

Dike No. 2:		
1,614.57 cubic yards riprap	$1,594 39	
Engineering and contingencies	94 29	
		$1,688 68
Dike No. 5:		
4,929.44 cubic yards riprap. 26 cubic feet anchor-stone	4,884 72	
Engineering and contingencies	295 42	
		5,180 14



I am, however, of the opinion that by removing the snags and constructing slight dams at some of the worst shoals the navigation would be so improved as to render it as good as that between Little Rock and Fort Smith, and this would seem to be all that is worth doing until the general improvement of the river is undertaken. The cost of this work would be about $100,000, which could be expended in one season.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. GEN. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. J. D. M'KOWN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE.
Saint Louis, Mo., January 27, 1879.

MAJOR: I herewith respectfully submit the following report of the examination of the Arkansas River from the mouth of the Little Arkansas River to Fort Smith.

In accordance with orders received from this office, I proceeded to Wichita, Kans., and commenced the examination of the river at the mouth of the Little Arkansas.

The latter stream empties into the main river a short distance above Wichita; part of the water is diverted from the natural channel to supply a mill, but again comes into the main river some 2½ miles below the city. The Arkansas River is very tortuous in its course, that portion from Wichita to Arkansas City passing through a prairie country, and has very little timber on the banks, a thin growth of cottonwood and willows prevailing.

The bed of the stream is very wide for the amount of water running, and is of a light sandy nature, quicksand prevailing in a large degree. In many places where the current is strong there is a thin layer of gravel over the sand, which, once broken through, shows the soft sand underneath.

As we go down the river rock becomes somewhat frequent, rock ridges often crossing the stream, sometimes almost amounting to rapids, and leaving but little room for the passage of boats at low-water.

I had the advantage of seeing the river at very low stage of water and in its worst condition. At no time during the examination was there a rise of more than 6 inches, and that lasted but a few days.

The distance from Wichita to Fort Smith I estimate at 409 miles, divided as follows:

	Miles.
From Wichita to Arkansas City	65
From Arkansas City to the State line	14
From State line to Grand River	236
From Grand River to Fort Smith	94
Total	409

The small amount of money available rendered rapid work necessary, and a hurried reconnaissance was all that could be made. On such information as I could obtain, I respectfully submit the following approximate estimate of the cost of improving the river for steamboat navigation at low-water.

The Little Arkansas River empties into the Arkansas about ¾ of a mile above the bridge at Wichita. The bed of the main stream is from 600 to 800 feet wide from there to the bridge. The slope of the river from the mouth of the Little Arkansas to a point 1 mile below is 3.03 feet; high-water mark at Wichita from the best information obtainable is 7.45 feet above low-water. The bridge at Wichita has the lower chord 10 feet above low-water, but as the landing would probably be below it, it need not be taken into consideration.

From Wichita to El Paso, a distance of some 15 miles, the slope of the river is about 3 feet per mile, or 45 feet for the whole distance. The bed of the river is generally wide, and to within 2 miles of El Paso needs a continued series of dikes and dams to contract it to a proper width, which would be about 150 feet. This would take a dike of 600 feet every half mile for 13 miles, or 7,800 feet in all. About 2 miles above El Paso the river narrows down to about the required width, with not less than 3 feet of water in the channel. This extends for nearly 2 miles.

About ½ mile above El Paso there is a rocky reef extending across the river, running out from the left where there is a rocky bank. The expense would be but slight to place it in good boating order—$2,500 would be sufficient.

From El Paso to Oxford the distance is 25 miles. The difference of level between the two places is about 69 feet, giving a slope of 2.75 feet per mile. This piece of river is a continued series of comparatively short bends, and, the water being forced on the convex side of them, forms a good channel in most places. It will require about 78,000 feet of dam for this distance, or 312 feet per mile.

About 1½ miles above Oxford there is a brush and rock dam, which is built for the purpose of throwing in a race or ditch, where it is used for mill-power. The dam is a slight, irregular-built affair, angling downstream.

The difference of level of the water above and below it at the left bank is 1.37 feet. The right bank here is about 40 feet high and of talcose slate.

At Oxford there is a ponton bridge. A roadway built to it is made of rock, brush, and prairie hay, the latter predominating, and seems to make an excellent dike, closing the river in to about 150 feet, and making a good channel along the bluff for about a half mile.

Some 4 miles above Oxford the Ne-Ne Scah Creek empties into the river, adding something to the volume of water.

Brush for mattresses is quite scarce on the river from Wichita to this place; but there is but little doubt that the tall rank prairie grass, which is indigenous to this region, and grows in great abundance, could be used to advantage in the work by mixing it in with the brush, and in all probability would be economical.

About ¾ of a mile below Oxford the river widens out and is full of bars. At 5 miles from Oxford, the banks on the right are high and contain considerable loose slate. The river bottom is of rock, but there is a fair depth of water—from 2½ to 6 feet. About 14 miles above Arkansas City, the banks on the left are about 30 feet high, of sand and clay, underlaid with loose rock.

The slope of the river from Oxford to Arkansas City, a distance of 25 miles, is 65 feet, or 2.6 feet per mile. There will be necessary for this piece of river about 16,500 feet of dike and dam—660 feet per mile. The approximate amount of water in the river at Arkansas City is 675 cubic feet per second. At this place there is a wagon-bridge about 600 feet in length, with the lower chord 20 feet above low-water. A draw would be necessary to allow the passage of boats. In the present state it is an obstruction to navigation.

From Arkansas City to Kaw Agency the distance is 44 miles. The fall of the river between these points is 110 feet, or 2.5 feet per mile.

It will take about 16,500 feet of work to improve this part of the river, or 375 feet per mile.

The river banks are becoming better timbered, and the river improving. Walnut Creek empties about 7 miles below Arkansas City and adds a fair amount to the volume of water in the river.

Below the creek the river changes somewhat in character. The banks and bluffs are higher and more rocky, the bed of the river more narrow, and timber more plentiful. Oak, hickory, pecan, walnut, hackberry, and many other varieties are common. Cottonwood, of course, is always to be found on the banks and low grounds. Below, and near the State line, and a few miles farther down, about the mouth of Chaloca Creek, a quantity of loose rock, apparently piled up during freshets, shows itself in the river. Some of this rock should be removed and a dam thrown in to concentrate the water. About $3,000 would do it.

On this piece of river, from Kaw Agency to Salt Creek, the distance is 62 miles. The slope of the river is 136 feet, or about 2.2 feet per mile. It will take about 28,000 feet of dam to improve it, or 451 feet per mile. On this part of the river snags are becoming more plentiful. Between Kaw Agency and Salt Creek the Salt Fork empties; it throws in considerable water.

From Salt Creek to Black Bear Creek, a distance of 15 miles, the river is wide and bad, and will take about 14,000 feet of dam to improve it, or 933 feet per mile. The slope is about 2.2 feet per mile, or 33 feet for the distance of 15 miles. Black Bear Creek comes in on the right, and adds something to the amount of water in the river, even when very low.

From Black Bear Creek to the Cimarron River the distance of 62 miles. The bed of the river is very wide and sandy, sometimes getting as wide as 2,000 feet. It will take some 20,500 feet of dam to improve this part of the river, or 500 feet per mile. The slope of the river is about 1.8 feet per mile, or 112 feet for the distance of 62 miles.

The Cimarron or Red Fork of the Arkansas comes in on the right, and contributes a considerable amount of water to the main river. Its deep red tinge is in strong contrast with the muddy water of the Arkansas, and the waters running side by side some distance before mingling have a marked and unique appearance.

From the Cimarron to the mouth of the Grand River the distance is 87 miles. The slope of the river in this distance is about 152 feet, or 1.75 feet per mile. It will take about 38,000 feet of dam to improve this portion of the river, or 437 feet per mile.

About 3 miles above the mouth of the Grand River is the bridge of the Missouri, Kansas and Texas Railroad. The length is 800 feet; there are four spans of 200 feet each, and the lower chord is 34 feet above low-water. The bridge is a strong and handsome structure, built of wood and iron. It has no draw, and may be considered an obstruction.

About ¼ of a mile above the mouth of the Grand Rirer the Verdigris empties and ma kes quite an addition to the volume of water. The Grand River discharges still more than the Verdigris, and together they make a very perceptible difference in the main stream.

Below the mouth of the Grand, the river changes very much in its character. The bed of the river is not so wide, the channel much better, and the bars and banks contain more gravel.

From the mouth of Grand River to Greenleaf's Creek, about 28 miles, the river is generally good; 5,000 feet of dam will suffice for this distance, but it is almost impassable in places on account of snags, which in some localities almost fill the water-way.

At Greenleaf's Creek the river was closed with ice, and the examination had to be abandoned. But as Mr. Abert had made a survey of that part of the river in 1869, his report will give information concerning it. The distance from Grand River to Fort Smith is 94 miles, and I should think that $150,000 would be sufficient for its improvement.

In the above estimates I have taken the cost of the dams at $4.50 per linear foot, which I think would be sufficient, as most all of the work would be in shallow water.

Summary.

Locality.	Distance, miles.	Linear feet of dam.	Cost of rock excavation.	Total cost.
Wichita to El Paso	15	7,200	.....	$32,400
El Paso to Oxford	25	7,800	$3,000	38,600
Oxford to Arkansas City	25	17,000	.....	76,500
Arkansas City to Kaw Agency	44	16,500	3,000	77,250
Kaw Agency to Salt Creek	62.5	28,000	.....	126,000
Salt Creek to Black Bear Creek	15	14,000	.....	63,000
Black Bear Creek to Cimarron River	41.5	20,500	.....	92,250
Cimarron River to Grand River	87	38,000	.....	171,000
Grand River to Fort Smith	94	.....	.....	150,000
Total	409	149,000	6,000	826,500
Add for contingencies and engineering expenses				73,500
Total				900,000

The Arkansas River passes through the Indian Territory, from the southern boundary-line of the State of Kansas, to Fort Smith, Arkansas, a distance of about 330 miles by river. Little trade could be expected from the Territory except in the Cherokee Nation, between Fort Smith and the Grand River, where perhaps some business might be done.

That portion of the country tributary to the river in Kansas, from Wichita to the State line, is rich, fertile, and well cultivated, and would derive great benefit from the opening of the river to navigation. But where so much of the river passes through an almost uncultivated country, it is questionable whether the expense of the improvement would be justifiable.

Respectfully, your obedient servant,

J. D. McKown,
Assistant Engineer.

Maj. Charles R. Suter,
Corps of Engineers, U. S. A.

O 19.

EXAMINATION OF KANSAS RIVER FROM ITS MOUTH TO JUNCTION CITY, KANSAS.

United States Engineer Office,
Saint Louis, Mo., February 5, 1879.

General: In accordance with your instructions of July 8, 1878, I have caused a reconnaissance of the Kansas River to be made from Junction City to its mouth by Mr. J. D. McKown, assistant engineer, and a copy of his report thereon is herewith submitted.

The Kansas River is one of the largest tributaries of the Missouri, and had in former days considerable commerce, but in its present condition it is absolutely impassable, owing to the artificial obstructions placed in it. There is a mill-dam at Lawrence, 49 miles from the mouth, and scattered along the 190 miles of river examined there are no less than 10 bridges unprovided with draws, and of course impassable for boats. Until these structures are removed or altered it is useless to undertake the improvement of the navigation.

From Junction City to Topeka, 104 miles, the least low-water depth is 12 inches, and thence to the mouth, 86 miles, it is not less than 24 inches.

Throughout its whole length the river is much obstructed by snags, which are constantly falling in from the caving banks and by shifting sand bars similar to those of the Missouri.

To give a least depth of 4½ feet from Topeka to the mouth, and of 3½ feet from Junction City to Topeka, by contracting the width of channel and protecting the banks, about $400,000 will be required, and the removal of snags and rocks from the channel will require about $50,000 more.

These estimates are only rough approximations, and no permanent work could be undertaken until a thorough survey had been made, the cost of which would be about $8,000. If the bridges were provided with draws, and a short canal with a lock were built around the dam at Lawrence, the removal of snags would enable small steamers to navigate the stream at all but the lowest stages of water, and would probably be of much benefit to the people living along the stream.

I am, general, very respectfully, your obedient servant,

Chas. R. Suter,
Major of Engineers.

Brig. Gen. A. A. Humphreys,
Chief of Engineers, U. S. A.

Report of Mr. J. D. M'Kown, assistant engineer.

United States Engineer Office,
Saint Louis, Mo., January 8, 1879.

Major: I have the honor to make the following report of the examination of the Kansas River:

Pursuant to instructions received from this office I proceeded to Junction City, Kans., on the 1st day of September, 1878, and at once made arrangements to procure the necessary equipage for the work. On the 11th day of September I commenced the examination, starting at Fogerty's mill, on the Smoky Hill River, 6 miles above the junction of the Smoky Hill and Republican Rivers. The confluence of these two streams forms the Kansas River.