

In conclusion, I recommend that should any money be appropriated for the Colorado, it be applied to the improvement of the following places, in the order named:

1. Gravel bar at Indian agency.
2. Gravel bar at Aubrey.
3. Gravel bar at Empire Flat.
4. Barriers.

Respectfully submitted.

Lieut. Col. C. S. STEWART,  
Corps of Engineers, U. S. A.

A. H. PAYSON,  
First Lieutenant of Engineers.

APPENDIX.

*Gravel bar at El Dorado Cañon.*—The permanent high-water banks at this place are from 1,000 to 1,200 feet apart, that on the left being about 15 feet high and thickly grown with willows; the right hand perpendicular "mesa" from 30 to 60 feet in height. At the lower end of the obstruction high gravel hills come down to the left bank, and the two shores approach to within 400 feet. At low stages a broad bar of cobble and sand, joining the left bank, rises from 2 to 3 feet out of water and narrows the river to from 600 to 800 feet, the practicable channel then being less than 200 feet in width, and barred at both ends by a gravel ridge. It has always been close to the right bank. The crossings on these ridges, which are also permanent in position, are about 2,400 feet apart, the upper and narrower having at the time of my examination 22 inches over it; the lower, only from 12 to 14 inches, in a swift rapid.

The plan includes the excavation of a channel through both crossings and the construction of a dam to direct the water over the lower one and close a narrow but deep passage, through which a good deal of water now runs along the right bank. The bar shown at the outer end of this dam is partially submerged cobble, through which the water flows freely. The material of these obstructions being large cobble and their position fixed, it is probable that the dredging alone would give durable benefit, while, since they are at the head of navigation, there is no danger of their removal causing trouble above.

*Four-Mile Rapid.*—The river here is suddenly narrowed by a broad cobble-bar joining left bank, and causing at low-water a very swift rapid, over which it would be necessary for a steamer to heave. There is ample depth until the rapid is passed, and it is not believed that any improvement is really needed, though some good might be done by scraping the bar at its head.

*Six-Mile Rapid.*—The right bank here is about 15 feet high, thickly grown with willows, and having the "mesa" from 15 to 30 yards back of it; on the left are high gravel hills. Through an "arroyo" in this mesa, 100 yards in width, a wash-out has poured a mass of large bowlders, some of them weighing several tons. They are seen forming a point on the right bank, a small clump further down on the left, and cropping out here and there above the water at low stages.

During the time that steamers come up to this place there is a swift rapid abreast the large rock close to the left bank, over which they are forced to heave with much difficulty.

During the lowest water there is ample depth and a gentle current, but submerged bowlders are found in places in the channel with from 2 to 6 inches over them. The plan provides only for the removal of these bowlders.

*Whirlpool Bend.*—At high-water the river here is about 800 feet wide, with a gentle current, and between tolerably permanent banks.

A point of high and nearly perpendicular "mesa" jutting out from the right bank causes the course of the stream to bend abruptly to the left, just below the obstructions.

At low-water a beach of coarse cobble, joining the left bank, narrows the river to some 300 feet and causes a very swift rapid, with two broad and shoal bars lying across above it.

The plan provides for the dredging of a channel through both these bars and a contraction of the water-way abreast the lower crest of the upper and worst of them by a dam of cribwork.

*Rapid at head of Round Island.*—At this point the river divides into two branches, one to the east, the other to the west of Round Island; the former being always the low-water channel.

There is a swift rapid in the east channel at the head of the island; but there is always plenty of water in it, and the sketch is given only to show the position of a dam, planned to close the west channel for the benefit of an obstruction below called

*Boulder-bar in East Channel.*—Over this there is a narrow passage with 2 feet of water and a current of about 5 knots at low stages. Although the steamers draw less

than this they cannot force their way up a rapid of that depth; since, in trying to do so, they settle by the stern.

It is thought that this place will be materially helped by closing the west channel; but provision is also made in the estimate for scraping the bar, which is formed of bowlders of considerable size.

*Side Channel.*—At this place a slough breaking out at right angles from and carrying nearly as much water as the main stream, forms with it a small island of cobble and sand. The left bank of the slough is of caving earth, and throughout, it is of sufficient width and depth for navigation, save at its head, where it is crossed by a very narrow ridge of gravel, with 2 feet of water and a swift rapid over it. The river proper also forms a rapid abreast the island, and is crossed diagonally by two bars, one narrow, above the mouth of the slough, and the other wider below it. Over both these I found 2½ feet in a narrow channel, and it is believed that closing the mouth of the slough will make the river navigable here at the lowest stages and improve it at other times, as will be seen from what follows.

At high-water this is also a dangerous place. The island is then a shoal, and a steamer going up is struck on the port bow by the swift current setting into the slough, which is very likely to force her ashore.

The same effect is marked, but less troublesome, coming down, and the remedy for both cases will be found in the proposed dam.

*Ford at head of Cottonwood Island.*—Just above this point a large slough with deep water in it, but less than 2 feet over the bar at its head, leaves the river to rejoin it 3½ miles below.

The bar, which forms the obstruction, is of rather fine gravel, with a narrow 2-foot channel over it, and less than 100 feet across.

It is believed that closing the slough will not only give enough water here at all times, but will also do much good to the river below. A dam has been planned for the purpose.

*Cottonwood Island Valley.*—This presents the usual valley characteristics, and at high-water there are formed in it numerous islands, separated by passages which afterward run dry.

Opposite the end of the 26th mile below El Dorado Cañon, the main stream at low-water divides into two channels, separated by narrow and shifting islands of sand. One of these keeps close along the mesa; the other, against the east shore of Cottonwood Island, has always been the channel used. There are in it, however, a gravel bed and group of bowlders, which, without entirely barring navigation, would make it difficult in very low stages. Both these obstructions are shown in the sketches.

It is thought that by brush and stone dams this portion of the river could all be kept against the permanent "mesa," and an improvement thereby effected which would probably be more lasting than the result of any efforts directed upon either the bowlders or the bar.

An estimate has been made for this purpose, but the dams are not shown in place, on account of the shifting character of the sandy islands, which it would be their object to join and strengthen.

*Mojave Crossing.*—The river at this place is from 800 to 1,000 feet wide; the right bank high and nearly vertical gravel hills, the left low "mesa."

The water-way is divided by a long and high ridge of large cobble into two channels. The right-hand and narrower one is never used, while that on the left becomes too shoal in low stages over a bar, which, beginning at the foot of the cobble ridge, stretches diagonally down and across the stream. The narrow channel is also crossed, at the head of the ridge, by a bar with only a few inches, in a swift rapid, over it.

It is proposed to close this passage by a dam built on this bar; and to contract the width of the other one by a second dam, starting from where the cobble ridge has sufficient height and extended out along the crest of the obstruction. It would also be necessary to dredge to the required width and depth.

*Gravel bar below Hardyville.*—The river here is some 800 feet wide; both banks being permanent "mesa."

From the foot of an extensive cobble flat, close to left bank and bare at low-water, there extends a broad, submerged, gravel ridge, partially overlaid with sand, which can be traced for nearly 3,000 feet downstream, and probably joins the right bank somewhere under the sand-bar, shown in the sketch. The difficulty is found in the crossing which has to be made over this ridge; for, although it is usually practicable, the position of the best water is always shifting, and boats are liable to damage from the gravel, where the sand, which usually overlays it, has been scoured off.

It is believed that a crossing could be made permanent by a wing-dam, built out anywhere along this ridge; but it is shown on the sketch where the survey found the best water.

The dam is of brush and stone and it is not likely that any dredging will be needed after the sand has been swept away.

*Pest House Rapid.*—This is formed by an island of sand and cobble, from 1 to 3 feet

out of water at low stages; the rapid being on its right and a broad but shoal passage on its left.

About 3,000 feet above the head of the rapid, the left hand permanent bank bends off abruptly, and close under it there is a third channel; which, though dry at the time of my examination, carries a great deal of water in floods and sometimes runs throughout the year.

Between this high-water channel and the one on the left of the island is a broad and low cobble flat so that the permanent banks abreast the head of the rapid are some 2,000 feet apart.

I found the current in the rapid about 4 knots and a practicable but narrowed channel  $2\frac{1}{2}$  feet in depth. This depth varies greatly in different seasons, as more or less water is carried through the other two passages and has been found as small as 14 inches.

The rapid is always the low-water channel. To make it always navigable, it will probably be necessary to close both the others, and two dams have been planned for the purpose, joined by a ridge of cobble. Their length is very great; but I do not see how this can be helped; in fact, it may be necessary to make them continuous. Dredging will not be needed.

Pest House Rapid is the last obstruction, above Camp Mojave, and embraced in "Estimate 1." Of the improvements planned below Camp Mojave, the first is:

*Aubrey Bar* (one mile above Aubrey).—This is a deposit of rather fine gravel, mixed with and generally overlaid by sand, stretching from bank to bank, for nearly 1,000 feet, up and down stream. It is the nucleus for shifting sand-bars which form on its top; and on the position and extent of these depends the depth of the low-water channel, which has always been found close under the right-hand shore.

At the time of my examination, the middle of the river, for the whole breadth of the gravel deposit, was filled by a sand island, out of water; and the scour being thereby directed through the channel, it was easily navigable, though it has been found with less than a foot through it.

The banks are permanent mesa, and about 700 feet apart.

A dam of brush and stone has been planned to keep the river, at low stages, over against the right-hand shore. No dredging will be needed, since the real obstruction is the sand over the gravel, which will be readily scoured out.

*Empire Flat* (lower end of Aubrey Cañon).—The river is here about 1,000 feet wide between permanent banks. The trouble is caused by a ridge of gravel, which apparently extends from the cobble point on the right shore over to the point of rocks which juts out from the left. This gravel is overlaid by sand, and, as at Aubrey, the condition of the low-water channel depends on the position and form of the bar. It is found, now on one, now on the other side of the river, and sometimes crosses over, along the gravel.

At the time of my examination, large spaces in the middle of the stream were filled by sand islands, out of water, and consequently there was ample depth for a steamer; but when the channel-way is not so diminished and spreads out over the whole width, it becomes a most troublesome place.

A dam of brush and stone has been planned, along the gravel ridge, to direct the low-water current over towards the rocky point. No dredging will be necessary.

*Agency Bar* (opposite Camp Colorado).—This obstruction differs from any before described. It is in the "Colorado Valley," and, in view of the great and sudden changes to which the river here is liable, it is not likely that any improvement will be permanent. But it is by far the most troublesome place below Camp Mojave, the river never being good here at low-water; and I believe that a small amount of money might well be spent here in the hope of securing some benefit, and with the chances in favor of its lasting over several years.

About  $\frac{1}{2}$  a mile above the bar, the river is between semi-permanent banks of high bottom, thickly grown with good-sized trees, and nearly 1,800 feet apart. It there divides into two channels of nearly equal size, and these diverge until they are separated at low-water by a plain of clay and sand, from 2 to 3 miles broad, intersected by several sloughs and seamed by various well-marked streaks of gravel. These streaks of gravel, each evidently the relic of some more than usually violent flood, lie generally in the direction of the main stream and are of rather fine materials, few of the particles being larger than a walnut.

The low-water channel has always been close to the right-hand edge of the timbered bottom, and, at the place shown in the sketch, crosses one of these gravel masses, which, starting here from the shore, extends out under the row of sand islands; its outlines within troublesome limits being well indicated by the 3-foot contours.

On the bar there is, at low-water, only from 6 to 14 inches, and, as the gravel in the channel is not overlaid by sand, it is always a hard and dangerous place to work over, and may be said to cause the main objection of the steamship company to sending boats as high as Camp Mojave during the lowest stages.

The plan provides for cutting off that portion of the river which flows down the

left bank by a dam of brush and stone; also, for the dredging which will be needed in the gravel.

*Barriers* (near middle of Picache Cañon).—At this place the rocky hills and gravel mesa separate a little, leaving a narrow strip of bottom on both sides of the river. Across this little valley extends a line of low rocky clusters, to which Lieutenant Ives gave the name of the Barrier Islands.

The low-water channel is found at different times in each of the two water-ways shown in the sketch, and it has also been close down the right bank through the broad sand-flat which joined it at the time of my visit.

In past years, however, it has oftenest been next the left bank, as I found it, but of late, the river has been working rapidly to the right in high-water by wearing away that shore, and unless this tendency be reversed, the low-water channel will finally shift in the same direction.

There is always plenty of water wherever it goes. Trouble is only found when it is close to the left bank, and is due to the narrowness of the passage between rocks, and the necessity which then arises for the steamer on getting up through, to make a sharp turn to the left, with much risk of dragging the barge on the sharp, submerged point of rock between stations 40 and 41 of the survey.

For the reasons above stated I think this will in time cure itself, and doubt the need for any work at this point, but so many complaints were made about it and so much damage has been already done here that I have estimated for a dam of brush and stone to prevent the stream at low-water from taking this objectionable course.

Respectfully submitted.

A. H. PAYSON,  
First Lieutenant of Engineers.

## JJ 5.

EXAMINATION OF HUMBOLDT RIVER AND CRESCENT CITY HARBOR,  
CALIFORNIA.

SAN FRANCISCO, CAL., September 20, 1878.

GENERAL: I have duly considered the letter of the department of July 8, 1878, in reference to an examination of Humboldt River, California, and Crescent City Harbor, California.

On the 6th of August last I wrote to the department that the sum of \$500 would be necessary to enable me to prepare plans and estimates of cost for improvements "proper to be made" at these two places.

At that time I supposed it might be necessary for me to make a personal examination of these harbors, but an inspection of the act of Congress "making appropriations for the construction, repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," approved June 18, 1878, shows that Humboldt River and Crescent City Harbor are mentioned, as is stated in the letter of the Chief of Engineers of July 8, "with a view to their adaptability as a harbor of refuge."

In view of the fact that both of these places were included among those which were examined by the Board of Engineers for the Pacific Coast in the year 1876, with a view of establishing a breakwater and harbor of refuge on the Pacific coast, at some point between San Francisco Bay and the mouth of the Columbia River, I cannot imagine a re-examination of them by me at the present time to be necessary.

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They were both included in the resolution of the House of Representatives of April 29, 1876. They were both thoroughly examined by the Board of Engineers for the Pacific Coast with the view of ascertaining if either of them could be converted into a harbor of refuge. They were examined, too, in connection with all the other possible places for a breakwater or harbor of refuge on this coast between San Francisco and the mouth of the Columbia River, and of all these places, "Hum-

boldt Bay," which I suppose to mean the same as "Humboldt River," was found to be the most impracticable. So very impracticable did the Board regard the improvement of the entrance to this harbor that it did not even make any "plan or estimate of cost for a breakwater at this place, deeming it, if not impossible of execution, highly improbable that a breakwater or jetties will be attempted here at the present time." And of the other places examined, the Board regarded Crescent City Harbor as the worst. It is contracted and full of sunken dangers, both inside the harbor and in approaching it.

The Board stated in its report that—

Crescent City Harbor is usually regarded as the most dangerous roadstead on this coast. \* \* \* Nevertheless, in order to have definite ideas as to the location and cost of a breakwater here, we have included it among the roadsteads for which we have given plans and estimates of cost for breakwaters.

In short, Humboldt Bay and Crescent City Harbor were the two places which the Board of Engineers, when considering the whole subject of a harbor of refuge on this coast, in 1876, reported particularly against.

I can only point to the report of the Board of Engineers for the Pacific Coast of February 14, 1877, as containing my views as to the impracticability of improving either of them.

That report contains my views, in every particular, as to the merits of these two places in connection with a harbor of refuge on the northern coast of California.

I have the honor to be, very respectfully, your obedient servant,

B. S. ALEXANDER,  
*Lieutenant-Colonel of Engineers.*

Brig. Gen. A. A. HUMPHREYS,  
*Chief of Engineers U. S. A.*

## APPENDIX K K.

### ANNUAL REPORT OF MAJOR JOHN M. WILSON, CORPS OF ENGINEERS, FOR PART OF FISCAL YEAR ENDING JUNE 30, 1879.

UNITED STATES ENGINEER OFFICE,  
*Portland, Oreg., October 22, 1878.*

GENERAL: I have the honor to transmit herewith reports of operations upon the works in my charge on the Pacific coast, for the portion of the fiscal year ending June 30, 1879, terminating this day.

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

JOHN M. WILSON,  
*Major of Engineers, Bvt. Col., U. S. A.*

The CHIEF OF ENGINEERS, U. S. A.

## K K I.

### IMPROVEMENT OF THE LOWER WILLAMETTE AND COLUMBIA RIVERS, OREGON.

The amount available at the commencement of the fiscal year was not sufficient to construct either of the dams projected for the improvement of the river and at the same time keep the dredge at work on the various bars; it was, therefore, determined to continue operations as usual dredging through the various bars in the Willamette and Columbia Rivers.

The United States dredge having been thoroughly repaired, was put into commission on July 15, and on the 16th was sent to

#### THE MOUTH OF THE WILLAMETTE RIVER,

where the channel through the bar had been filled up during the annual freshet of the Columbia in May, June, and July.

Operations were commenced on the 17th, and by August 3 a cut 100 feet wide and 17 feet deep at low-water had been made by excavating 4,915 cubic yards of mud and sand.

The dredge was towed on the 6th of August to

#### SAINT HELEN'S BAR, COLUMBIA RIVER,

where a similar filling to that at the mouth of the Willamette had occurred, the channel dredged in 1877 having been entirely filled up.

The cause of this bar has already been fully discussed in previous reports, and it is only necessary to say that dredging will be required annually until the projected dams are constructed.