

miles below. Probably 600 cords or thereabouts per year are brought up by the steamers from that point, and this work can all be done in a few days during the summer months. There is little else to take the boats above Camp Mojave, or Hardyville, so called.

As to the improvements below Camp Mojave and above Ehrenberg, there is so little prospect now of anything but greatly diminished traffic in the river since the practical completion of the railway eastward from Yuma to Maricopa Wells, that I do not feel justified in recommending any expenditure under the plan submitted for them, nor indeed for those higher up.

Since the foregoing was written, my attention has been called to an extract from an Arizona paper, the "Prescott Enterprise," which appeared in a San Francisco paper of this date, as follows:

In all probability the last boat which will bring Prescott freight from Yuma to Ehrenberg has concluded its mission, and hereafter steamers on the Colorado River, which have been plowing through its waters successfully for 17 years, will grace that stream only semi-occasionally.

There will be forwarded to-morrow by express four sheets, as follows, viz:

1 Tracing—Sketch of Colorado River between El Dorado Cañon and Pest House Rapid, &c. General scale, 1 inch to 2,000 feet; special, 1 inch to 200 feet.

1 Tracing—Sketches of obstructions in Colorado River below Camp Mojave. Scale, 1 inch to 200 feet.

1 Tracing—Sketch of construction for improving the Colorado River. Scale, 2 inches to 2 feet.

1 Sheet (profile paper)—Curve showing oscillations of water's surface of Colorado River at Yuma, from observations made daily by agents of Colorado Steam Navigation Company, from March 31, 1878, to March 31, 1879.

Very respectfully, your obedient servant,

C. SEAFORTH STEWART,  
*Lieutenant-Colonel of Engineers.*

The CHIEF OF ENGINEERS, U. S. A.

REPORT OF LIEUTENANT A. H. PAYSON, CORPS OF ENGINEERS.

SAN FRANCISCO, CAL., April 10, 1879.

COLONEL: I have the honor to submit the following report of my examination of the Colorado River, made by your directions in December and January last. Having secured the services of Mr. D. W. Taylor, transitman, and two rodmen, the party left San Francisco December 4, and reached Yuma on the morning of the 6th. The day was spent in engaging a pilot, cook, and boatman, and buying the necessary provision and camping outfit. We left Yuma on the steamer Cocopah at noon of the 7th, and after a very good passage, considering the stage of the river, reached Camp Mojave on the 18th. Here, with the assistance of the commanding officer, Major Van Horn, I secured the services of six Mojave Indians, and having gotten our skiffs in order and left all supplies, provisions, luggage, &c., at the post, we made our first camp at Hardyville the same night. The next morning we started our instrumental line north. For the first four days we were greatly delayed and suffered intense discomfort by reason of a violent northerly gale, which blew incessantly, and at times reached such force that tracking the boats upstream became impossible, and we were obliged to make camp where we found ourselves. After this the weather remained fine till we reached the mill at El Dorado Cañon, on the afternoon of the 26th. The 27th was spent in making a survey of the bad obstructions found in the river just below this place. Though El Dorado was the northern limit of the examination I was to make, the river seemed so good beyond, that on the 28th I started north again, and camped the same evening above Roaring Rapid (so named by Ives), in the lower part of the Black Cañon. During the night a violent storm of rain and sleet set in, for which, being without any tents, we were totally unprepared. The Indians, moreover, declined to go any farther. As what I had seen of the river the day before had convinced me that El Dorado was practically the head of possible low-

water navigation, there was no valid reason for going farther up, so I turned back with some reluctance and reached the mill the same afternoon, the storm still continuing.

On the morning of the 30th we started down for Camp Mojave, where we arrived on the morning of the 4th of January, having been obliged to stop at many places to make special examinations of bad parts of the river. My Indians left me here, but I succeeded in getting four others, and started again on the 5th, reaching Ehrenberg on the 10th and Yuma on the 15th, where the party was broken up.

The following work was accomplished:

1st. A transit, stadia, and rough level line was run from below Pest-House Rapid to El Dorado Cañon, and the river sketched.

2d. Two lines of accurate levels were carried; the one to include several of the swiftest rapids, the other in the comparatively slack water of Cottonwood Island Valley, to get some idea of the maximum and minimum fall.

3d. Special surveys were made of 25 places, the shore-lines being put in by stadia and soundings taken where it was necessary and possible. Quite a number of these surveys have not been plotted, for the reason that I did not think any improvement at such places needed or practicable.

There are submitted with this report four sheets of drawings, showing the river from Pest-House Rapid to El Dorado Cañon on a scale of 1 inch to 2,000 feet, and on the enlarged scale of 1 inch to 200 feet, those points between the cañon and Yuma where it is thought that some change for the better might be effected.

PHYSICAL CHARACTERISTICS.

The Colorado River proper is formed by the junction of the Grand and Green, latitude  $39^{\circ} 17' N.$ , longitude  $109^{\circ} 50' W.$ , approximate.

Its length, following the windings of its course, from this point to the Gulf of California is about 900 miles, of which the first 400 lie in the Grand Cañon and its extensions, the so-called Black and Boulder Cañons. Through its tributaries and the Green and Grand Rivers it drains an enormous area of over 240,000 square miles, including the southwestern part of the Wyoming, nearly half of Utah and Colorado, almost the whole of Arizona, and considerable portions of Nevada, California, and New Mexico. From the foot of the Grand Cañon to the sea its only tributary at low stages is the Gila, which enters at Yuma; but 200 miles above the last-named point a large quantity of water is received in times of flood through "Bill Williams's Fork."

Shortly before its issue from the wonderful trough it has cut for itself in the great tableland west of the Rocky Mountains, the river's course from southwesterly bends to nearly due south; and thence to Yuma, preserving the same general direction, it flows through a succession of desert valleys, gradually enlarging as we go down, and inclosed by a network of mountain ranges of small elevation and volcanic origin. Below Yuma the country is a broad sand and gravel plain, from which rise here and there low rocky hills.

The valleys above mentioned, which once formed the beds of ancient lakes, are level gravel "mesas," from 50 to 150 feet higher than the present water-surface; joining the mountains in long slopes of eroded material and composed of rounded fragments of erupted matter in endless variety.

As the waters of these lakes, falling over the lowest parts of their separating barriers, gradually cut a deeper channel for themselves, the submerged portions decreased in size until finally they were fully drained, and we see now a narrow and rapid river; alternately in cañons where the mountains or "mesa" come directly to the banks, or else bordered by slender strips of fertile bottom, formed from the sediment it has carried, and limited laterally to those areas in which at various times it has found its course.

In the cañons the banks are permanent, the course almost invariable, and the water usually confined to a single channel; the obstructions consist generally of rocks or gravel.

In the valleys, the river at high stages forces its way at will through the unstable material of the soil, and as it falls shrinks into a maze of shallow and ever-shifting channels, separated by broad bars of clay and sand.

Changes are incessantly going on and are of surprising rapidity and extent. The river is now in some places 6 miles away from its position when explored in 1857-'58; it sometimes shifts from 2 to 3 miles in a single flood; while even in the lowest stages large tracts are being swept bodily away and reformed elsewhere.

Going down the river in January, I saw a place where a sand bar, from 100 to 200 feet in width and 6 inches out of water, was precisely where we had found the steamer channel coming up a month before; while, day or night, one is never out of hearing of the splash of caving banks.

High-water of the Colorado takes place some time in June; it then gradually, but continually, falls till December, and is at about its lowest stage through that month



and a part of January. The surface at any point is hardly ever at a constant level for 24 hours; changes of from 1 to 3 inches in that time being almost continuously in progress. After some time in January the rises begin to exceed the falls, and the river slowly but surely improves until the spring melting of the snow in the mountains, usually during the last of May, causes again the annual flood.

The extreme range at Yuma is from 12 to 14 feet, above, it of course increases, especially in the gorges, until, in the foot of the Black Cañon, I saw enormous drift lodged over 30 feet above the water; while Lieutenant Ives mentioned similar marks as indicating a rise of 40 feet a little further to the north.

The following are the distances from the mouth of the river to various points along it. The information on which they are based is imperfect and conflicting, and they can only be regarded as probable approximations.

From the Gulf to Yuma is by river 150 miles, though in a straight line only 75 miles.

	Miles.
The distance from Yuma to Castle Dome Landing is .....	28
Ehrenberg .....	111
Camp Colorado (Indian agency) .....	179
Aubrey (Bill Williams' Fork) .....	200
Camp Mojave .....	285
Hardyville .....	297
El Dorado Mill .....	344

Although it is difficult to make the distinction exact, of the 297 miles between Yuma and Hardyville, about 100 miles may be considered cañon, the rest as having the valley characteristics before described.

They succeed each other as follows:

	Miles.
Valley from Yuma to Picache Cañon .....	13
Picache Cañon .....	46
Great Colorado Valley .....	120
Aubrey Cañon .....	37
Chin-e-hue-vis Valley .....	18
Mojave Cañon .....	17
Mojave Valley .....	46

From Camp Mojave to El Dorado is cañon with the exception of the little valley of Cottonwood Island, 5 miles long and from a  $\frac{1}{4}$  to  $\frac{1}{2}$  a mile in width.

#### LEVELS AND DISCHARGE.

By the railway surveys the height of low-water surface at Yuma is 117 feet above the sea; the distance being by river 150 miles, we find for the corresponding low-water slope .78 feet per mile. It was determined at Yuma by actual leveling in March, 1876, by party under Lieutenant Bergland, as 1.2 feet per mile.

A second railway survey crosses the river 6 miles above the "Needles" in Mojave Cañon, and 245 miles above Yuma. By leveling from a bench-mark of this survey, we found the surface of the water January 6, 1879, to be at reference 425.4, which gives the average slope from this point to Yuma as 1.23 feet per mile.

This seems very probable, the fall per mile at Camp Mojave having been also determined by the levels of Lieutenant Bergland's party as 1.2 feet.

From the railway crossing to Camp Mojave is 40 miles; calling the slope 1.3 feet per mile, low-water surface at Camp Mojave would be 52 feet above that at the Needles, or reference 477 above sea.

By careful and long-continued barometric observations in 1876, Lieutenant Bergland found the surface of the river, then nearly at its lowest stage, at Camp Mojave, to be at reference 533. This is a grave discrepancy for which it is difficult to account. It seems hardly possible that the railway survey could be so much in error; while taking the barometric determination as correct, we get the average low-water slope between Yuma and Camp Mojave, 2.03 feet per mile, which is nearly double what it was found to be by actual levels at both those places, and larger than the average slope determined by my own levels, from Camp Mojave north, for more than 50 miles; though this latter stretch of river, flowing as it does in a cañon and over frequent rapids, has visibly a greater fall than that below.

It is to be noted also that Camp Mojave being one of the stations used by Colonel Williamson, its attitude is given in his work on the barometer and is about 100 feet less than that found for it by Lieutenant Bergland's party. The post being on a level "mesa," there could not have been any considerable difference in the position of the instruments in the two cases.

The level line of my party began at the foot of Pest House Rapid, a few miles above Camp Mojave, and continued to El Dorado Canon, the distance being 50.5 miles and the mean slope 2.03 feet per mile.

Two carefully run lines, each about 3 miles in length—one in the valley of Cottonwood Island, the other over some of the swiftest rapids—gave 1.4 and 3.7 feet per mile respectively for minimum and maximum fall in this portion of the river.

It will thus be seen that the fall is very unequally distributed, the profile showing a series of slack-water pools, separated by rapids.

This point can be further illustrated as follows:

The fall from El Dorado Cañon to foot of Cottonwood Island Valley is 56.08 feet, the distance being 27 miles. Separate levelings were made at the principal rapids, found in this portion, and it was shown that nearly half of the total fall occurred in less than  $\frac{1}{3}$  of the distance.

At the swiftest place the river fell 5.155 feet in 2,100, corresponding to 12.67 feet in a mile, notwithstanding the fact that the water's surface was only taken at the extreme limits of the special survey made here, and that the distance includes, consequently, not only the rapid proper, where most of the fall probably took place, but also considerable reaches of slacker water above and below it.

Taking the railway reference of low-water at the "Needles," the following is the approximate height of low-water at El Dorado Cañon, the northern limit of my examination:

	Feet.
Rise from sea to Yuma .....	117
Rise from Yuma to "Needles" .....	308
Rise from "Needles" to Pest House Rapid .....	65
Rise from Pest House Rapid to El Dorado .....	103
Total .....	593

#### DISCHARGE.

It is quite difficult to form any idea of the discharge of a river like the Colorado, where so much of the water must of necessity flow beneath its bed, and where the fluctuations of the latter are so extreme and uncertain. A gauging at any place affords no certainty that the river's discharge there will be the same at some future time when the water stands at an identical level; nor, having a discharge and water-level for any particular case, can we even approximately predict the discharge for some other level from the consequent enlargement of the water-way.

Either a rise or fall in the river may be attended by a scouring or filling of the bed, and although it is probable that the hydraulic radius in a section may be a function of the reference of the water surface in it, it does not seem as if it would ever be possible, in material of such unstable character, to deduce the one from the other.

Lieutenant Bergland found the discharge of the Colorado, in September, 1876, at Camp Mojave, to be 11,610 cubic feet per second, the river being nearly at its lowest level. Though the river may not actually fall considerably after this, it is certain that the discharge decreases very materially.

In January, 1879, in a straight and uniform portion of the river just above Camp Mojave, I measured a section only 1,600 square feet in area, with a hydraulic radius of 2.6 feet.

A discharge, such as Lieutenant Bergland found, not far from the same point, could only take place through this section as the result of a mean velocity of over 7 feet per second.

I estimated the actual mean velocity as something less than 2 feet, and even considering the water which must flow beneath the sandy bed, do not think it safe to put the extreme low-water discharge here as more than 3,000 cubic feet per second.

At Yuma, in March, 1876, below the mouth of the Gila, Lieutenant Bergland found a discharge of 7,658.7 cubic feet per second, with a cross-section of 2,726 square feet, and hydraulic radius of 5.8; the river being then about at its lowest stage. Lieutenant Michler, while on the Mexican Boundary Commission in 1854-'55, estimated the low-water discharge at the same point as 6,200 cubic feet per second.

The railway company have carefully measured sections from time to time, in almost the same position as one of Lieutenant Bergland's, to aid them in designing their bridge. I have found the largest one of these to be that of June 8, 1877, with an area of 8,412.5 square feet, and hydraulic radius of 15.3 feet, which, without any increase over the low-water velocity, would discharge nearly 24,000 cubic feet per second.

Although the Colorado receives no tributary between the mouths of the Virgin and the Gila, it does not perceptibly decrease in size between those points as we go down, even in its extreme low stage.

The rainfall in the basin through which it flows is small and uncertain, varying in different places from  $\frac{1}{2}$  an inch to 10 inches, and it is therefore probable that the river stores up for itself, in the sand and gravel which it overflows in times of flood, large quantities of water, which are afterward received gradually by infiltration as it falls.



COMMERCE AND NAVIGATION.

Before the railway reached the Colorado River at Yuma, all supplies sent from San Francisco to the interior of Arizona went by sea-going steamers to the head of the Gulf of California, and were there transferred to the river boats of the Colorado Steam Navigation Company, to be left at various points along the river and freighted overland to their destination. The most considerable portion of the transportation was between the gulf and Yuma, which was the starting point for Tucson; and of that on the upper river, the greater part was to and from Ehrenberg, from whence there was the most convenient road to Prescott, and the important country adjacent.

Above Ehrenberg we find only the Indian agency at Camp Colorado, the so-called towns of Aubrey and Hardyville, the military post of Camp Mojave, and the little mining camp at El Dorado Cañon.

Aubrey and Hardyville are each small adobe buildings, occupied as stores, at which supplies are landed for a few mining camps in the interior, of which the most important are Signal, Hackberry, and Mineral Park.

The mine at El Dorado is said to be a good one but the company is supposed to be in financial difficulty, and its abandonment in the near future is, to say the least, not impossible.

As soon as the railway crossed at Yuma, the best part of the river business was stopped at once; the steamers passed into the hands of the railway company; the old establishment at the mouth of the river was abandoned and all trips from thence to Yuma discontinued.

During the past winter the Southern Pacific road has been rapidly pushed into Arizona, and, when operations are discontinued for the hot weather of the coming summer, its terminus is expected to be at Maricopa Wells, 190 miles east from Yuma. When this happens, freight for Prescott and its tributary districts will no longer go by boat to Ehrenberg but by rail to Maricopa Wells; and with this change disappears at once not only the greater portion of the remaining need for river transportation, but also the chief reason for the existence of the town of Ehrenberg itself.

We are, therefore, confronted with the fact that our estimate of the necessity for increased communication facilities by the river must be based on the needs of the country above Ehrenberg, dependent on it for supply.

It is of course not improbable that new mines may be discovered in the very imperfectly known country adjoining the Colorado's course, but such a consideration is altogether too uncertain a one to be entertained at present; while with reference to future agricultural development in the very limited areas of fertile land through which the river flows, it may simply be said that none will be possible, unless preceded by such works of reclamation and control as would in themselves definitely settle the question of navigation.

Roughly stating the extent of these arable lands as 500 square miles, by the ordinary methods of estimating the quantity of water needed for their irrigation, it will be seen that more than one-half of the low-water discharge would have to be diverted for that purpose.

By the railway company I have been furnished with statistics of the river traffic since it came under their management; they cover a period of 19 months from May 21, 1877, to January 1, 1879.

Before the first-named time there are no data which can be obtained. I have tried to separate these statistics for the different sections, in the following table:

FREIGHT CARRIED.	
	Tons of 2,000 lbs.
1. Between Yuma and Ehrenberg .....	7,973.3
2. Between Yuma or Ehrenberg, and points between Ehrenberg and Hardyville .....	4,784.7
3. Between Yuma and points above Hardyville .....	77.9
4. Points between Ehrenberg and Camp Mojave, and points above Camp Mojave .....	25.1
5. Between Camp Mojave and points above .....	2,864.2
Total freight business for 19 months .....	15,725.2

Probably the greater part of the item in the 4th line of the table was for Hardyville. The 5th line contains a large item which I believe consists mainly, if not wholly, of fire-wood, towed up from Cottonwood Island, 26 miles, for the supply of the quartz mill at El Dorado Cañon.

I have not been able to get statistics of the passenger traffic in a very intelligible form, but the following numbers will give some idea of its amount:

PASSENGERS CARRIED—

From Yuma .....	1,621	From Drift Desert .....	9
Ehrenberg .....	687	Swan Lagoon .....	6
Aubrey .....	230	Quien Sabe .....	1
Castle Dome .....	71	Indian Agency .....	21
Chimney Peak .....	64	Empire Flat .....	8
Picache Mill .....	3	Chin-e-hue-vis .....	3
Road's Ranch .....	4	Camp Mojave .....	100
Camp California .....	6	Hardyville .....	35
Gaston's .....	2	Cottonwood Island .....	2
Taylor's .....	2	El Dorado .....	11
Total passengers .....	2,286		

It remains to show what facilities for commerce the river affords in its present unimproved condition.

The head of high-water navigation was put by Lieutenant Ives in the lower part of the Black Cañon, and a steamer has actually ascended to the now abandoned town of Colville, 25 miles above the mill at El Dorado, but the difficulties and dangers of this upper portion of the river, combined with the lack of any present reason for going there, have made the latter place the practical upper limit of the navigable portion of the stream.

To this point the boats in use on the Colorado can go at any time from the spring rise till the latter part of August or fore part of September, without other obstacles than those interposed by the swiftness of the current.

Above that, Hardyville becomes the low-water head of navigation, and can generally be reached, with more or less difficulty, at all times; though occasionally, in extremely low stages, freight for this place has to be landed at the foot of Pest House Rapid, 4 miles below.

It may be safely said, therefore, that if there is freight enough to pay for the trouble, it can be sent to the foot of Pest House Rapid in all seasons, and to El Dorado Cañon for from 3 to 4 months in each year.

The chief obstacles to the low-water navigation are encountered in the valleys, which may be said to form an almost continuous obstruction, over 200 miles in length, while in the cañons there are comparatively few.

Above Camp Mojave there is probably quite as much water as below; but the general character of the bars changes from yielding and semi-fluid sand to cobble of constantly increasing size, and steamers are unable to force their way over or through them, as they are continually obliged to do in the river below.

The boats in use on the Colorado are from 150 to 170 feet long, 30 to 37 feet beam, and draw slightly more than 2 feet. Their load is carried on board in high stages; but during low water it is placed on a barge and the latter towed astern by a long line, which reaches to a tow-post set amidships in the steamer's hull.

Previous knowledge of the channel is of no avail, and the pilot judges the course of the river at each moment by the appearance of the water surface, shape of the bars, direction of the drift, and other slight indications significant alone to his experienced eyes. A sounding pole is kept going constantly, and the boat is frequently aground each day. She is then hauled over by all sorts of devices, with spars, anchors, and capstan, or, as a last resort, is backed up to the bar, and digs her way slowly through by stirring up with the wheel the loose material of the bottom, until enough has been carried away by the rapid current. In this manner they have actually made a cut for themselves and hauled a barge through a bar of fine gravel, over which there had been found only from 2 to 3 inches of water.

A trip from Yuma to Hardyville can generally be made, in low stages, in from 10 to 14 days; the return in from 5 to 10.

Much uncertainty is introduced into these calculations by the wind, which occasionally blows with extreme violence straight up or down river, greatly hindering or even completely preventing navigation for 3 or 4 days at a time.

As a result of all this and the lack of any competition, transportation is extremely expensive, freight being charged for in pounds and the weight estimated by measurement. Cost will vary greatly for different classes of supplies, but the average price for the government from Yuma to Camp Mojave is said to be 4 cents per pound.

PLAN FOR IMPROVEMENT.

It is evident from the nature of the Valley River, which has been before described, that no permanent or important relief can be hoped for from any partial measures.

Any plan to be of value must embrace the whole of this portion, and insure throughout the confinement of the stream to one low-water channel, and the certain protec-



tion of its limits, as well as those of flood discharge, from the enormous destructive power of such a torrent as the Colorado becomes at certain seasons of each year.

When we consider the smallness of the interests now involved, the uncertainty whether adequate works could be constructed at all, and the certain extreme cost of the effort, it becomes quite clear that the day is yet far distant for even the suggestion of a plan.

The only hope of permanent improvement, with reasonable expenditure, is to be found in the application to the removal of obstructions of rock or gravel found where the channel's course is defined by permanent banks, and in the attempt to secure low-water navigation between Pest House Rapid and El Dorado Cañon.

With reference to this latter point, it is to be noted that since the low river carries enough water to supply a channel of practicable width and depth, and having a uniform slope, equal to the average between the two places, such an improvement is possible; whether or not within reasonable limits as to cost, can only be determined by experiment.

The river consisting of reaches of deep and comparatively slack water, separated by short and shoal rapids, the masses underlying the latter can only be removed at the risk of forming new obstructions by draining the river above them. Moreover, since the material of the bed is too large to be removed by scour alone, the requisite depth must be gained by excavation, and the resulting enlargement of the water-way counteracted, as far as possible, by a contraction of its width.

Works for this purpose will stand on cobble or small bowlders, and be exposed to very violent tests from the sudden occurrence and extreme height of the spring floods.

For these reasons they have been designed as outworks of round timber filled with stone, and of triangular or rectangular cross-section, as they are squarely or obliquely opposed to the action of the current.

Dams of brush and stone have been estimated for at certain places below Camp Mojave, where they would be on sand and in water highly charged with sediment.

Sketches of the various forms of construction proposed are furnished with this report. It is almost impossible to make even an approximate estimate of the cost of these works.

The country is remote from all sources of supply and the transportation is absolutely in the control of a monopoly, which, should the government decide upon extensive operations, would probably make it advisable for it to own the necessary steamer, lighters, &c. In any case the transport of material will be a very large item, and cost will vary greatly with the distance of the location from suitable timber and its position, whether above or below the supply. No growth of wood of sufficient size can be found above Cottonwood Island, and it is doubtful if there is enough even there for the river between it and El Dorado.

It might be necessary to partially replace the crib-work by brush and stone, both of which the country will furnish in abundant quantities. Most of the labor could be performed by Indians.

The following estimate is submitted as the best approximation I could make under the circumstances. I am only certain that the amount is not too large. The works planned are shown in red on the enlarged sketches, and a brief description of each place, with reasons for location, &c., is appended to this report.

## ESTIMATE.

1. For securing a channel 200 feet in width and 3 feet in depth at low-water from Camp Mojave to El Dorado Cañon.	
Dredging:	
El Dorado Cañon.....	17,793 cubic yards.
Whirlpool Bend.....	6,164 cubic yards.
Mojave Crossing.....	4,230 cubic yards.
28,187 cubic yards, at \$1.....	\$28,187
Construction No. 1:	
Whirlpool Bend, 560 feet, at \$3.50.....	\$1,960
Construction No. 2:	
El Dorado Cañon.....	900 feet.
Rapid head of Round Island.....	850 feet.
Side channel.....	750 feet.
Ford at head of Cottonwood Island.....	980 feet.
Pest House Rapid.....	1,480 feet.
Mojave Crossing.....	780 feet.
Total.....	5,740 feet, at \$3.50..... 20,090
Construction No. 3:	
Gravel bar below Hardyville, 950 feet, at \$3.....	2,850
Scraping boulder bar, east channel of Round Island.....	1,000

Removing bowlders, 6-mile rapid.....	\$1,000
Construction of 4 brush and stone dams in Cottonwood Island Valley, 6,000 feet, at \$3.....	18,000
Proportion of \$5,000 for lighters, camp equipage, and transportation.....	4,400
Add 10 per cent. for contingencies.....	77,487
Total.....	7,748
2. For improving certain gravel bars between Camp Mojave and Yuma.	
Dredging:	
Gravel crossing (Indian agency), 2,000 cubic yards, at \$1.....	\$2,000
Construction No. 3:	
Bar at Indian agency.....	750 feet.
Aubrey Bar.....	400 feet.
Barriers.....	430 feet.
Empire Flat.....	1,200 feet.
Total.....	2,780 feet, at \$3..... 8,340
Proportion of \$5,000 for lighters, camp equipage, transportation, &c.....	600
Add 10 per cent. for contingencies.....	10,940
Total.....	1,094
Total estimate:	
Above Camp Mojave.....	85,235
Below Camp Mojave.....	12,034
Grand total.....	97,269

## SUMMARY.

The Colorado River, between Yuma and Camp Mojave, about 300 miles, is generally navigable, though with more or less difficulty, at all seasons of the year. It has been shown that most of the Ehrenberg trade will disappear during the coming summer; leaving it out, therefore, the freight carried to and from all points on this portion of the river has, during the past two years, averaged less than 300 tons per month.

The principal obstructions to navigation being the shoal and shifting channels in the valleys, no plan will give any permanent change for the better unless it provides for the entire and certain confinement and control of more than 200 miles of river, while there is manifestly no present justification for so vast an expenditure as the execution of such a plan would entail.

Improvements, however, could be effected, and would probably be permanent, at certain gravel bars for about \$13,000.

The section of the river between Camp Mojave and El Dorado Cañon can at present be navigated for more than three months in the year, and throughout it, low-water navigation could probably be provided for about \$90,000, though unforeseen contingencies might increase that amount.

Most of the freight which seeks to go above Camp Mojave is for Hardyville, while the distance between the two places is only 7 miles and traversed by a good road.

During the entire 19 months preceding January 1, 1879, less than 100 tons was transported from below to points above Hardyville, the principal and only important reason for the navigation of the upper portion of the river being the supply of wood to the El Dorado mill.

There seems no reason why this business could not perfectly well be done during high-water in the future as heretofore, and I am therefore decidedly of the opinion that the interests now involved are very far from warranting the expenditure of so much money, not really to enable the transportation company to accommodate them, but merely to render it more convenient to do so.

In a country whose only possible future lies in the discovery of mineral wealth, such discovery should precede and create the demand for increased communication facilities, its case being widely different from that of an agricultural district, where the construction of proper means of communication may, in itself, make practicable and hasten the development of its resources.